CONSTRUCTION PROGRESS OF THE SSRF INJECTOR

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Abstract

Shanghai Synchrotron Radiation Facility (SSRF) is a third generation synchrotron radiation source facility under construction. To meet full energy top-up injection requirements of 3.5GeV storage ring, the injector of SSRF was designed which consists of an 150 MeV linac, a two super-period 28 cells FODO type booster and two transport lines (LT and HT). The cycle rate of the booster is 1 or 2 Hz.

In this paper, the brief description of SSRF injector design, and the progress of construction of the linac, booster and transport lines are described.

INTRODUCTION

As a third generation synchrotron radiation source facility, the SSRF storage ring calls for a 3.5GeV full energy injector, a top-up injection is also demanded [1]. After the SSRF project was approved in 2004 [2], the SSRF injector was redesigned to satisfy these new demands, a new detailed scheme of SSRF injector was carried out [3]. In the finally scheme, the SSRF injector is comprised of a dedicated 150MeV linac, a two-fold 28 cells booster and two beam transport lines. The high reliable linac is used as the pre-injector to meet the requirements of the booster injection. Figure 1 shows the schematic layout of SSRF injector.

The injection cycle rate has been fixed to 2 Hz. With this cycle rate and single bunch of 1nC charge, the booster can smoothly perform normal injections and continuous top-up injections. To speed up the commissioning of storage ring, the multi-bunch mode of the injector is also included in the renewed design, which produces maximal 150 bunches occupying a total time of 300ns.

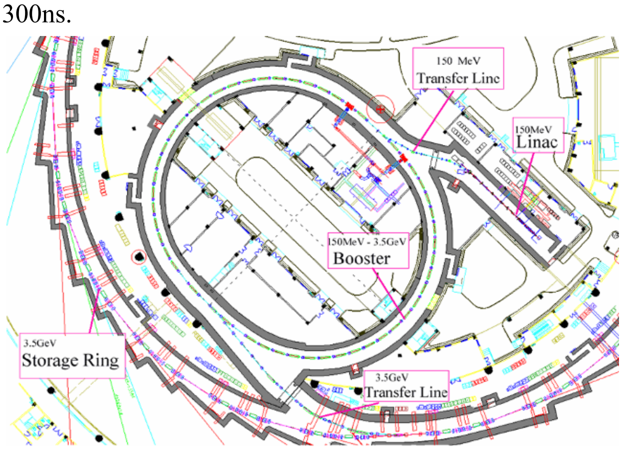

Figure 1: Schematic layout of SSRF injector

SSRF was started construction in the end of 2004. The beam commissioning will be completed in April, 2008 according to the schedule. The building construction has been basically finished. The linac installation was started in November, 2006, and the beam commissioning will be started in April, 2007. The Booster will start commissioning before October, 2007. Up to now, most of on-line installing components, power supplies, and instruments are under manufacture or purchasing for the SSRF booster and transport lines.

LINAC

The 150MeV linac is used as the pre-injector of 3.5GeV booster, which consists of four 3m long constant gradient accelerating sections and an injection section. A thermionic cathode electron gun, a 499.65MHz sub-harmonic buncher and a 2998MHz buncher, compose the linac injector section. The main beam parameters of the linac are listed in Table 1.

Table 1: The main parameters of linac

Nominal energy (MeV)	150
Repetition Rate (Hz)	1~5
Beam charge (nC)	
Single-bunch	1
Multi-bunch,	3~5
Pulse to pulse energy stability	0.25%
Relative energy spread	0.5% (rms)
Normalized Emittance (mm.mrad)	<100
Rf Frequency (MHz)	2998

The buncher and four accelerating structures are powered by two 45MW klystrons, each is driven by a 1kW solid-state amplifier. The pre-buncher is driven by a 500MHz r.f. amplifier.

Manufacture and test of all linac components have almost been finished. Mechanical and electrical installation are close to be completed. The beam commissioning will begin from April 2007. Figure 2 shows the progress of linac installation

BOOSTER AND TRANSPORT LINE

The SSRF booster performs as a synchrotron to accelerate the electrons from the linac energy of 150MeV to the storage ring energy of 3.5GeV. To achieve the emittance demands of top-up injection, the design of booster has been carefully optimized: 1) A reasonable low nature emittance and a relative large dynamic aperture. 2) Keeping bending magnet field strength at about 0.8T to limit the energy loss per turn and therefore cut down the scale and cost of RF system. 3) The booster is seated in an independent tunnel for the convenience in commissioning and maintenance.

