COMMISSIONING OF THE SSRF BOOSTER*

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Abstract

The SSRF Booster, designed to accelerate the electrons from 150MeV to 3.5GeV, is a FODO structure synchrotron with 180m circumference and 2Hz repetition rate. The commissioning of the SSRF booster from the LTB transfer line started on Sept. 30th evening, 2007, the first turns of beam in the booster was obtained in 20 hours. With about 60 hours effective commissioning effort, the electrons were accelerated to 3.5GeV on October 5th morning, 2007. And then the first 3.5GeV beam was extracted to BTS transfer line on October 30th, 2007. In this paper, the SSRF booster is introduced and its commissioning results are presented.

INTRODUCTION

Shanghai Synchrotron Radiation Facility (SSRF) is a 3rd generation light source, which consists of a 150MeV LINAC, a full energy booster synchrotron and a 20-DBA storage ring. It will provide 4nm·rad nature emittance electron beam at 3.5GeV [1][2].

SSRF booster is used to accelerate the electron beam from 150MeV to 3.5GeV. It is composed with 2 super periods, 28 standard FODO cells and 180m circumferences. The curvature radius of dipole is 14.515m, which can reduce the eddy currents effectively during the energy ramping. There are also eight 2.9m straight sections, which used for the installation of injection, extraction and radio frequency systems [3].

BOOSTER PARAMETERS

Fig.1 shows layout of one standard booster cell. Fig.2 shows lattice functions in one quarter of the ring.

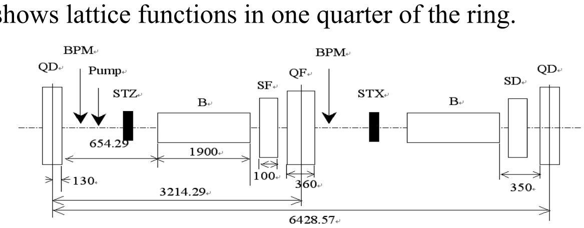

Figure1: Layout of one standard booster cell.

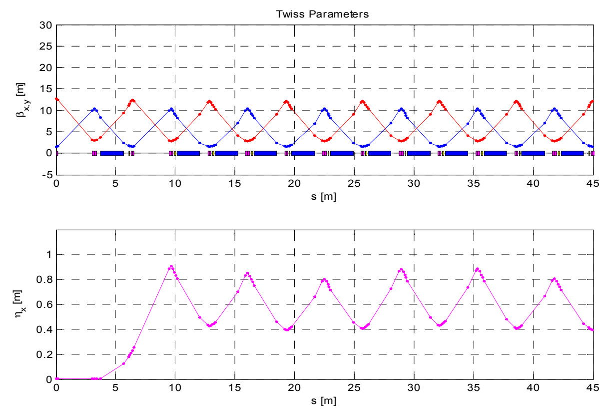

Figure 2: Twiss parameters of SSRF booster synchrotron. (One fourth of the ring is shown.).

There are two modes, single bunch and multi bunch, designed for booster commissioning, which can satisfy both the accumulative rate and the top-up injection requirements of the storage ring. The main parameters of the booster are shown in Table 1.

Table 1: Main Parameters of the Booster

Parameters		Value
Energy range (GeV)		0.15~3.5
Current (mA)	Single bunch	2
	Multi bunch	15
Repetition rate (Hz)		2
Cell length (m)		6.4286
Length of long straight (m)		2.904
RF frequency (MHz)		499.654
Harmonic number		300
Nature emittance (nm·rad)		104
Tune, ν_H /ν_V		8.181/5.229
Natural chromaticity, ξ_H/ξ_V		-9.91/-7.45
Nature energy spread		7.799×10^{-4}
Momentum compaction, α_P		0.01849
Damping time, $\tau_{H,V,L}$ (ms)		4.77/4.60/2.26
Longitudinal tune, ν_s		0.019
Bunch length (mm)		21.4

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INSTALLATION AND COMMISSIONING

Installation

Installation of SSRF booster began in Jan. 2007. After three months preparation, the first standard girder with all magnets and vacuum chamber was installed into booster tunnel on Apr. 16, 2007. The mechanical installation was finished at the end of August. The pre-commissioning of all sub-systems, such as power supply, radiofrequency, vacuum and beam diagnosis, was carried out till the end of September.

Commissioning Milestones

The commissioning of the SSRF booster from the LTB transfer line started on Sept. 30th evening, 2007. With about 60 hours effective commissioning effort, the electron beam was accelerated to 3.5GeV on Oct. 5th, 2007. The beam was extracted from booster to high energy transfer line at the end of October. The milestones of booster commissioning are summarized in table 2.

Table 2: Commissioning Milestones of Booster*

Sept. 30th	Start from LINAC exit
~ 2 hours	Beam to booster entrance
Oct. 1st	First turn & multi turns
Oct. 2nd	Beam stored
Oct. 5th	Ramping to 3.5GeV
Oct 29th	Extraction from booster
Nov. 27th	Multi-bunch mode
May 28th, 2008	Reach 2mA (Single bunch mode)

*The booster commissioning was carried out only in off-work hours.

Transfer Efficiency

As an injector of storage ring, transfer efficiency of the booster is one of the most important parameters. Fig. 3 is the signal from booster WCM, which is installed before the injection kicker. Fig. 4 shows the signal from ICT at LINAC and high energy transfer line (HT). The transfer efficiency between LINAC exit and storage ring entrance is about 75%, and the efficiency of the booster is almost 100%.

Tune Scan

To get a high transfer efficiency and a stable beam, choosing a good working point is very important Fig.5 shows a 2-D tune scan results at the injection energy, red point represents low beam current, correspondingly, blue means high current.

