THE UPGRADE OF HEFEI LIGHT SOURCE(HLS) TRANSPORT LINE *

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Abstract

To enhance the performance of Hefei Light Source, an upgrade project is undergoing. The magnet lattice of storage ring will be reconstructed with 4 DBA cells, whose advantages are lower beam emittance and more straight section available for insertion devices. In order to assure smooth beam accumulation process under new low emittance lattice, the injector, which is composed of electron linac and beam transfer line, would be updated. The detail upgrading of Hefei Light Source transport line will be described in this paper. It include the upgrading of lattice, the orbit control of beam transfer line and others. It is hopeful to realize a high transfer efficiency and high injection efficiency for new low beam emittance storage ring.

INTRODUCTION

HLS is a dedicated second generation VUV light source, whose main body is composed of 800MeV electron storage ring, 200MeV linac and beam transfer line. There are two factors affecting light source performance: large beam emittance and less number of straight sections. In order to improve HLS performance, an upgrading is undergoing now[1]. The main purpose of upgrading are increasing the number of insertion devices, lowering the ring's beam emittance and improving the beam orbit stability. After upgrading, separate function DBA was adopted as the standard cell of ring. There are four 4.0m long straight section and four 2.3m long straight section. The emittance of lattice will be reduced to 36nm.rad in achromatic mode and to 20nm.rad in distributed dispersion mode. The orbit stability will be smaller than 5μm.

After upgrading, the beam accumulation process will be more difficult under low injection energy. Improving injection efficiency is essential to obtain high beam intensity. In order to improve injection efficiency, the injector should be upgraded also. The demanding to the injection beam is shown in table 1. As comparing, the old injector beam properties are shown in table 1 also.

The injector of HLS was constructed twenty years ago, and poor beam properties cannot meet the requirements of new ring. Several upgrades were proposed. A new thermal-cathode gun will be constructed to reduce the beam emittance and to get ns pulse time structure. Cooperating with new time system, bunch by bunch filling would be realized in the future. A new phase control system also will adapt to promote the energy stability of injector. An new beam trajectory monitoring system and related steering magnet system will be applied. It will be helpful to control the position and angle of injected beam.

Table 1: Demanding to the Injection Beam

parameters	demanding	Old machine
Charge	1nc/1ns	80mA&0.5μs
Energy spread	0.5%	0.8%
Energy stibility	0.5%	0.7%
Normalized emittance (rms)	40mm•mrad	200mm•mrad
dx&dy(rms)	0.2mm	No
dpx&dpy(rms)	0.2mrad	No

A 53m long transport line connects the storage ring of HLS and LINAC. In its preliminary design, there exist phase space mismatch between transport line and storage ring, which maybe results in lower injection efficiency and sensitivity of injection process to injected beam conditions. And the injection position of the ring will be moved about one meter distance also. So in order promote the transfer and injection efficiency, the lattice of transport line must be redesigned. And in order to control the orbit of transport line to meet the demanding of the ring, the BPMs and correctors will be reconstructed also.

THE NEW LATTICE OF TRANSPORT LINE

The transfer line design is optimized to transfer the beam efficiently and to meet the optics requirements at the injection point. There are two main changes for the transfer line. The first one is to realize the moving of injection point. The second one is free the dispersion at injection point[2].

For the new ring lattice, the injection point move toward downstream about 1.0 meter, and the injection straight section moves outward about 20cm relative to old straight section. The detail of moving is shown in the Fig. 1.

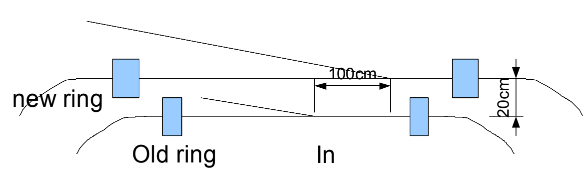

Figure 1: The changing of injection point

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In order to fulfil the up two purpose, two 4 degree rectangle bend magnets are installed. The two magnets can realize the shifting of transport line and the matching of horizontal dispersion of injection point.

