OPERATION STATUS OF HLS-II*

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Abstract

After a major renovation, the Hefei light source (HLS), renamed HLS-II, was brought into trial operation in the beginning of 2015. The light source was operated about 7290 hours in 2015. In this period of time, The HLS-II delivered about 4800 hours of beam time to users for various experiments, and provided about 2500 hours of beam time for machine studies and resolving problems encountered during the operation. The light source achieved an overall reliability of 97.7% and mean time between failures (MTBF) of 88 hours. This paper summarizes the operation results and reports some critical machine studies for improving the performance of the light source.

INTRODUCTION

After a major renovation, the Hefei light source (HLS), renamed HLS-II, was brought into trial operation in the beginning of 2015. The HLS-II is comprised of an 800 MeV linac, a beam transfer line and an 800 MeV electron storage ring (SR). Some critical parameters of the facility are listed in Table 1.

Table 1: Main Parameters of the HLS-II Facility [1]

Name	Value
Linac Energy (MeV)	800
SR Energy (MeV)	800
Circumference of SR (m)	66.13
SR Magnet lattice	DBA
SR Beam emittance (nm·rad)	38
SR tunes(ν_x/ν_y)	4.414/3.346
Beam current (mA)	300
Operation Mode	Decay
Number of IDs installed	5
Number of Beamlines	10

Since the Linac provides electron beams with the same energy as that of the SR, the electron beam can be injected into the SR with a full energy, and the light source has the potential to be upgraded to topoff mode. The SR is built using four double bend achromatic (DBA) cells to gain 38 nm·rad emittance at 800 MeV. Five different types of insertion devices (IDs) — undulators are installed in the SR. Ten beamlines are currently in operation. Among these beamlines, 5 of them are using the radiation from the IDs, while others using the dipole radiation.

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This paper summarizes the operation result of the HLS-II light source in year 2015. Some important machine studies for improving the performance of the light source are also presented in this paper.

THE OPERATION OF HLS-II

The HLS-II was operated about 7290 hours in year 2015 from Jan 4 to Dec. 31.

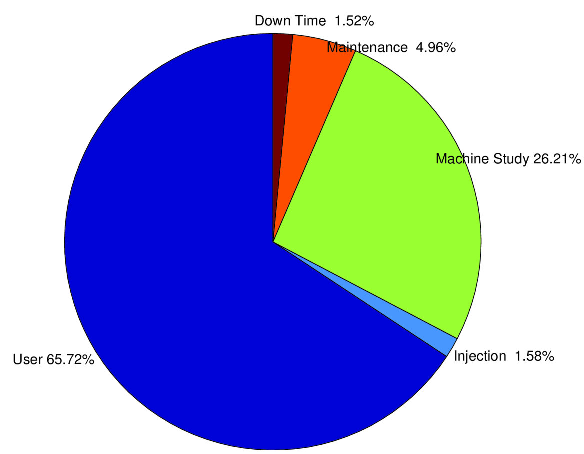

Figure 1: Beamtime distribution of the HLS-II in 2015.

During this period of time, the light source delivered about 4800 hours for user programs, and about 2500 hours for accelerator related activities, including machine studies, vacuum scrubbing, machine maintenance and beam injection. The total un-scheduled machine downtime is about 111 hours. The beam time distribution is shown in Fig. 1. In this period, the overall availability of the light source is about 97.74%, and the mean time between failures (MTBF) is about 88 hours. This high level operation in the first year of trial operation was realized in spite of many challenges for the newly built accelerator complex.

VACUUM LEAKING AND RECOVERING

Two pieces of in-vacuum water pipe used for cooling the synchrotron radiation absorber, close the 5th and 6th dipoles (B5 and B6), were detected having vacuum leakage. These pipes and absorbers were replaced and the machine was soon back to operation. However, the vacuum at the location of leakages toke a long time to recover. To speed up the process of the recovering, we periodically scanned the beam orbit, especially in the vertical direction, during non-user beam time to increase degassing.

The result of vacuum scrubbing using orbit scan method is shown in Fig. 2a, which indicates that degassing from the

