SSRF INJECTOR DIAGNOSTICS COMMISSIONING RESULTS

Chen Yongzhong, Leng Yongbin,Zhou Weiming,Yan Yangbin,Chen Zhichu,Chen Jie
Shanghai Institute of Applied Physics, China.

Abstract

This paper presents Injector beam diagnostics layout of the Shanghai Synchrotron Radiation Facility(SSRF) that includes the 150MeV LINAC, booster(3.5GeV) and beam transport lines. The different eam diagnostics monitors for beam current, beam position and beam profile are briefly described, and the diagnostics data acquisition architecture is present too. Commissioning Results of the LINAC are presented, as well as the commissioning status of the booster .

INTRODUCTION

The Shanghai Synchrotron Radiation Facility(SSRF) is a low emittance 3rd generation light source consisting of a 3.5GeV storage ring, a full energy booster and a 150MeV LINAC, as well as dozens of beam lines and experimental stations.

A layout of the complete injector setup is shown as Figure.1. The injector consists of two main parts: linac generates electron by the thermal cathode gun and 500MHz sub-harmonic pre –buncher ,and accelerates the electron to 150MeV. The main injector is a full energy booster operating energy up to 3.5GeV, which is mounted to the inner wall of the storage ring tunnel.

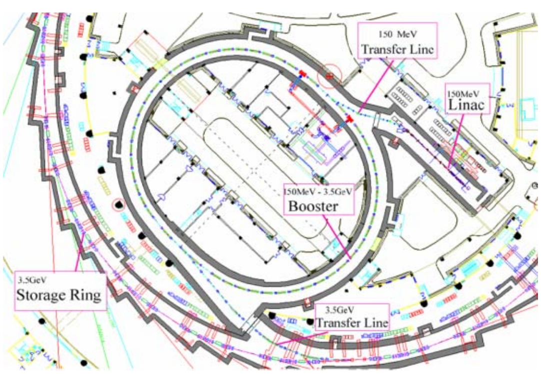

Figure 1: Layout of SSRF injector.

The main booster parameters is listed in table 1.

Table 1: booster Main Parameters.

Inject Energy		MeV	150
Extract Energy		GeV	3.5
Normalized emittance		mm mrad	<110
Current	Single Bunch	mA	2
	Multi-Bunch		5
circumference		m	180
RF frequency		MHz	499.654
Repetition rate		Hz	2

DIAGNOSTICS DESCRIPTION

Overview

A comprehensive ranges of diagnostic monitors has been installed on the SSRF injector, from linac through linac to booster transfer line(LTB),the booster and the booster to storage ring transfer line(BTS). The layout of the booster beam diagnostics monitors are showed as table 2:

Table 2: SSRF Injector Diagnostics monitors

	linac	LTB	booster	BTS
BPM	3	3	50	5
WCM	5	2	1	3
ICT	1			1
Faraday Cup	1			
Screen Monitor	5	3	4	4
DCCT			1	
SLIT		2		1
Stripline Kicker			2	

Beam Position Monitor

The Beam position monitor ,with 4 one-end-shorted 60 degree stripline electrode[1], has been chosen to install on booster ring as well as linac and transfer lines. The stripline length of linac and transfer line were chosen to 150mm,because the BPM signal frequency which BPM electronics deal with is chosen to 500MHz,but the stripline electrode length is only 75mm that is limited by available space on booster ring. The electrode of linac and transfer lines is located on the horizontal plane and vertical plane respectively, but on the booster ring, the 4 electrodes are located at diagonal position where there is 45 degree to horizontal and vertical axis.

The Libera electronics[2] for each BPM are installed on booster ring as well as linac and transfer lines. The Libera is the digitalized BPM processing electronics adopted by most of 3rd generation synchrotron radiation facilities recently. Libera is an all-in one solution that enables accurate beam position monitoring, trouble-free commissioning, and local and global feedback building.

Current and Charge Monitor

Five KEKB[3] design wall current monitors(WCM) were installed on the linac to monitor the bunch structure and the transfer efficiency. Two WCMs were installed on first and end of the transfer line to measure the beam transfer efficiency. One WCM was install on the injection location of the booster ring to monitor the beam intensity during the beam energy ramping procedure. The WCM signal is connected to oscilloscope Tektronix TDS70604 on linac, while the TDS71054 is chosen on booster .