Figure 2: Progress of SSRF linac installation

The circumference of the SSRF booster, comprising of 28 cells, is 180.0 m. The nature emittance is about 100 nm·rad. The layout of one standard cell of booster is shown in Figure 3. The beta functions for one super-period are shown in Figure 4. Table 2 and Table 3 summarize the main parameters and magnet parameters of SSRF booster.

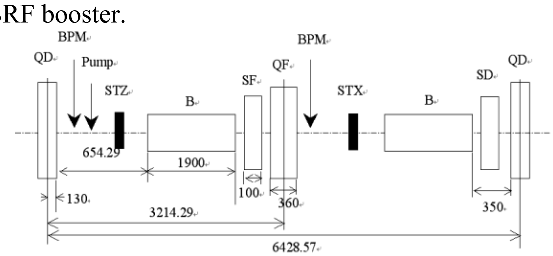

Figure 3: Schematic diagram for one cell

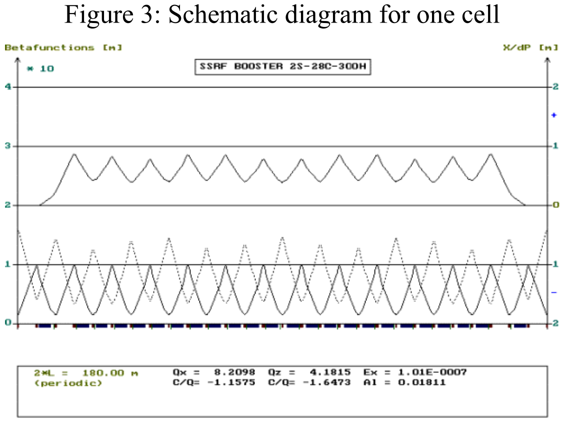

Figure 4: β-function and dispersion of booster

Table 2: Main parameters of the SSRF booster.

Parameters item		Unit	Value
Injection energy		GeV	0.15
Extraction energy		GeV	3.5
Beam current	Single bunch	nC	1
	Multi-bunch	mA	<15
Cycle rate		Hz	2
Circumference		m	180
Harmonic number			300
Super-period number			2
Cell number			28
Natural emittance at 3.5 GeV		nmrad	101
Energy loss per turn(3.5GeV)		MeV	0.915
Cell length		m	6.4286
Betatron tune, ν_H/ν_V			8.2/4.18
Natural chromaticity, ξ_H/ξ_V			-9.50/-6.89
Max. β function, β_H/β_V		m	10.0/16.0
Max. dispersion D_H		m	0.878
Nature Momentum spread			7.8×10^{-4}
Momentum compaction, α_P			0.018
Damping time, $\tau H/\tau V/\tau L$		ms	4.8/4.6/2.3
RF Frequency		MHz	499.65
RF Cavity (5 cells cavity)			2
Required RF voltage V_0		MV	1.74
Synchrotron tune, f_Z			0.0191

Table 3: Magnet parameters of the SSRF booster.

Bending magnet	
Number	48
Magnetic length (m)	1.9
Max. dipole field (T)	0.804
Gap height (mm)	32
Quadrupole magnet	
Number of QF, QD	28, 28
Magnetic length (m), QF/QD	0.36/0.26
Max. gradient (T/m), QF/QD	15.94/-15.64
Aperture radius (mm)	30
Sextupole magnet	
Number of SF, SD	22, 26
Magnetic length (m)	0.10
Max. gradient, SF/SD, (T/m^2)	109/-102
Aperture radius (mm)	30

The booster injection system consists of a septum and a fast kicker. The extraction system is comprised of a fast kicker, three bump magnets, a thin septum and a thick septum. The schematic layout and beam envelops of the injection and extraction are shown in Figure 5 and Figure 6 respectively.

The SSRF booster will use the biased sinusoidal wave as the dipoles magnetic field ramping curve, and the ramping curve of quadrupoles must trace the dipoles with precision of 0.1%.

