NSRL PHASE II PROJECT

Zuping Liu, Yuan Ji Pei, Yuming Jin, Weimin Li,
Xiangqi Wang, Anqi Zhou, Lei Shang, Yongjun Li

National Synchrotron Radiation Laboratory
University of Science and Technology of China
Hefei, Anhui 230029, P.R.China

Abstract

Status of the HLS (Hefei Synchrotron Radiation Light Source) is briefly described. The machine has been running for SR users at home and abroad since 1993. The typical operation parameters are: energy of 800 MeV, current of 150 mA and lifetime of 10 hrs .

A plan of the Phase II Project of NSRL (National Synchrotron Radiation Laboratory) is described here. The plan is mainly composed of two parts, one part is to add another 8 beamlines and experimental stations, another is to construct an undulator and improve the machine to upgrade its performance, such as reduce the emittance down to 27 nm.rad, the brightness of the light from the undulator will be increased three orders up and so on.

The NSRL Phase II Project has started and will be completed in the end of 2000. The total budget is about 125 M Chinese Yuan.

1 INTRODUCTION

HLS(Hefei Light Source) is a dedicated SR light source which is mainly composed of an injector of 200 MeV electron LINAC and a storage ring of 800 MeV(see Fig.1)[1].

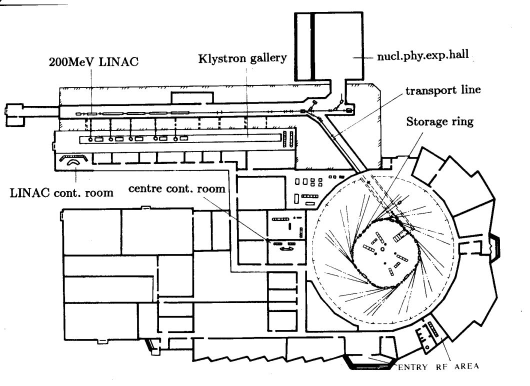

Fig. 1 Layout of the HLS

A total of 51 beam lines and experimental stations could be accommodated. Up to now there are only five beamlines and experimental stations, which are named Soft X-ray lithography, Photochemistry, Time resolved spectroscopy, Soft X-ray microscopy and Photoelectron spectroscopy, respectively. Now these stations have run for users at home and abroad. Many research results have been reported.[2] These existing experimental stations will not satisfy the various needs from researchers on different scientific fields. So we plan to upgrade the machine so as to enhance its qualities, stability and reliability, to construct another 8 beamlines and experimental stations to expand the SR application range. The plan is named as “NSRL PHASE II PROJECT”.

2 STATUS OF HLS MACHINE

The machine has run well and provided beam time of 18741 hours for SR users at home and abroad in 1992-1997. The statistics of operation time in 1992 - 1997 is shown in Fig. 2.

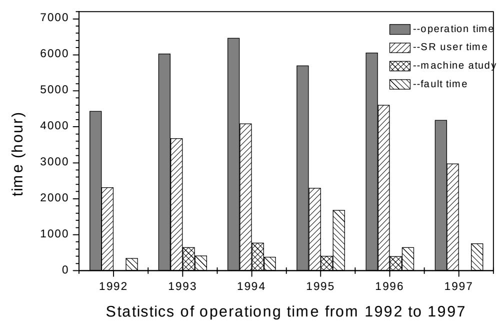

Fig.2

The routine typical operation parameters are: energy of 800 MeV, current of 150 mA and lifetime of 10 hrs. A typical recorded current curve versus time in the storage ring is shown in Fig. 3.

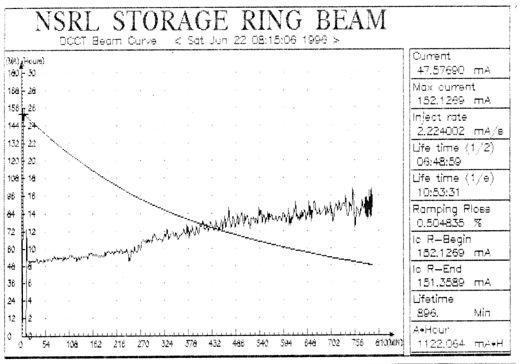

Fig. 3 Beam current curve in the ring of HLS

The operating schedule is following: about ten months a year is for operation time, as in the summer and winter the machine is shutdown for maintenance and holidays. During the operating time, every two weeks makes a period of operation, in which 11.5 days , 24 hrs per day the machine is running for users , two and half days are for machine study and machine maintenance.