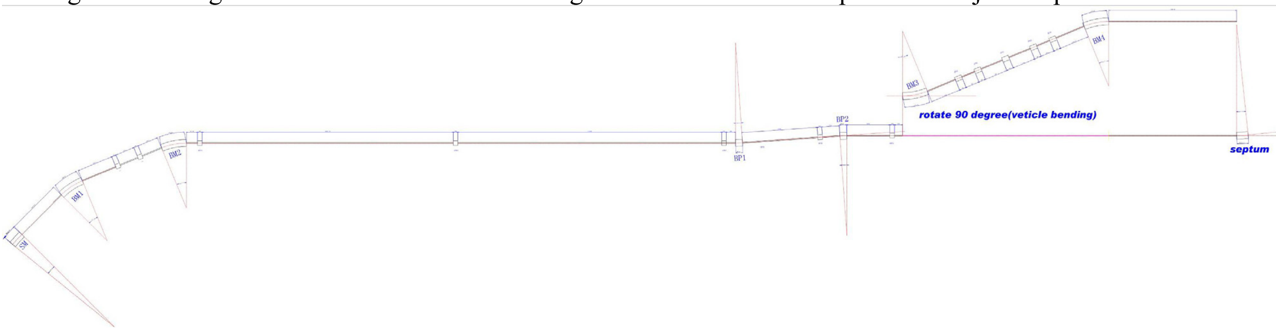

Figure 2: Layout of new transport line

The layout of new transport line is shown in Fig. 2.

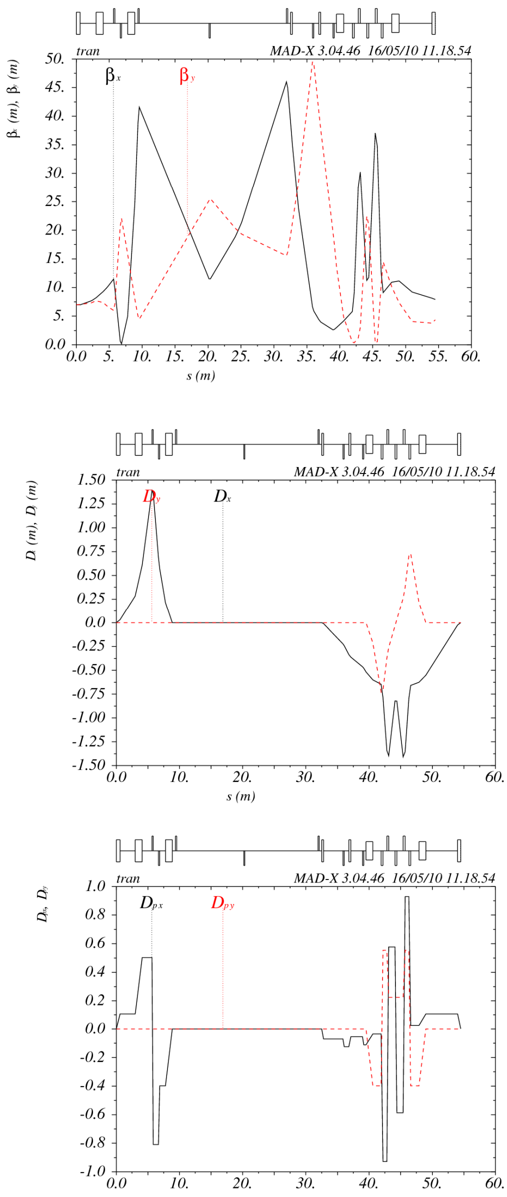

Figure 3: beta function, dispersion and .dispersion derivative of new transport line

The new HLS transport line consists of four modules:

1) Horizontal acromat section, from switching magnet to the second dipole (BM2) with a horizontal deflection angle of 51 degree totally, makes the horizontal dispersion function and its derivative zero at the exit of second dipole.

2) Optical matching section, which is a dispersion free section, from the second dipole (BM2) to the first 4^0 dipole (BP1). Three quadruples are used to match optical function.

3) Horizontal dispersion matching section, from the entrance of first 4^0 dipole (BP1) to the entrance of third 22.5^0 dipole (BM3). This section realize the 20 cm shifting of transport line and the matching of horizontal dispersion of injection point.

4) Vertical acromat section, from the entrance of third dipole (BM3) to injection point with a deflection angle of 22.5×2degree in vertical direction. Transfer the beam to the storage ring's plane. The difference of height from LINAC plane to ring plane is 3.2m. At injection point, the dispersion function and its derivative in two directions are matched to zero.

The optics of new transport line is shown in Fig. 3[3]. The beta functions of two directions are smaller then 50m. The absolute maximum value of horizontal dispersion is smaller than 1.5m. And the absolute maximum value of vertical dispersion is smaller than 0.8m. The twiss parameters at injection point are matched to the ring's demanding.