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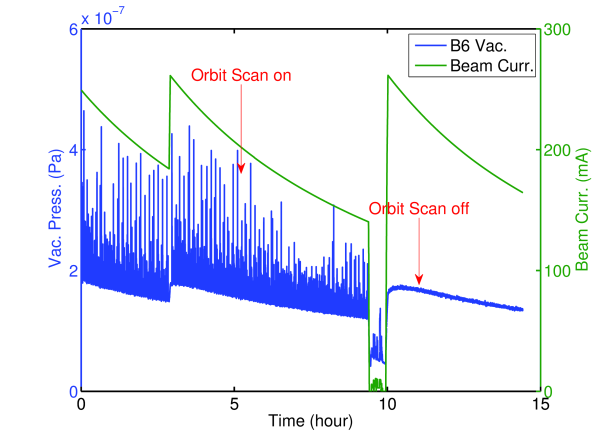
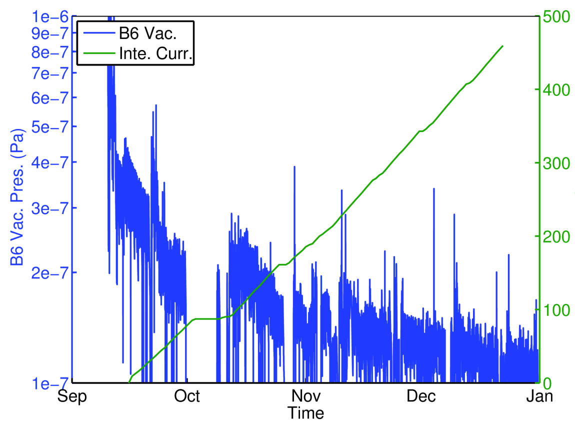


(a)



(b)

Figure 2: Vacuum scrubbing and recovering at the location of the 6th dipole, B6. (a) Orbit scan for vacuum scrubbing;(b)Vacuum recovering.

new absorbers is significantly speed up. Figure 2b shows that the vacuum at the location of B6 toke about 4 months to reach 1E-7 Pa level.

PRELIMINARY STUDY USING THE 4-TH HARMONIC RF CAVITY

A 4-th harmonic RF cavity was installed in the HLS-II storage ring [2] to control beam instabilities and reduce intro-beam scattering effect. A PID feedback loop based upon EPICS is developed to effectively control the high voltage across the cavity [4]. Using this cavity, we performed preliminary studies on the beam bunch stretching.

During the experiment, the high voltage of the high harmonic cavity (HHC) was varied from 20 kV to 54 kV by tuning the cavity resonance condition. At some designated voltages, the beam bunch distribution in the longitudinal direction was measured using a streak camera. The RMS bunch length is calculated and plotted as a function of the high voltage of the cavity, as shown in Fig. 3. The figure indicates that the bunch is stretched more than 30% from its original length. Our experiences in the operation indicate

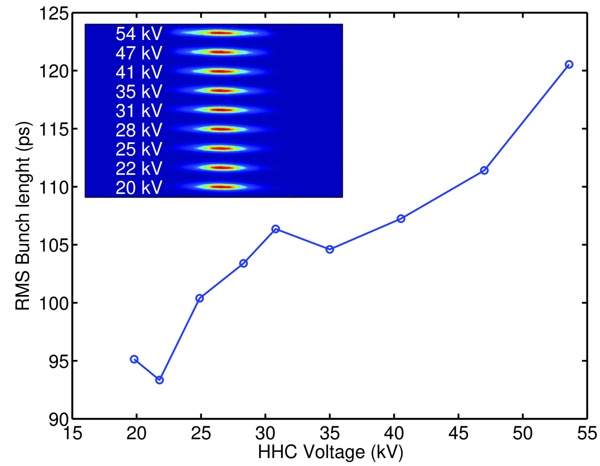


Figure 3: Beam bunch stretching using the 4th harmonic RF cavity.

that this bunch stretching helps significantly to suppress the longitudinal coupled-bunch instabilities.

ORBIT STABILIZATION

A stable transverse orbit of the electron beam in the storage ring is critical for user experiments and the light source operation. The orbit of the HLS-II storage ring is stabilized using a Matlab based feedback program [3].

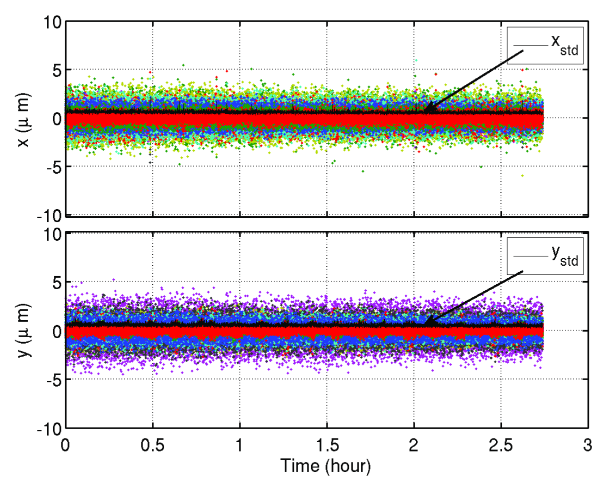


Figure 4: The orbit stabilization of the HLS-II storage ring. All the BPM values and the rms orbit value over all BPMs are plotted as a function of time.

There are 32 orbit correctors and 32 beam position monitors (BPMs) are used by the feedback program. The singular value decomposition (SVD) method is adopted in this program. After carefully measuring the quadrupole centers as the golden orbit, improving the performance of the corrector power supplies, and optimizing the BPM system, the peak-to-peak variation of all the BPMs is limited within 10 μm, and the rms orbit variation is less than 2 μm, as shown in Fig. 4.

