Recent Status of 200MeV Electron LINAC of HESYRL

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Abstract

The 200 MeV electron LINAC as an injector of the electron storage ring of 800 MeV, which is a facility dedicated to Synchrotron Radiation and located new campus of the University of Science and Technology of China, is described. Since Nov. 1987, the LINAC began to commission successfully, the machine was improved, such as improving the power supplies stabilities, reducing the jitter time of the trigger system for the modulator etc. Now the LINAC is operating very stable.

Typical operation parameters is as following: energy of 200 MeV, pulse current of 80 mA and energy spread of 0.8% FWHM. Main operating parameters and measurement results are given in this paper.

1. Introduction

The Synchrotron Radiation Facility of HESYRL (Hefei National Synchrotron Radiation Laboratory) is mainly composed of a 200 MeV LINAC and an electron storage ring (see Fig.1) which is a dedicated Synchrotron Radiation Light Source covering the wavelength region from soft X–ray through far infrared.

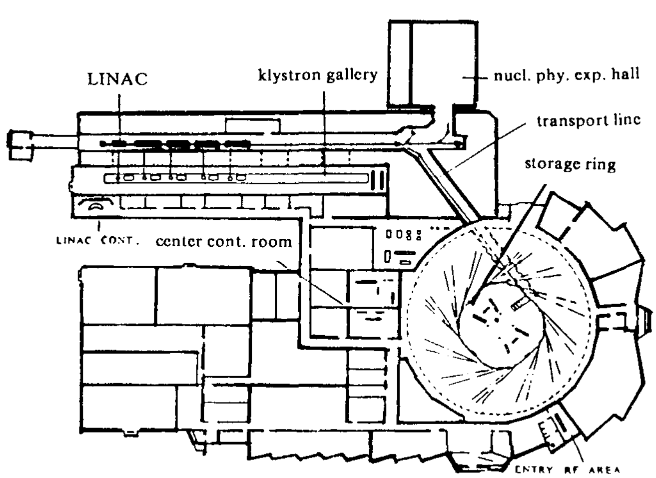


Fig.1 layout of HESYRL machine

The 200 MeV electron LINAC is not only an injector for the 800 MeV storage ring at HESYRL, but an electron accelerator used for nuclear physics research, and applications in other fields as well[1,2,3]. It mainly includes accelerating system (preinjector, accelerator units and beam diagnostic sections etc.) which are located in the tunnel, a RF system which is located in the klystron gallery, and so on.

The plane layout of the LINAC and cross section of its building is shown in Fig.2. The LINAC tunnel was constructed semi underground. The beam position of the LINAC is 3.2 m below the orbit plane of the storage ring. Since the building was completed at the end of 1986, the tunnel ground has sunk a lot. Now the foundation of the building is becoming stable.

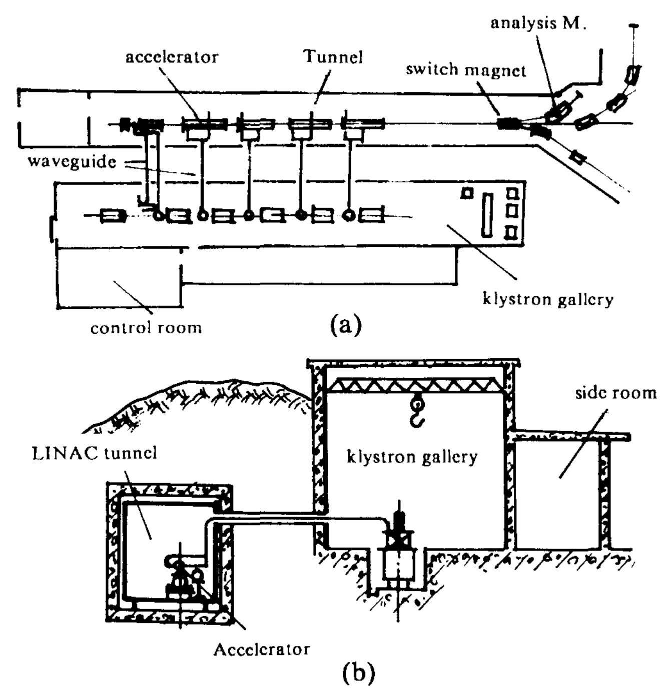


Fig.2 (a) The plane layout of 200 MeV LINAC
(b) Cross section of LINAC building

All components and equipments for the LINAC were ready and were tested by the end of 1986, On Nov.24, an electron beam of 222 MeV, 58 mA was achieved which reached the design values. In Apirl, 1989, the LINAC successfully provided beam for the storage ring. Now the machine operation is more stable. Typical operating parameters are 200 MeV, 80 mA, energy spread of 0.8% and energy stability of 0.4%.

