Performance of Linac Preinjector for SPring-8

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Abstract

The construction of the SPring-8 linac (2856 MHz, 60 pps) was started in 1991 March. The preinjector system was already installed in Tokai Establishment of JAERI, and its commissioning is under way. We obtained the initial data of the electron gun, bunching section and several monitors. The electron beam is emitted by Y796 (EIMAC) cathode assembly, and extracted by 200 kV high voltage. Three types of grid pulsers were prepared to generate different pulse length, 1 nsec, 10~40 nsec and 1 μsec. On the 1 nsec mode, this gun generated 22 A peak currents. The electrons were transported to the prebuncher along the magnetic field, about 600 Gauss, produced by eight helmholtz coils. After two prebunchers and one buncher, the electrons bunched in about 5 bunches. The bunching efficiency was obtained to be 64~65 %, and the electrons were accelerated up to 9 MeV in the buncher with 2 MW RF power.

I. INTRODUCTION

Electron or positron is accelerated up to 1.15 or 0.9 GeV by SPring-8 [1] linac, and injected into the synchrotron. This linac will have 26 acceleration tubes, 3 m length, accelerated 16 MeV/m. The linac will operate five beam modes. It's shown in the Table 1. In the table 1, single pulse mode means the single bunch in synchrotron and storage ring, not linac. RF frequency of synchrotron and storage ring is 508 MHz. That bucket size is 1 ns. So, we are requested the short pulse beam less than 1 ns.

Positron will generate at an area, where electron energy is 250 MeV, having a movable target for electron / positron conversion. When they request the positron beam, we will insert the target into the beam line. We assume the conversion efficiency to be 0.1 %. So, before the target, it requests high currents (over 10 A) electron beam.

The preinjector system is very important section to decide the performance of linac. It was installed in Tokai Establishment of JAERI, and its commissioning is under way.

Table 1. Linac control modes

	pulse width	electron	positron
Long pulse mode	1 μs	100 mA	X
Short pulse mode	10 - 40 ns	300 mA	10 mA
Single pulse mode	1 ns	300 mA	10 mA

II. GENERAL DESCRIPTION

A. Layout of Preinjector

The preinjector system is consists of electron gun, two prebunchers, one buncher that driven by one booster klystron (Mitsubishi Electric Co. model PV2012, 7 MW peak) and several beam monitors. The arrangement of linac preinjection system is shown in Figure 1.

A distance between electron gun and first prebuncher is far, about 900 mm. In this space, there are a gate valve and the monitors of the electron beam, like two types current transfers (CT) and a profile monitor with magnetic fields by eight helmholtz coils [2].

The gaps between first prebuncher (PB1), second prebuncher (PB2) and buncher are 222 and 152 mm respectively. After buncher, one Q-triplet and several monitors like CTs, bending magnet and Faraday cup for energy measurement, slits and wire grid monitor for emittance measurements and beam windows and streak camera for bunch length measurements, are placed.