We have carried out some beam instabilities research in HLS storage ring. It included head-tail instability, bunch lengthening and energy spread widening, beam-cavity interaction, study on forming a single bunch by RFKO method etc.[3]

During machine study, we got beam current of 64 mA in a single bunch in the storage ring using RFKO (Rf Knock Out) method. We found that the RF clearing electrode is useful to restrain the transverse instabilities in vertical direction. We also found that the RFKO method can be used to overcome some instabilities, such as forming a three-bunch-train pattern in the storage ring, which means the beam in the ring is not uniformly filled(as Fig. 4 shown), and then the beam is easily accumulated to more than 300 mA.

Last year, a transverse optical klystron was installed in one long straight section and got some results of spontaneous emissiom.

The High Brilliance mode Lattice (HBLS) was tried in a machine study and got a stored beam current of 25 mA. We found that higher current stored is limited by the jitter time of the injection system.

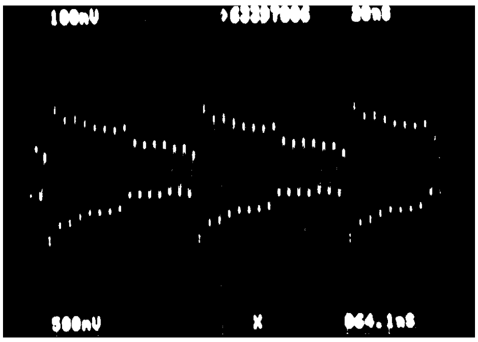

Fig. 4 Photograph of an uneven distribution

A 6 Tesla wiggler was installed this year and just successfully passed its first test with beam.

3 PLAN OF NSRL PHASE II PROJECT

Providing high quality, bright photon beam is vital to the success of a synchrotron radiation laboratory. We are making continuous efforts to improve machine stability and beam availability, construct new beamlines and experimental stations as many as possible to expand the application range and raise the rate of utilization. In 1994, we submitted a proposal named Phase II Project of National Synchrotron Radiation Laboratory to Chinese government. Last year, the proposal was authorized by the government. The budget is about 125 M Chinese Yuan from 1997 to the end of 2000. The summary of the plan is following:[4],[5]

3.1 Upgrade of the machine

- Increasing the brightness of the HLS

At the beginning of 1990's, we have designed different lattice configurations, such as GPLS(General Purpose Light Source) , HBLS(High Brilliance Light Source) and so on, so that the machine can meet the demands of users in different fields. So far the machine is only routinely operational on GPLS mode with an emittance of 166 nm.rad. We tried to run the HBLS mode and once got stored beam of 25 mA, 200 MeV in the ring, but it is difficult to repeat. This is because of the exciting current in one of the tree kickers is so small that the current amplitude and its jitter time are hard to keep stable. These will result in an imperfect and instable bump orbit. Another reason is that the space for two sextupoles were occupied by two kickers. This leaves only fourteen sextupoles, instead of sixteen, now installed in the storage ring so the symmetry distribution of the sextupoles along the ring is destroyed and the dynamic aperture is reduced (as Fig.5 showed).

According to theoretical calculation and operating experiences, we will redesign the injection system that four ferrite kickers will be located in a same straight section in order to create spaces for two additional sextupoles. With this change, calculations of injecting tracking and dynamic aperture were done. The results calculated show that the dynamic aperture is obviously enlarged after the two chromaticity correct sextupoles are added to the storage ring.

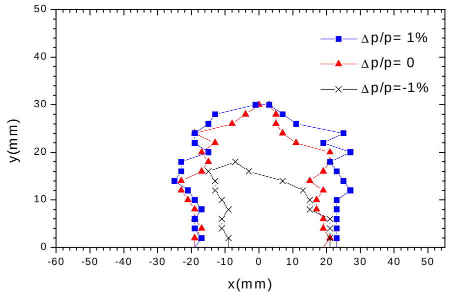

Fig. 5 Dynamic aperture with fourteen sextupoles

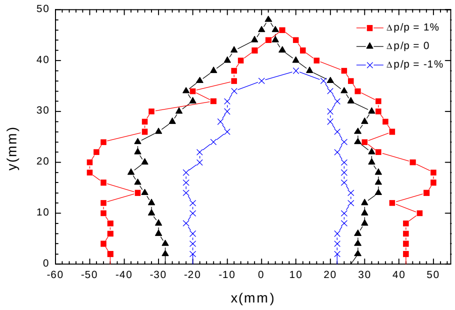

fig. 6 Dynamic aperture with sixteen sextupoles

It is clear that this improvement will favour the beam current accumulation and increasing the beam lifetime. Fig.5 and Fig.6 show these results in different cases, using program MAD and PATRICIA respectively.