A Faraday cup designed to measure the 150MeV beam charge was installed at the end of linac. The Faraday cup is based on a copper core to capture the charge particles surrounded by a lead shield to absorb the radiation.

A integrating current transformers(ICT), which is a non-destructive measurement of the beam charge during normal operation, was installed in the front of the bending magnet of the linac, the other one is installed on the beginning of booster to storage ring(BTS). We used standard commercial ICT device from BERGOZ company, and the signal from the ICT is connected directly to oscilloscope, then we use the integration function of oscilloscope to calculate the charge, in addition, the value is cross calibrated with Faraday cup.

Commercially parametric current transformer(PCT) from BERGOZ is installed on booster to measure the absolute beam current in the ring. We used 6-1/2 Digital Multimeter(NI PXI7040) to acquire the DC current signal from the BCM electronics.

Beam Profile Monitor

There are several screen monitors(SM) from linac to BTS line, most of them are one screen(AF995R fluorescent plate) monitor used to show the spatial distribution and to check focussing result during commission, however, we use SM to measure the transverse beam parameters like emittance, energy and energy spread accurately as well as the beam profile shape on linac, so we installed two four-stage pneumatics SM monitors on linac. One screen which material is YAG:Ce crystal plate is used at the initial commissioning and at low beam charge situation, another screen which material is made from 100nm aluminium deposited on a polished silicon wafer, generating optical transition radiation(OTR)when electron hits on it, is used to measure beam energy spread and beam emittance respectively, because the OTR represents a linear radiation source. The last screen is calibration screen where holes array radius is 1mm and spacing is 5mm. CV-A11 CCD camera,whicht has high sensitivity 0.05lux and pixel cell size is 7.4μmX7.4μm, is used at all screen monitors. The camera is located below beam pipe 1.1 meter through planar - mirror optical relay to reduce the radiation damage. PXI based frame grabber(NI PXI1409) is employed with switch module and synchronization electronics.

Stripline Kicker

Two transverse kicker used to measure the booster tune parameter during beam ramp up procedure ,one for horizontal and one for vertical plane, are installed where the beta function is much large on both planes. The kickers are based on a pair of striplines(30-cm length, 2-mm thickness), and the stripline coverage angle is 120°. We use white noise generated by Agilent 33220A to kick beam through 50W power amplifier (HSA4101).

Slit

Two slit , one for horizontal and the other for vertical plane, were installed on LTB line as well as one horizontal slit was installed on BTS line. The slits are drove by stepper-motor which position resolution is 1μm through optical grating encoder. The slit is titled to the beam with 45°where a fluorescent screen is placed, so we can monitor the scrape of the slit through a viewport when the slit is moving. The slit electronics are based on PXI /Windows XP architecture.

Data Acquisition System

SSRF injector beam diagnostics system is distributed into three stations, one station is in charge for linac, the second is for LTB and half of the booster ring, the last one is for BTS and half of the booster. The data acquisition architecture of station is shown as Figure 2 .

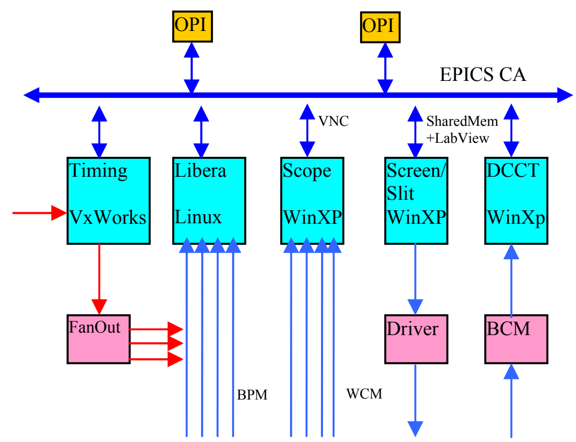

Figure 2: layout of the diagnostics station.

The beam diagnostics software is based on EPICS architecture that is adopted by many accelerator facility . All timing signals of one station is provided by VME module-EVR200[4] which operating system is VxWorks. The Libera, running on Linux environment, provides not only all kinds of beam position records but also many electronics diagnostic records. We used remote control software(VNC) to view and fully operate the oscilloscope panel from the control room. On other measurement , such as DCCT ,SLIT control and beam profile measurement, LabVIEW ,which runs on Windows XP environment, is used to programme driver code, then, we only write EPICS database records to acquire information such as image, step-motor status through SharedMemory IOC[5] software package.

