

CURRENT STATUS AND R&D PLAN OF PAL TEST LINAC*

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Abstract

The Test Linac consists of a thermionic RF-gun, an alpha magnet, and two S-band accelerating structures. The RF-gun is a half-cell cavity with a tungsten dispenser cathode of 3-mm diameter on axis. The performance of the Test Linac has been improved since the completion of installation of 1998 so that the machine stability and the beam transmission efficiency along the linac were remarkably improved. The performance upgrade includes the replacement of pulse modulator for klystron and quadrupole magnets, adding a momentum slit in the alpha magnet chamber, etc. The Test Linac can provide a bunched electron beam: the beam energy of up to 85MeV, the pulse length of 4 microsec, the pulse current of 100mA, and the repetition of 10Hz. R&D activity will be carried out to achieve the bunch length of a few hundred femto-seconds, which includes an optimisation study of bunch compression in the alpha magnet and a chicane magnet for further bunch compression. In this paper the status of Test Linac is described as well as R&D to be carried out in the future.

1 CURRENT STATUS

The PLS (Pohang Light Source) is a third generation light source which consists of a 2.5GeV storage ring and a 2GeV full energy injector linac. Besides these accelerators the Pohang Accelerator Laboratory has another small electron linac named "Test Linac" which was constructed for R&D of coherent radiation generation using high brightness electron beam. The Test Linac consists of a thermionic RF-gun, an alpha magnet, and two S-band accelerating structures. The RF-gun is a half-cell cavity with a tungsten dispenser cathode of 3-mm diameter on axis. The Test Linac can provide a bunched electron beam: the beam energy of up to 85MeV, the pulse length of 4 microsec, the pulse current of 100mA, and the repetition of 10Hz.

The Test Linac is placed at the same tunnel area of the 2GeV linac (see Fig. 1) and in parallel with from the start point of the 2GeV linac, which enables the end of Test Linac to be connected to the 2GeV linac with a minor modification. It means that if the connection is made the electron beam from the Test Linac can be further accelerated through the 2GeV linac up to 2GeV energy.

Fig. 2 shows the component layout of the Test Linac. There is a drift space of 2meter between AC#1 and QT1 where a chicane will be installed for magnetic bunch

compression. The beam profile monitors, not shown in Fig. 2, are located at the entrance of AC#1 and AC#2, and on straight line after the beam analysing magnet. An OTR (optical transition radiation) monitor is used to measure the length of micro bunch with a streak camera. Three beam current transformers (BCT) are installed including BCT2, not shown in Fig. 2, between QT1 and AC#2.

Table 1 shows the machine parameters of the Test Linac. A 65MW SLAC-5045 klystron feeds RF power to two accelerating structures and a RF-gun. A high power attenuator and a phase-shifter are located at the waveguide line to the RF-gun, and a high power phase-shifter at the waveguide line to AC#2. The thermionic RF can generate an electron beam of 1MeV energy.



Figure 1: A photo of Test Linac tunnel.

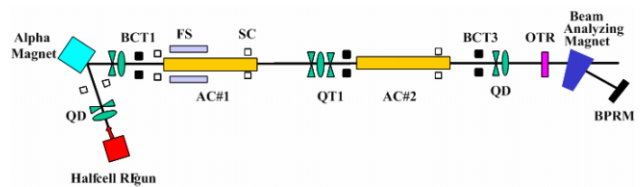


Figure 2: Component layout of Test Linac. QD: quadrupole doublet, BCT: beam current transformer, FS: focusing solenoid, AC: accelerating column, SC: steering coil, QT: quadrupole doublet, OTR: Optical transition radiation, BPRM: Beam profile monitor.

2 PERFORMANCE UPGRADE

The performance of the Test Linac has been improved since the completion of installation of 1998 so that the machine stability and the beam transmission efficiency along the linac were remarkably improved. The performance upgrade includes the replacement of pulse

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modulator for klystron and quadrupole magnets, adding a momentum slit in the alpha magnet chamber, etc.

The momentum slit inside the alpha magnet chamber plays an important role in the improvement of beam transmission. The selected particles with large momentum and small energy spread by the momentum slit can be accelerated without a big loss through the AC#1 and AC#2. Fig. 3 shows the oscilloscope signals of RF and BCT during the beam operation. In this beam test the RF pulse width is 1.5 μ s. The first and second traces represent the forward and reflected RF power of the RF-gun. The third trace represents the BCT1 that is located at the exit of alpha magnet, and the last trace the BCT3 at the exit of AC#2.

Table 1: Machine parameters of the Test Linac.

Energy, MeV	85.0
Pulse Beam current, mA	100
Pulse length, μ s	4
Pulse repetition rate, Hz	10
Micro bunch length, ps	4 (measured)
RF Frequency, MHz	2856
Thermionic RF-gun	Half cell
RF-gun beam energy, MeV	1.0

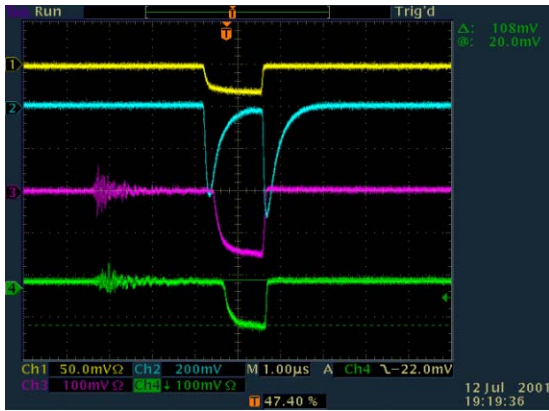


Figure 3: Oscilloscope signals of RF and BCT during the beam operation. First: Forward RF power to the RF-gun, Second: Reflected RF power from the RF-gun, Third: Beam current (BCT1), Fourth: Beam current (BCT3).