In order to further increase the dynamic aperture, we try to divide the sextupoles into different families, say, three families and two families. We found that the dynamic aperture in x-direction with a three-family configuration is two times as large as the conventional two-family. Results calculated using program RACETRACK are shown in Fig.7 and Fig.8 respectively.[6]

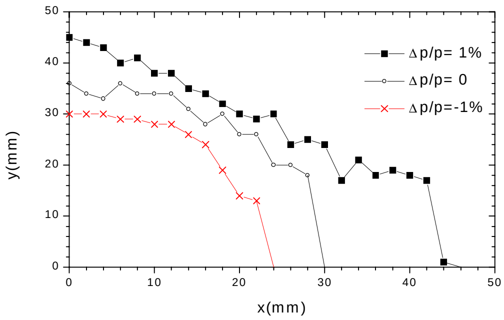

Fig. 7 Dynamic aperture with two-family sextupoles

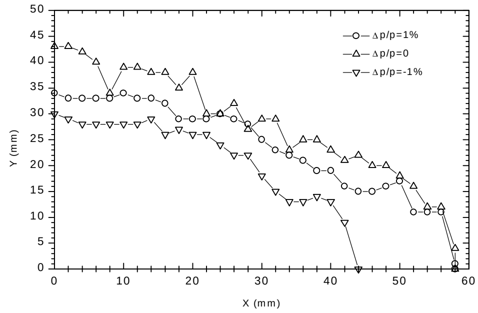

Fig. 8 Dynamic aperture with three-family sextupoles

- Reconstructing the injection system to meet the requirements of HBLS mode and improve injection stability.

The bump orbit shape formed by the exist kicker system is dependent on the Twiss parameters of the HLS ring, because there are four quadrupoles between kicker 2 and kicker 3. Moreover, the three spark gap switches are employed as a switch of pulse power supplies for the kickers. The jitter time of them can hardly be kept small enough. So it is difficult to accumulate the current in the storage ring when the HBLS mode will be commissioning. In order to make the HBLS mode available to users, one good way is to make the bump orbit is independent of the lattice parameters. So we plan to build a new injection system which will be composed of four ferrite kickers and located in a same long straight section where there is no quadrupole. At the same time we will develop new power supplies which will employed a thyratron as switch in order to make the jitter time less than 2 ns and have them run more stable. Fig.9 (a), (b) show a sketch map of the existing and new injection system and their bump orbits of GPLS and HBLS, respectively. The summary parameters of the new injection system are listed in following table. In terms of these parameters, injecting tracking study was done.

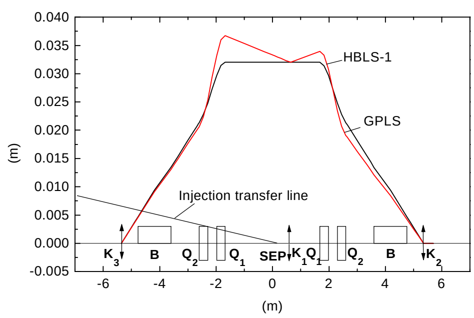

Fig. 9(a) Sketch map of existing three-kicker system and bump orbits of GPLS, HBLS

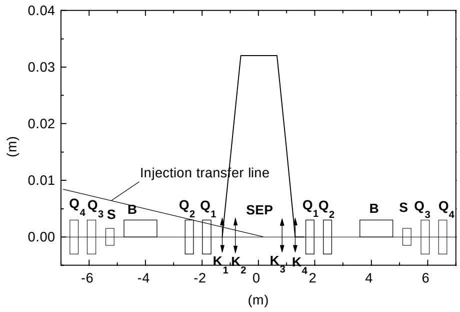

Fig. 9(b) Sketch map of the new kicker system and bump orbit

Main parameters of new injection system

Injection energy	200 MeV
Maximum bump orbit offset	32 mm
Maximum deflection angle of each kicker	49.19 mrad
Waveform of the kicker magnetic field	half Sine with att.

Tracking code which was developed by ourselves included the following functions: Twiss parameter calculation, bump orbit calculation, single particle tracking, beam bunch tracking. The tracking results show that more than four turns of the injected beam can be captured in one cycle without losing during injecting process, when $\Delta p/p = \pm 1.0\%$, jitter time $t_j = 20 \pm$ ns, injected beam emittance.[7]

- Developing a 29-period undulator and put it running to increase the light brightness 2-3 orders up, in the range of 100 to 1620 angstroms.