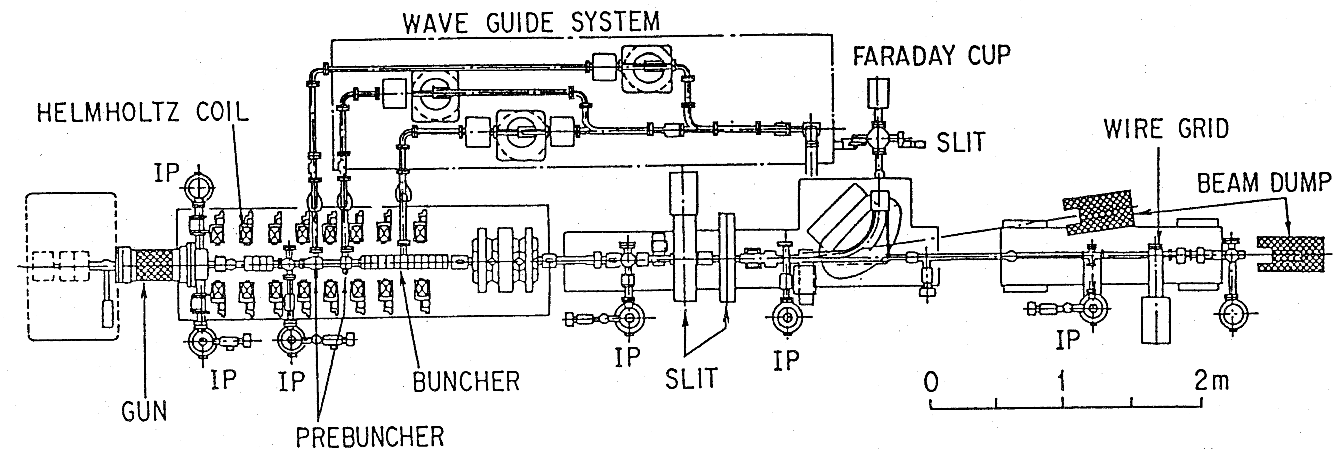

Figure 1. Arrangement of the Linac Preinjector

B. Electron Gun

The electron gun is the traditional thermonic gun with three grid pulsers. The electron beam is generated by a cathode assembly: model Y796 (EIMAC) with a cathode area of 2 cm^2. It is able to produce 10 A/cm^2 [3] pulsed beam currents at an extraction voltage of 200 kV. Three grid pulsers stay in high voltage station. And the generated pulses are transported through long coaxial tube, 1068 mm, with 12 ohm impedance.

The grid pulser for long pulse is traditional transistor pulse generator. The cathode emission current is obtained to be 3 A of 1 μsec pulse beam, and its fluctuation is less than ±1.5 % within a flat-top of 3 μsec. The grid pulser for short pulse is Kentech nanosecond pulser. Generated short pulse is led to 12 ohm coaxial tube by four 50 ohm coaxial cables for impedance matching. The beam current is obtained to be 12 A of 40 nsec pulse beam The grid pulser for single pulse is Kentech model HMPS. Rise time of the generated pulse is 60 ps with output impedance of 50 ohm. Output impedance is converted to 12 ohm by impedance converter, and output pulse is formed to 1 ns pulse by crip line method with short stab, then output voltage becomes 200~320 V. The width of pulse is dominated by the short stab length. We prepare five short stabs, which lengths are 195 mm, 165 mm, 135 mm, 70 mm and 35 mm for 1.5 ns, 1.25 ns, 1.0 ns, 0.5 ns and 0.25 ns pulse width. The layout of 1 nsec pulse transport line is shown in Figure 2. The beam current is obtained to be 22 A peak of 1 nsec pulse beam with 135 mm short stab.

The emission characteristics versus gun high voltage, grid voltage at grid bias 60 V of single pulse beam with 135 mm short stab are shown in Figure 3,4. The jitters of single pulses are less than 170 psec. The dependence of the short stab length is shown in Figure 5 with grid pulse voltage 320V and grid bias 60 V. Cathode emission currents are measured by wall currents monitor and the transient recorder SCD5000. This monitor has a fast rise time of about 250 ps. In Figure 5, cathode emissions don't rise for fast rise grid pulser (50 ps). Y796 cathode assembly rises about 1 ns. For single pulse mode, we will use the 70 mm short stab.