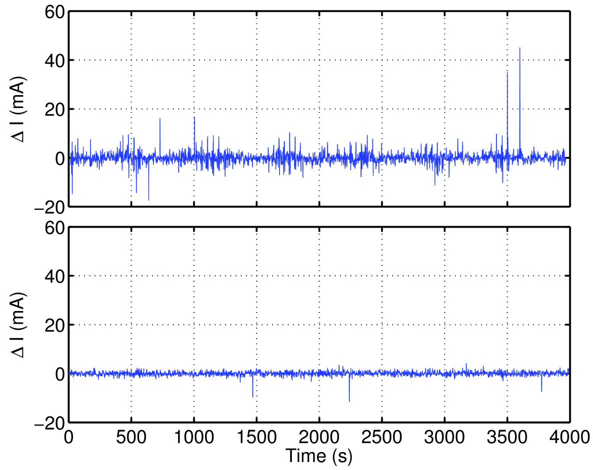


Figure 5: The stability of the PS output at fixed setpoints. (up) before optimization; (down) after optimization.

POWER SUPPLY OPTIMIZATION

In order to achieve stable movement of the electron beam, the performance of the power supplies (PSs) used to energize the main magnets in the HLS-II storage ring were improved by tuning its control parameters. Two types of optimization were performed. The first optimization was to increase the PS's output stability at a fixed setpoint by tuning the parameters of the built-in feedback loops. The PS stability before and after optimization is plotted in Fig. 5, which shows that the peak-to-peak variation of the PS output is more than 40 mA, which is about 200 ppm with respect to the full range of the PS. After optimization, the peak-to-peak variation is less than 10 mA and 50 ppm with respect to the full range.

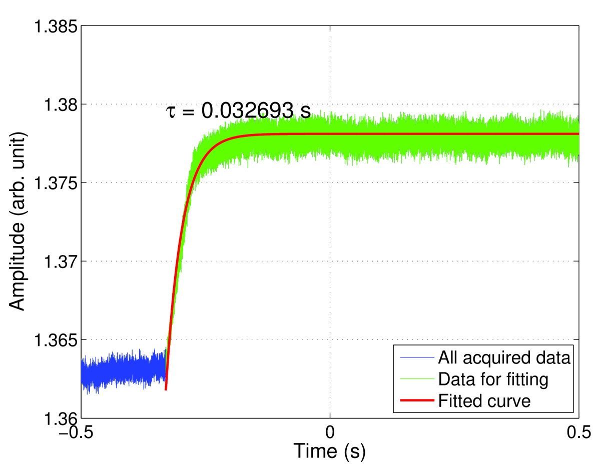


Figure 6: The rising curve of the power supply output.

The second optimization was to reduce the time constant of the PS. Before optimization, the power supplies needed more than 3 seconds (3τ) to reach their setpoint values, and had obvious overshoot in the rising curve. Through optimization, these dynamic features are significantly improved, as shown in Fig. 6. The figure shows the rising time (τ) is reduced to 33 ms and the output has a smooth transition from the old value to the new setpoint. This feature is of extremely importance for energy ramping and online compensation of the residual field of the insertion devices.

STABILIZING THE RF CAVITY

The water cooling system plays a key role in stabling the RF system of the storage ring, especially during sudden transition of atmosphere temperature.

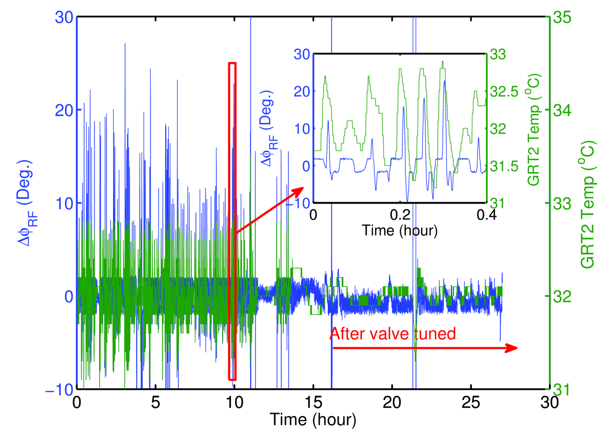


Figure 7: Impact of the water cooling system on the phase stability of the RF cavity.

After carefully studies, we found that the valve adjusting resolution is the main reason to cause this problem. With carefully tuning the valve resolution according to the weather, this problem has been well solved, see Fig. 7.

SUMMARY

The HLS-II has been in trail operation from Jan 4 to Dec 31 in 2015. It delivered about 4790 hours to the users for various experiments. It also provided about 2500 hours for accelerator related activities. The light source achieved 97.74% of overall reliability and 88 hours of MTBF. A series of machine studies has been perform both to resolve problems encountered in the operation and to improve the performance of the light source complex. The light was brought into routine operation since Jan 2016. The operation in 2016 would benefit from all of the machine studies performed in year 2015.

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