3 R&D PLANS

The measured length of micro-bunch of the 60MeV beam was 4ps with the current system: a half-cell RF-gun and an alpha magnet [1]. In order to get the bunch length of a few hundred femto-seconds, we consider a chicane magnet for further bunch compression. We also consider a 1.6 cell thermionic RF-gun as well as an optimisation of bunch compression in the alpha magnet.

Fig. 4 shows the chicane system for bunch compression. Electron with smaller momentum has a longer path length

than with higher momentum. Electron beam should have a longitudinal phase space like the left one in Fig. 5 to get bunch compression; Lower momentum particle is ahead of the reference particle. During the transport through the chicane the longitudinal phase-space changes to the right, so the bunch length is shortened. Fig. 6 shows the PARMELA simulation result of bunch compression. In the simulation the alpha magnet is not included because there is no available element for alpha magnet in the PARMELA code, and it is assumed that the emitting RF phase of electron from the cathode is from zero to 10 $^\circ$, a 10ps-long bunch. A factor of 3 of bunch compression is obtained by a chicane.

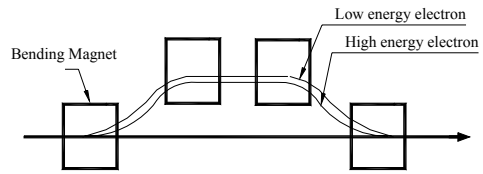


Figure 4: Chicane

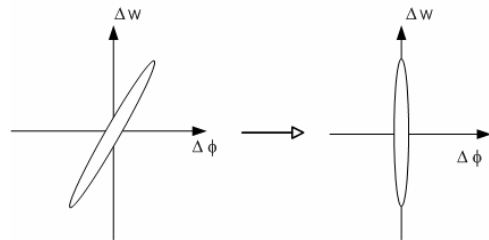


Figure 5: Longitudinal phase space. Left: before chicane, right: after chicane.

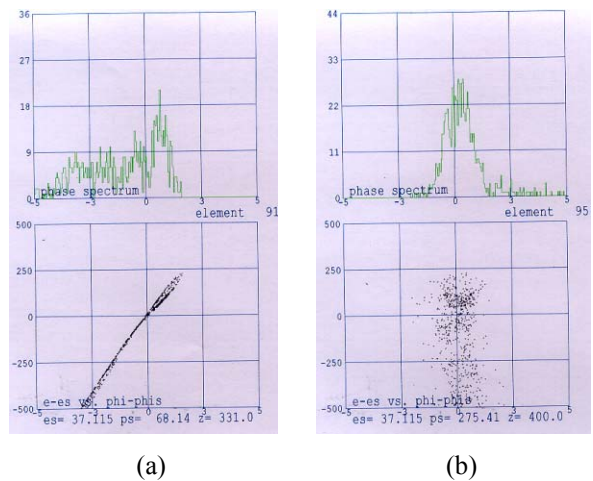


Figure 6: PARMELA simulation of bunch compression. (a) before chicane, (b) after chicane.

To get a higher bunch compression ratio a higher beam energy from RF-gun is preferred. So, we designed a 1.6-cell thermionic RF-gun that is very similar to the 1.6-cell photocathode RF-gun as shown in Fig. 7, but it has a large coupling factor of 3 [2]. The cathode mounting structure is also same to the half-cell RF-gun of TEST LINAC. The output beam energy is designed to be 2.5MeV.

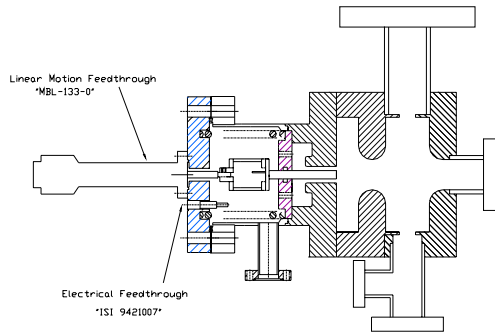


Figure 7: 1.6-cell RF gun.

4 SUMMARY

The status of the Test Linac is briefly described along with the machine description. After the upgrade of klystron modulator and alpha magnet chamber, the operational stability and acceleration efficiency were greatly improved. To get a femto-second electron bunch using the Test Linac, R&D plans such as magnet bunch compression and 1.6-cell RF-gun are introduced and explained.

5 REFERENCES

- [1] H. S. Kang et al., "Beam Quality Measurement of 100-MeV Test," Proc. of PAC'99, New York, March 29 – April 2 (1999).
- [2] H. S. Kang et al., "Design of 1.5-cell RF-gun for 100-MeV Test Linac," Proc. of the 4-th Asian Symposium on Free Electron Lasers (Taejon, Korea, June 8 - 10, 1999).