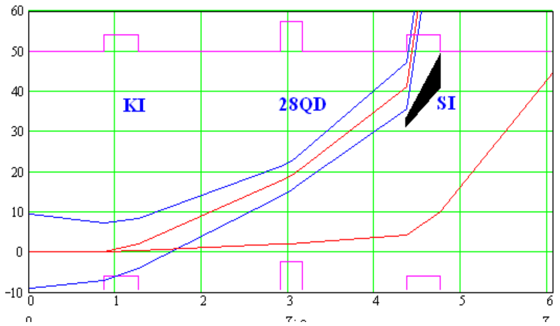

Figure 5: Schematic layout of booster injection

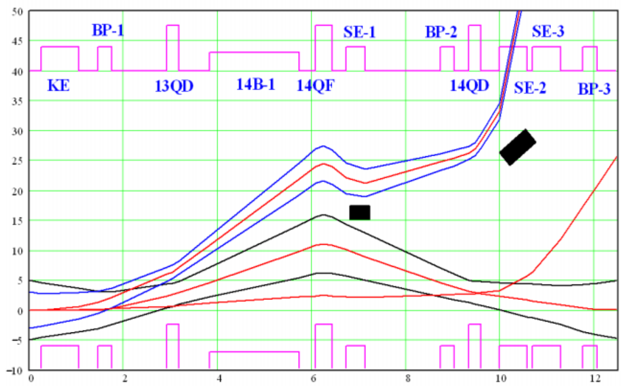

Figure 6: Schematic layout of booster extraction

Schematic layouts of magnets and diagnostic components for the low energy beam transport line (LT) and high energy beam transport line (HT) are shown in Figure 7 and Figure 8.

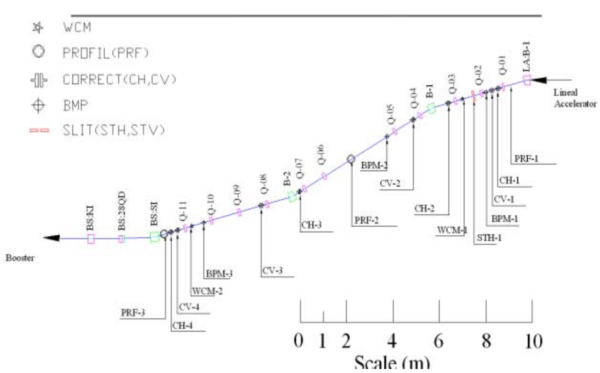

Figure 7: Schematic layout of LT

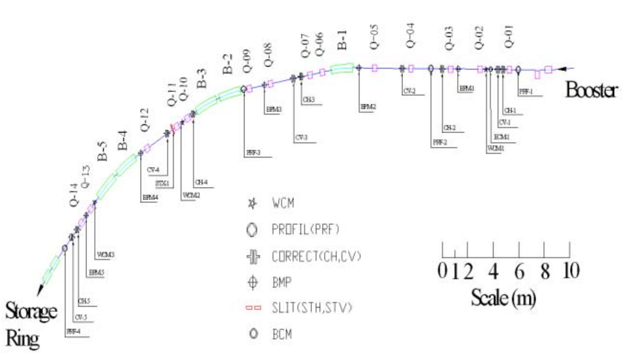

Figure 8: Schematic layout of HT

The prototype of key devices, such as dipole magnet, 2Hz dynamic dipole power supply, kicker and septum, fast pulse generators etc., have been developed and tested. Most of online devices are in the mass productions.

The installation of utilities in booster tunnel and technical halls was already started from January, 2007. In the meantime the pre-installation of booster cells was also started, and cells installation into tunnel will be started from April 2007.

Figure 9 and Figure 10 show some progress of SSRF booster.

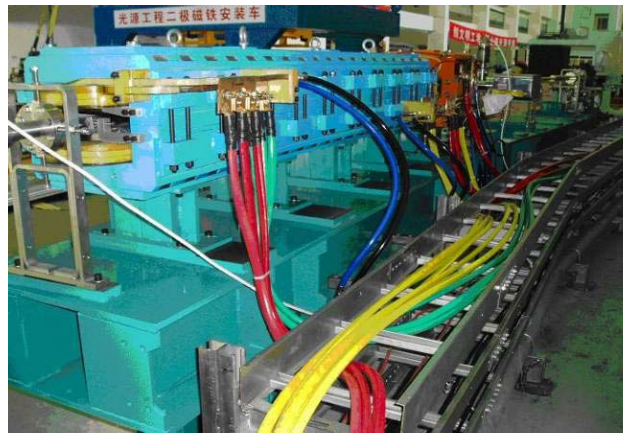

Figure 9: Test installation of a booster standard cell

Figure 10: Utilities installation in Booster tunnel

REFERENCES

[1] Z.T. Zhao, Construction of Shanghai Synchrotron Radiation Facility, These proceedings.

[2] Z.T. Zhao, H.J. Xu, Progress of the Shanghai Synchrotron Radiation Facility, proceedings of APAC 2004, Gyeongju, Korea.

[3] D.M. Li, Q.Gu, Z.T.Zhao, The New Scheme of SSRF Injector, proceedings of APAC 2004, Gyeongju, Korea.