COMMISSIONING OF THE 150 MEV SSRF LINAC

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Abstract

The 150 MeV SSRF linac has been integrated and commissioned from late 2006 to middle of 2007. This paper presents the design, installation, commissioning and status of this linac.

INTRODUCTION

The SSRF linac generates an electron beam suitable for injection through the linac-to-booster (LTB) transfer line into the booster synchrotron. The main systems of this linac as electron source, bunching section, accelerating structures, RF supply and control system will be described according to their performance in the following paragraphs.

Figure1: LINAC layout.

Electron Source

The electrons are provided by a 100KV DC conventional electron source as shown in figure 2. Besides flexible time structure, high current and acceptable emittance, this gun can provide electron beam in the two modes which needed for the storage ring. The width of the output electron beam under single bunch mode is 1ns, and the repetition rate should synchronise to the reference bunch clock signal of the booster. Main beam parameters are listed in the Table 1.

Table 1: Main Beam Parameters

	Single bunch mode	Multibunch mode
Charge nc	2	10
Max.width ns	1	200
Repetition rate pps	1--10	1--10

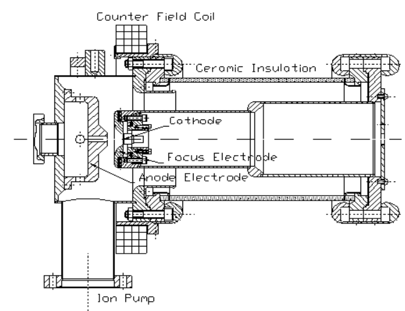

Figure 2: Electron gun.

The Bunching Section

The bunching section has the purpose to compress the bunches in order to make the beam acceptable for the 3GHz wave of the accelerating structures. It is composed of a 499.654MHz subharmonic pre-buncher and a 3GHz buncher. The layout of the bunching section is shown in figure 3, including the electron gun and the solenoids.

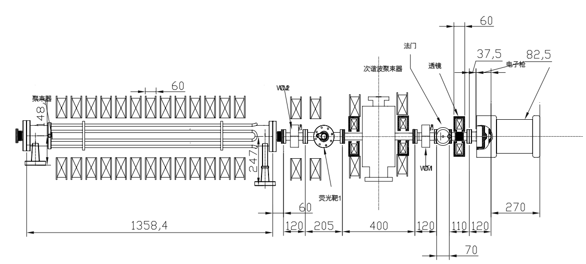

Figure: 3: Buncher section.

The sub-harmonic buncher is a 500MHz re-entrant cavity with 40mm gap operating at the same frequency with the storage ring. The following 3GHz buncher and the accelerating section, are used to insure a sufficient bunching in order to reach a high transmission rate with low energy spread. The advantage of this configuration is that the low pressure to the gun, so that ensure the high quality The buncher is a section of travelling structure, consists of 9 altering phase velocity cavities and 31 light velocity cavities. The parameters of the buncher are listed in Table 2.

Table 2: The Parameters of the Buncher

Work frequency (MHz)	2997.924
Operation mode	$2\pi/3$
Cavity number	40
Length (m)	1.35
Voltage ratio of standing wave	1.1
Bandwidth (VSWR1.2) (MHz)	4
Input power（MW）	7
Output energy（MeV）	>13

The Accelerating Structures

Four identical accelerating structures of the 3m SLAC type accelerate the bunched beam up to the final energy. They are constant-gradient copper structures operating in $2\pi/3$ mode at 3GHz. In order to compensate space charge effects and RF defocusing, the beam is focused by a set of more than 30 pancake coils. Meanwhile, two sets of quadrupole triplots at the second and the third acceleration section and after the last section are used to guarantee the quality of the electron beam.

Table 3: The Parameters of the Accelerating Structure

Work frequency (MHz)	2997.924
Cycle number	89+2×0.5
Length (m)	3.0
Shunt impedance (M/m)	54
Attenuation (Neper)	0.554
Group velocity，v_g/c	0.0224~0.0075
VSWR of input and output coupler	<1.1
Bandwidth (VSWR<1.2) (MHz)	4
Phase shift per cycle (degree)	120
Temperature (°C)	45

RF and Microwave Power System

The high power RF system is driven by two 3GHz modulator units, each with one Toshiba2100B klystron. The first modulator-klystron unit drives the SHB, the TWB and the first accelerating structure, and the second modulator-klystron drives the second accelerating structure, the accelerating structures are designed to give 35Mev beam acceleration for input power of 11-13MW. Power is transmitted to the accelerating and bunching structures through waveguide. The 500MHz master oscillator signal is used to drive the electron gun and the SHB, and to ensure synchronization of the high-power RF with the SSRF booster and storage ring.

Control System

The goal of the control system is to realize equipment monitoring and control functions of the various subsystems in the linac system, under the internal subsystems interlock system protection and the protection of the inter-system safety interlock conditions. It includes a magnet power control subsystem, microwave control subsystem, e-gun control subsystem, modulation control subsystem, water control system, the vacuum control system, timing control subsystem, machinery interlocking protection subsystem and beam diagnostic control subsystem. The EPICS control system is used, which is based on the "standard model" structure of distributed control system, which is distributed, open, easy expansion, multi-platform. It consists of monitoring, process control layer and devices control layer, three level.

RESULTS

During debugging process, the beam measurement system in linac needs to provide functions includes the beam position, beam intensity, charge, the cross-section, emittance and energy spread measurement. The overall layout of the beam measurement probe is shown in Figure 4.

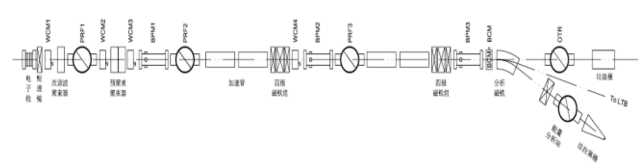

Figure 4: overall layout of the beam measurement probe in linac

The bunching effect of sub-harmonic cavity in linac are shown in Figure 5 and Figure 6 respectively.

Figure 5: the beam waveform when the sub-harmonic cavity does not operate.

Figure 6: the beam waveform when the sub-harmonic cavity operates

The ultimate debugging results are shown in table 4.

Table 4: Design Targets and Debugging Results

	Design Target	Result	
Energy (MeV)	150	152	162
Single Bunch Mode	1ns,1nC	0.3nS, 1.06nC	0.3nS,1.1nC
Low current in Single bunch Mode	1ns,0.2nC	0.3nS, 0.2nC	0.3nS,0.2nC
Central energy stability	0.5% (rms)	0.2%	0.2%
Energy spread	0.5% (rms)	0.2%	0.2%
RMS emittance (x)	50 mm·mrad	37 mm·mrad	36 mm·mrad
RMS emittance (y)	50 mm·mrad	32 mm·mrad	34 mm·mrad
RF frequency(MHz)	2997.924		
Repetition rate (Hz)	2		

At present, all the indicators in the SSRF linac have reached or exceeded goals of the design, can provide qualified for the intensifier beam.

Thank IHEP in Beijing, NSRL, IMP and other units for their strong support and large help during the work process of the SSRF linac, sincerely.

REFERENCES

[1] The preparatory design report of Shanghai Synchrotron Radiation Facility .Shanghai: National Synchrotron Radiation Center, 2001.1-22