After making these improvements as mentioned above, the photon brightness will be increased (see Fig. 10).

- Improving the dc power supply system to increase the beam stability and reduce the fault time.

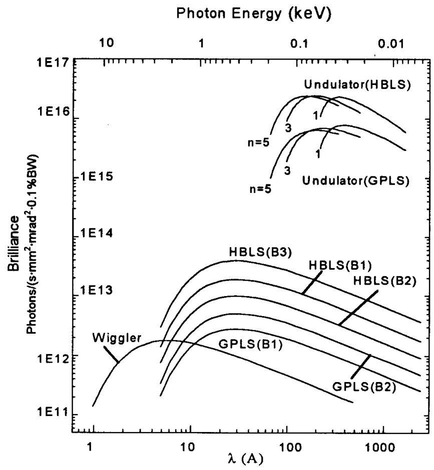

Fig. 10 Brilliance curve of SR from HLS (after Phase II Project)

- Developing a feedback system and put it in operation to make the beam position stable.

- Improving the RF system to increase the power output, reduce the fault time, and to meet the requirements of different mode operations.

When the HBLS mode is running, more than 200kV RF accelerating voltage will be necessary for a sufficiently long Toushek lifetime. Fig.11 shows the curve of the lifetime versus RF cavity voltage Vc, in the condition of sufficient energy acceptance.

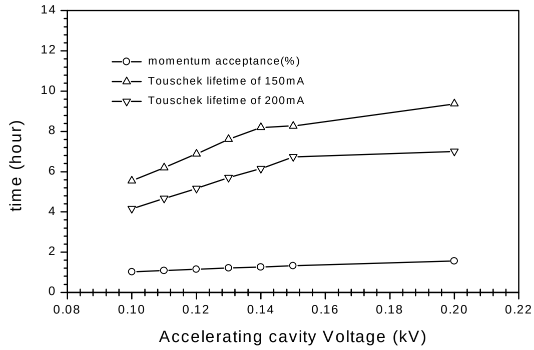

Fig. 11 Lifetime vs. RF cavity voltage

- Upgrading of the control system.

3.2 New beamlines and experimental stations

Constructing 8 beamlines and experimental stations. They will be used for Surface physics, X-ray diffraction and Scattering, LIGA, Atomic and molecular science, Photo-acoustic and photo-thermal spectroscopy, Infrared and far infrared spectroscopy, Soft X-ray magnetic circular dichroism, and Metrology and spectral radiation standard. Description of the new stations has been reported elsewhere.[8]

3.3 Budget and schedule

Total budget is about 125 M Yuan.

The schedule is roughly as following:

Oct., 1997-June 1998 design work and make contract with factories and companies.

Jan., 1998-Dec. 1999 developments, manufacture and tests of the parts which will be installed in the machine successively.

From Jan., 2000 installation and commissioning.

4 ACKNOWLEDGMENTS

We credit the success of constructing and running HLS to our colleagues in the National Synchrotron Radiation Lab., and to the scientists and engineers of other institutes as well for their collaborations. During making the NSRL Phase II project, many scientists at home and abroad have been giving us so many suggestions and help. We would like to express our heartfelt gratitude to them here.

5 REFERENCE

[1] Y. J. Pei, Proc. of the 4th Intl. Con. on Synchrotron Radiation Sources and 2nd Asian Forum on Synchrotron Radiation . 123 (1995).

[2] X. Y. Zhang, J. of China University of Science and Technology, Vol. 25(1995), 69.

[3] Y. J. Pei & W. M. Li, Proc. of 6th National Particle Accelerator Physics Symposium in China, Changsha, Hunan, (1997).

[4] Y. J. Pei, Proc. of the Sixth China-Japan Joint Symposium on Accelerators for Nuclear Science and Their Applications, p.32, 21-23 Oct. 1996, Chengdu, China.

[5] D. H. He, Y. J. Pei & Y. M. Jin, et al. J. of Shenzhen Univ., Vol. 14, No.1 P.1-17,(1997).

[6] A. Q. Zhou, Y. J. Li & W. M. Li, et al., J. China Univ. of Scie. & Tech., to be published in 1998.

[7] L. Shang, X. Q. Wang & Y. J. Pei, to be published in N.I.M. in 1998.

[8] Z. P. Liu & X. Y. Zhang, Proc. of 6th Intl. Conf. on Synchrotron Radiation Instrumentation, to be published in J. of Synchrotron Radiation, May 1, 1998.