2. General Description of the 200 MeV LINAC

Design of the 200 MeV electron linear accelerator was determined according to the following consideration:

1) requirements of the storage ring at HESYRL;
2) economics (reducing the cost);
3) theoretical calculation;
4) experience on a prototype 30 MeV LINAC which was been operated since 1981[4];
5) simple fabrication.

The accelerating structure of the LINAC is a constant impedance, $2\pi/3$ mode, traveling wave, disk– loaded waveguide structure. The cross section of disk–loaded waveguide is shown in Fig.3. The accelerating system includes a preinjection section (which consists of 3 meters and some focusing components), 4 accelerator units, each of which comprises 2 three–meter accelerator sections, 5 beam diagnostic sections which are located between accelerator units and used for monitoring the beam current, beam position and beam profile, and a microwave power system and a vacuum system.

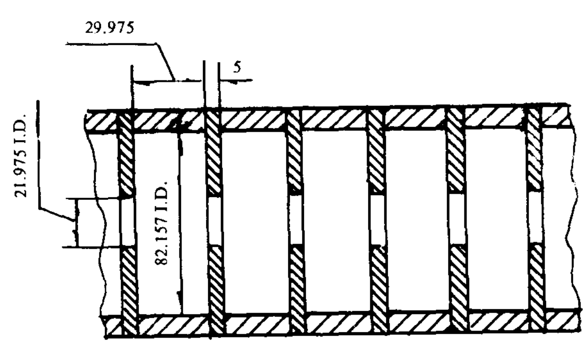


Fig.3 Cross section of disk–loaded waveguide

A switch magnet and some DC bending magnets were installed behind the LINAC in order to control the beam direction, which can deflect the beam into either the storage ring, the energy analysis magnet and the nuclear physcis experiment hall or the beam dump (see Fig.1).

The microwave power fed into the accelerator is provided by 5 klystron. One of them feeds only the preinjector, the others feed the accelerator units, one by one respectively, the microwave power from the klystron feeds into the accelerator by means of a waveguide system which passes through a shielding wall of 4 meters thickness between the tunnel and the klystron gallery. Klystrons, modulators and all power supplies for the LINAC are located in the klystron gallery (see Fig.2) .

The vacuum system of the 200 MeV LINAC includes two subsystems. One of which is the vacuum system of the accelerator structure, the other is the waveguide vacuum system. The vacuum system of the accelerator structure consists of a manifold of 150 mm I.D., which is used as the major exhaust pipe, and sputter ion pumps of 200 l/s to be used for maintaining the high vacuum of the accelerator. The waveguide vacuum system is composed of 6 subsystems. A sputer ion pump of 50 l/s is used for each waveguide branch to maintain the pressure of 1×10^{-8}Torr.

The design figures of the main parameters and measuring results of the 200 MeV LINAC are listed in table 1.

Table 1 Main parameters of the 200 MeV linac

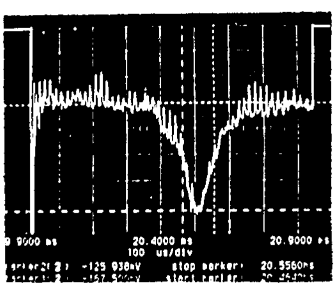
Parameter	Design value	Reached Value
Electron energy	224 MeV	225 MeV(50mA)
Current (pulse)	50 mA	130 mA(195MeV)
Pulse width of beam	0.2–1 μs 3–4 ns	
Energy spread	1%	0.8%
Output of klystron	15 MW	
Number of klystron	5	
Operating frequency	2856 MHz	2856.04 MHz
Type of mode	$2\pi/3$	
Accelerator structure	constant impedance	
Electrical field strength	122kV/cm	
Group velocity	$V_g=0.012$ c	
Attenuation of field	$\alpha=0.178$/m	
Number of accelerator section	9	
Total length of the linac	35.128 m	
Vacuum (without beam)	5×10^{-7}Torr	1×10^{-8}Torr
(with beam)	1×10^{-6}Torr	1×10^{-7}Torr