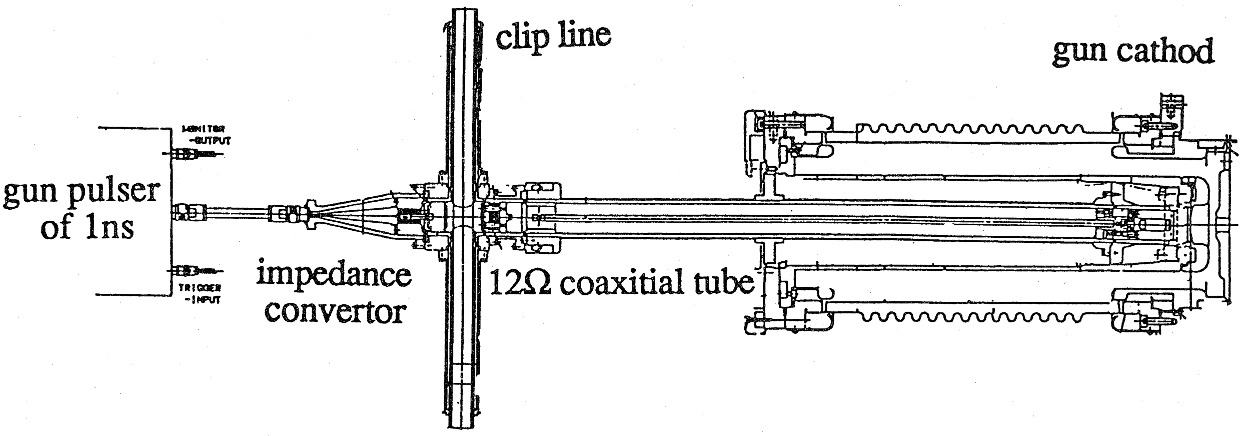

Figure 2. Layout of pulse transport line

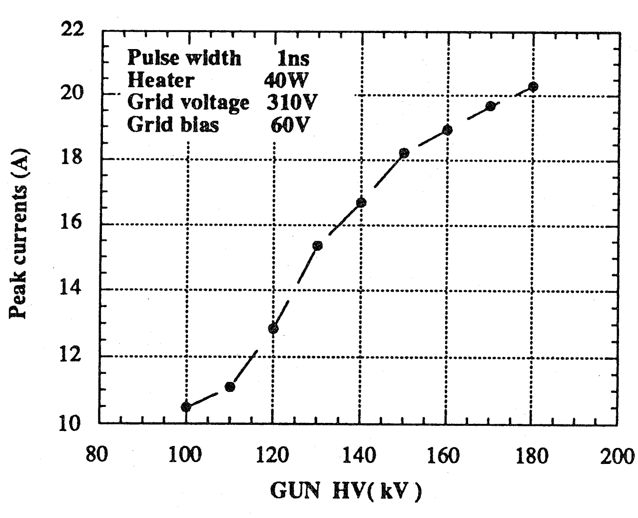

Figure 3. Emission current characteristics versus gun high voltage

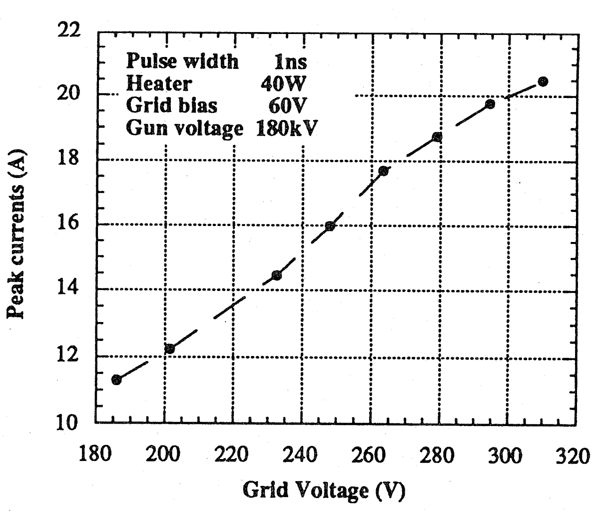

Figure 4. Emission current characteristics versus grid voltage

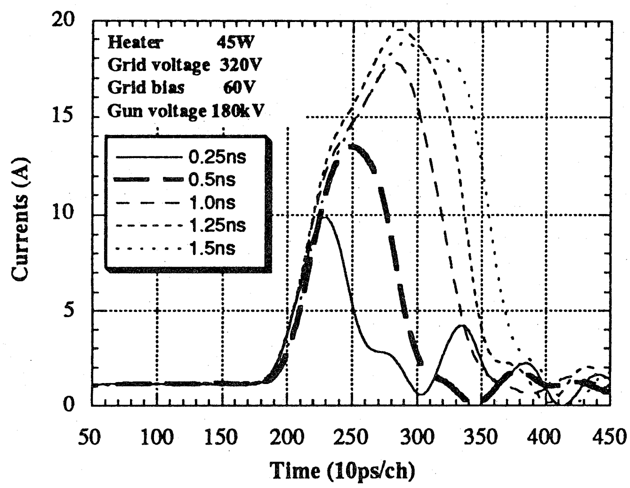

Figure 5. Gun emission of single pulse mode
Pulse length is adjusted by short stab length.