Figure 3: WCM with about 100% efficiency and extraction.

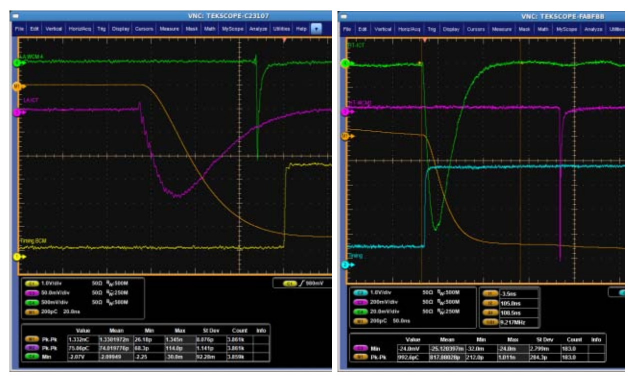

Figure 4: ICTs at LINAC and high energy transfer line. Left: LINAC ICT 1.332nC. Right: HT ICT 0.993nC.

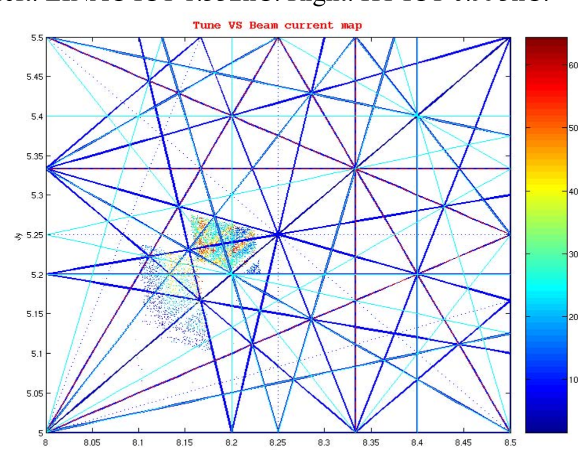

Figure 5: 2-D Tune scan.

Dipole Scan

Scanning dipole at DC mode is a practical way to measure the energy acceptance of the booster. Fig. 6 shows the relationship between dipole current and BPM's sum signal. From the picture, we got the energy acceptance of the booster is about ±1.5% and the central energy stability is about ±0.5%.

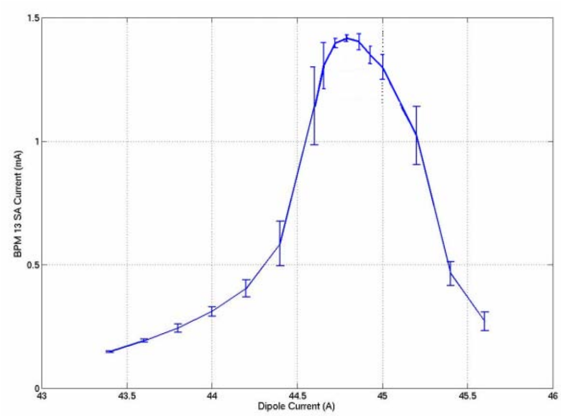

Figure 6: Dipole current vs. BPM sum current.

Closed Orbit Distortion

Due to a good mechanical alignment of the magnets and sorting of the dipoles [4], the electrons can be accelerated smoothly without any corrector in the booster. The closed orbit without correction is shown in Fig. 7. Because the quadrupoles are connected in series, it is difficult to find the accurate BPM offset by BBA and to correct the COD to a small value.

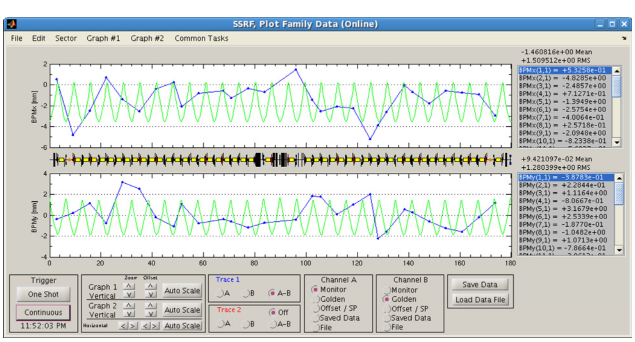

Figure 7: Booster closed orbit without correction.

Current Stability

Current stability is another very important property of the booster because of the requirement of the top-up operation. Fig.8 shows the current stability in two hours with booster multi-bunch mode, about 15%.

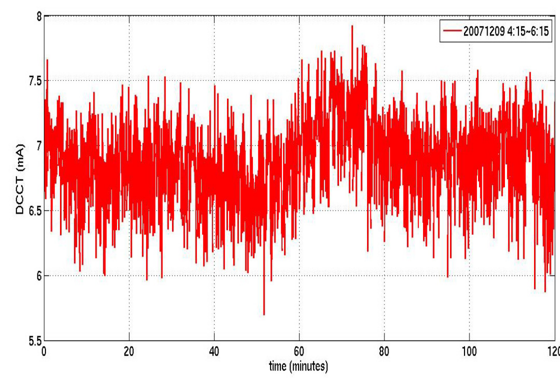

Figure 8: Current stability with multi bunch mode.

CONCLUSIONS

The commissioning of the SSRF booster is very successful, both the beam current and the transfer efficiency has achieved the its purpose. However, there are still something which could be done in the future, such as tune and chromaticity measurement and correction by adjust quadrupoles and sextupoles ramping curve respectively, COD correction at the injection point, improve the efficiency and the current stability, etc.

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