3. Operation and improvement

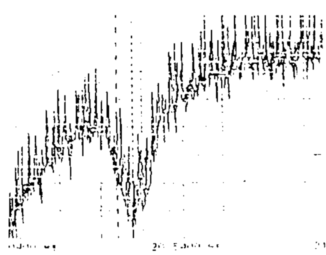
At the beginning of Nov. 1989, we began to adjust and test the LINAC, were 220 MeV, 58 mA respectively, which reached our design value. After that we stopped commissioning the machine and installde the transport line between the LINAC and storage ring. On Feb.4, 1988, the electron beam from the LINAC passed easily through the whole transpor line except its vertical section. In June, 1988, energy analysis equipments were installed and energy spread measured was less than 0.8% (FWHN).

Now, the LINAC has been operated easily and more stably. Since April, 1989, the LINAC has stably provided the electron beam of 200 MeV, 70 mA for injecting into the storage ring of 800 MeV. Fortunately, it took us only 23 hours to get first stored beam of 4 mA in our storage ring during the first test day.

During commissioning the machine in 1989, we found that electron energy from the LINAC was changed suddly sometimes and was slowly change more in the morning and the evening every day. These instabilities made the storage ring is to be difficult to get higher injection beam current. In order to overcome the instabilities, we improving all trigger for the five modulators to make its jitter time to be less than 20 ns, and improving the equipment of the furnish power so that its voltage change is reduced from ± 36 volt down to ± 3.8 volt. After that, the beam energy stability of the LINAC is improved and relative change rate $\Delta E / E$ is less than 0.7%.



(a)



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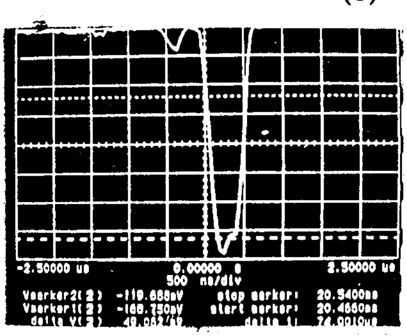

(c)

Fig.4 (a) Waveform of energy spectrum
(b) Waveform of energy spectrum multi-recorded
(c) Current waveform near injection point

Recently, we added an energy stabilizer which is composed of a shifter of the fifth klystron, measurment equippment and information processing system. After the improvement above mentioned, the energy stability was improved that the energy change rate is less then 0.4%, which made the injection beam current into the storage ring to be more than 200 mA during injection time of 1 minute and the maximum accumulating beam current in the storage ring is more then 350 mA.

The waveform of the energy spread and energy change measured is shown in Fig.4.

Typical operating parameters are listed in table 2.

Table 2. Typical operating parameters of the linac

Output of klystron 1#	10.2 MW
Output of klystron 2#	16.2 MW
Output of klystron 3#	15.7 MW
Output of klystron 4#	16.5 MW
Output of klystron 5#	11.7 MW
Current of the gun filament	1.2 A
Anode voltage of the gun	−80 KV
Current of the gun	160 mA
Current of the preinjector	112 mA
Capture coefficient of the preinjector	70%
Current near the switch magnet	80 mA
Energy of the beam	200 MeV.

References

[1] Wang De–fa, Pei Yuan–ji, and He To–hui, The proceedings of international conference on Linear Accelerator 1986, SLAC. (1986).

[2] Y.J.Pei et al, The proceedings of the 3rd international Conference on Synchrotron Radiation instrumentations, Rev. of Sci. & Instr., Vol. 60, No.7(1989).

[3] Y.J.Pei, D.F.Wang, Proceedings of 4th symposium of Particle Accelerator Society, Beijing, China(1988.12).

[4] Y.J.Pei, The proceedings of the 2nd China–Japan joint symposium on Accelerator and their Applications, Lanzhou, China. (1983).