C. RF system

The diagram of the RF system is shown in Figure 6. The master trigger synchronizes with AC power line, 50 Hz. When it injects the synchrotron, this trigger will get from the synchrotron control system.

RF master oscillator is the synthesizer, Hewlet-Packard model 8664A. Low power RF, about 1 dBm, from the master oscillator inputs to the 300 W TWT amplifier, LogiMetrics model A500/S. TWT amplifier output is led the klystron input. A modulator of the booster klystron has a good stability of an output voltage, that is, the fluctuation is less than ±0.2 %. This is required to have a good stability because this is used for a microwave source for all high-power klystrons. The modulator has a 16-steps line type pulser. The FWHM of this modulator's output is 5 μsec, and the flat top is 2.4 μsec. Wave guide line filled with SF6 gas is divided three lines by directional coupler for PB1, PB2 and buncher. The driven power of PB1, PB2 and buncher is 20 kW, 40 kW and 2 MW. For power and phase control, IϕA is in a way.

When the injector system is moved to the SPring-8 site, 27 high power klystron's drive power is supplied with this wave guide line divided by directional coupler.

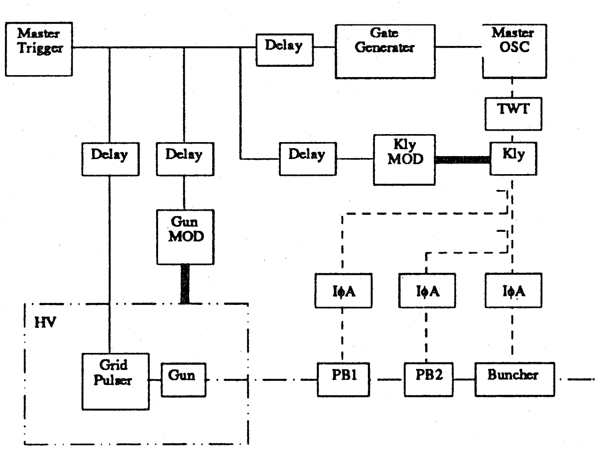

Figure 6. Diagram of RF system

D. Bunching Section

The gap voltage of the prebunchers is 20 kV and 30 kV, respectively, and the drift distance between two prebunchers is 222 mm. The velocity modulation by the prebunchers causes 68 % of the electrons to be bunched into 50 degrees in phase spread at the entrance of the buncher, which is located at the place of 152 mm away from the second prebuncher. The beam is finally bunched to 5 degrees in phase, and a beam energy is expected to be 9 MeV at the exit of the buncher. The energy spectrum of single pulse beam mode is shown in Figure 7.

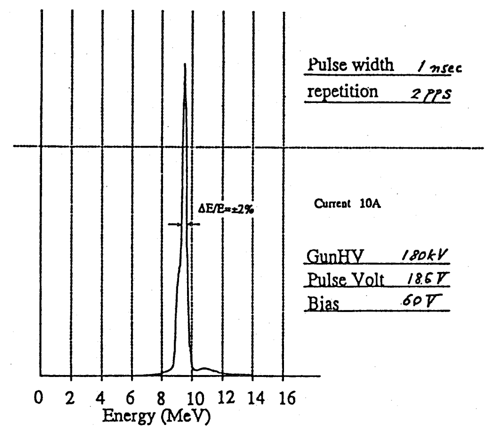

Figure 7. Energy spectrum of single pulse beam

III. CONCLUSION

The preinjector system of SPring-8 linac has been completed and installed temporary in Tokai Establishment. We are testing the performance of the preinjector system, electric gun, bunching section, modulator and klystron system, monitor, control system and total beam character. In result, we think the performance of preinjector system is enough to fill the request of the SPring-8.

The next problem is the endurance for the running operation on SPring-8 injector. We will carry out the long run operation, especially the life time of the gun cathode to the vacuum pressure.

IV. Reference

[1] H.Kamitsubo, "8 GeV synchrotron radiation facility project in Japan: JAERI-RIKEN SPring-8 Project.", Nucl. Instr. and Meth., A303, 1991, pp. 421-434

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