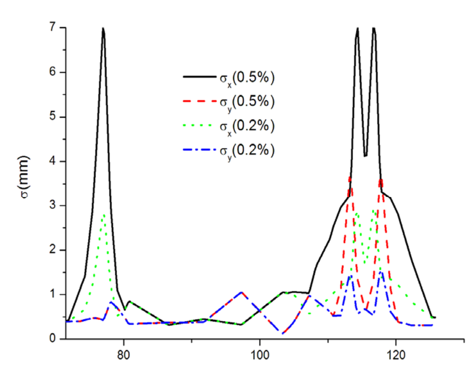

Figure 4: The beam envelope of different energy spread in new transport line

The beam envelope under different energy spread in new transport line is shown in Fig. 4. The maximum beam envelope is decided by the energy spread, and it is about 7(H)&4(V) mm under 0.5% rms energy spread and 3(H)&1.5(V) mm under 0.2% rms energy spread.

THE TRAJECTORY CONTROL OF NEW TRANSPORT LINE

The alignment errors and strength errors of quadrupoles and bend magnets cause the distortion of beam trajectory. The distortion of trajectory reduces the transfer efficiency of transport line and causes the emittance increasing dramatically. Large residual dispersion at injection point also will cause low injection efficiency.

10 single pass BPMs and 10 pair correctors are used to control the trajectory of transport line. A BPM is located as close as possible to the injection point. It is used to confirm the final beam parameters from transport line.

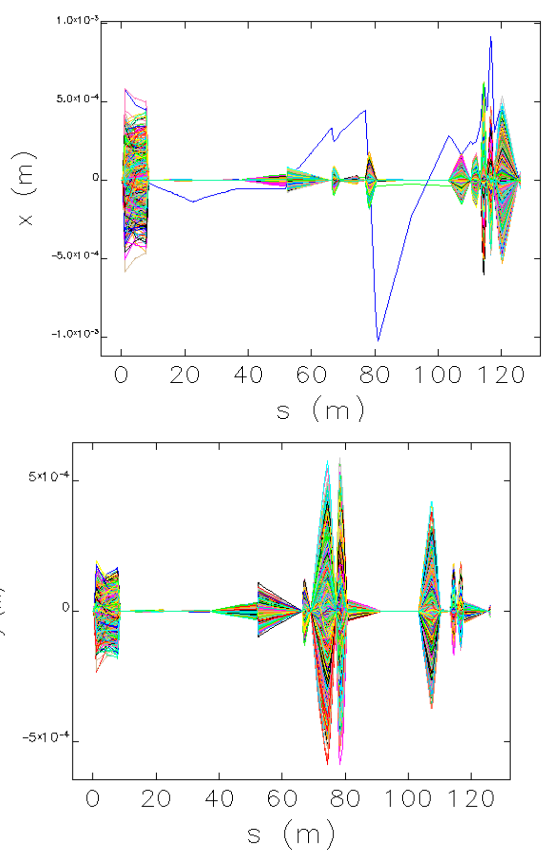

Figure 5: 1000 random seeds simulation of trajectory corrections of transport line.

Figure 5 give the corrected central trajectories of from LINAC to transport line simulated by elegant[4]. In the simulation, the LINAC and the transport line are treated together. The errors setting is shown in table 2. The simulations are run by 1000 random seed. The maximum trajectory offset is smaller than 1mm. The maximum strength of correctors is lower than 1mrad. At injection point, the position and angle errors are under 0.2mm and 0.2mrad.

Table 2: Errors Setting of Orbit Correction Simulation

Parameter(rms)	bend	quadrupole
Dx&dy&dz(mm)	0.2	0.2
Rotate error(mrad)	0.5	0.5
Strength error	0.05%	0.1%

All errors cutoff at 3σ.

The normalized emittance after trajectory corrections at injection point is shown in Fig. 6. After including the residual dispersion, the emittance fulfil the demanding of injection.

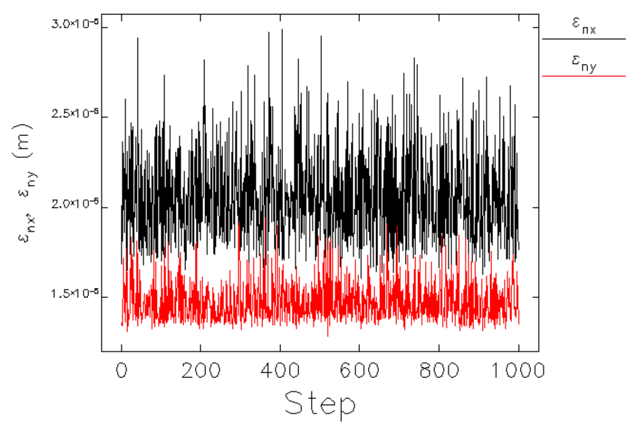

Figure 6: The normalized emittance after correction

SUMMARY

After the upgrading of HLS transport line, with lower beam emittance and higher transport efficiency in beam line, we can expect high injection efficiency for the new storage ring. The ring will run more efficiency and stably.

ACKNOWLEDGEMENT

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