The operator interface of beam diagnostics system is written by EDM tool, but some application programme, such as emitance and tune measurement, are written by Matlab which is also the programming tool of SSRF commissioning, so the codes can be exploited directly between beam diagnostics and physics group.

COMMISSIONING RESULTS

Linac Commissioning Results

The Beam parameters of Linac has been achieved during linac commissioning, as shown in table 3.

Table 3: Linac commissioning results.

Charge /bunch	nC	1.8(Max)
Energy	MeV	158
Energy stability	%	<0.5
Energy Spread (rms)	%	<0.5
Normalized emittance	mm mrad	50

The beam size is very critical for energy spread and emittance measurement, we adopted "rms area " method integrating 1D transverse profile which is subtracted from background level. The beam profile behind 45ºbending magnet is shown as figure 2:

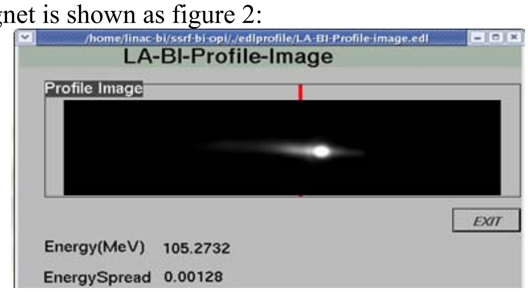

Figure 2: Linac energy spread baem profile.

Booster Commissioning Results

Figure 3: booster WCM signals.

Figure 3 shows the last WCM of LTB and booster WCM signals on oscilloscope, the inject efficiency is about 952% from the WCM data.

Figure 4 shows the DCCT current of the booster ring during beam energy ramp procedure(from 158Mev to 3.5GeV). The spike signal in the DCCT curve is caused by the extract power supply.The whole transfer efficiency from Linac to the end of BTS is about 70%.

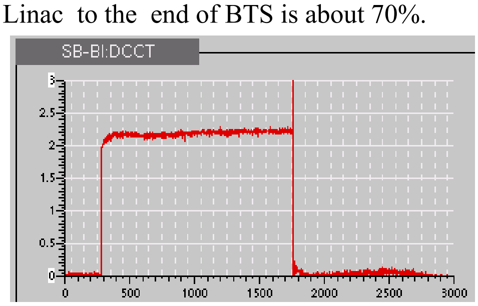

Figure 4: Booster DCCT curve.

One turn-by-turn BPM data, which length is 40 thousand turns, is recorded during ramping up while kicking the beam with white-noise power signal, then the tune evolvement curve(both in X/Y plane) is obtained by FFT methods ,as shown in Figure 4.

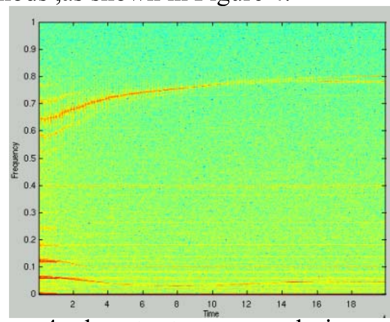

Figure 4: booster tune curve during ramping up.

The phase-space ellipse can be obtained from two locations BPM turn-by-turn data. Figure 5 shows the

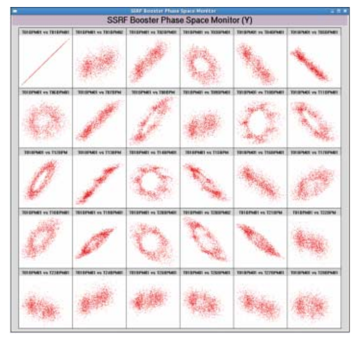

Figure 5: Booster Phase-space ellipse along the ring.

phase-space envolvement along the ring ,which is very helpful to booster commissioning.

COCLUSIONS

The SSRF injector beam diagnostics system has been successfully installed and commissioned in 2007 as well as run for storage ring from 2008 . Most of beam parameters has been reached .

In order to increase the whole injector beam transfer efficiency from linac to storage ring, we will install a new ICT on LTB line in July this year, in addition, the beam emittance measurement of the booster ring will be scheduled in July too.

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