Initial data of Linac Preinjector for SPring-8

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Abstract

The construction of the SPring-8 (Super Photon ring 8 GeV) linac was started in 1991 March. The preinjector of linac (2856 MHz, 60 pps) 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 thermal 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, by eight helmholtz coils. The bunching efficiency was obtained to be 64~65 %, and the energy spread was obtained ±2 % at the enertgy of 9 MeV after the buncher with 2 MW RF power.

I. INTRODUCTION

SPring-8 has constructed in Harima Science Garden City, 100 km west of Osaka, near Himeji. And it is composed by three accelerators, linac, synchrotron and storage ring. Electron or positron is accelerated up to 1.15 or 0.9 GeV by this linac, and injected into the synchrotron then, accelerated to 8 GeV.

SPring-8 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. 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 of the SPring-8 linac 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.

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.

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 mm^2. It is able to produce 10 A/mm^2 [1] 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

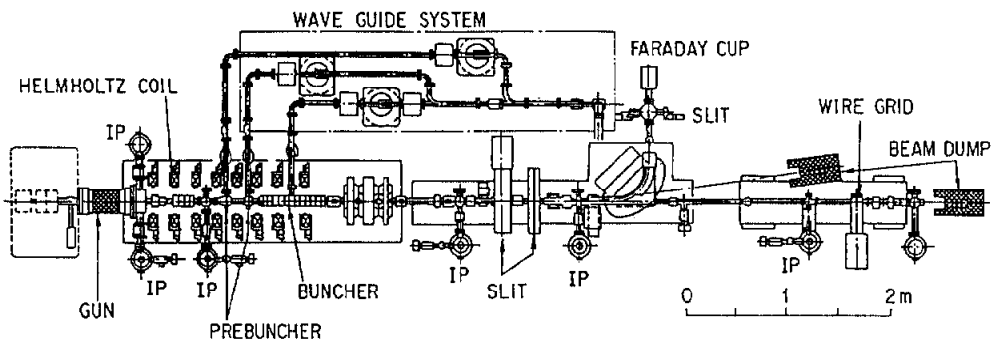


Figure 1 Arrangement of the Linac Preinjector

generator. The beam 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 clip line method with short stab, then output voltage becomes 200~320 V. 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. The emission characteristics versus gun high voltage, grid voltage at grid bias 60 V of single pulse beam are shown in Figure 3,4. The jitters of single pulses are less than 100 psec. Typical gun emissions of short and single pulse modes are shown in Figure 5. The current form of long pulse is measured by Peason current transformer. Short and single pulse beam are measured by wall currents monitor.

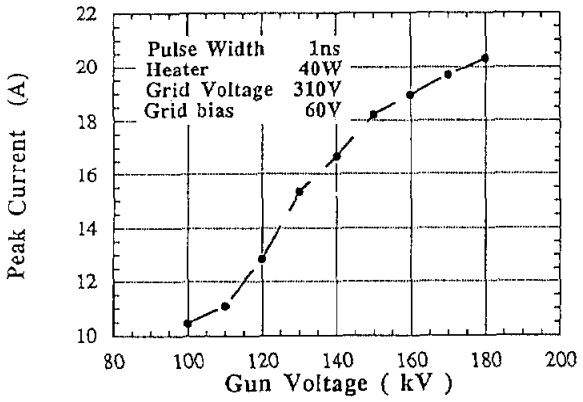


Figure 3. Emission current characteristics versus gun high voltage

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.

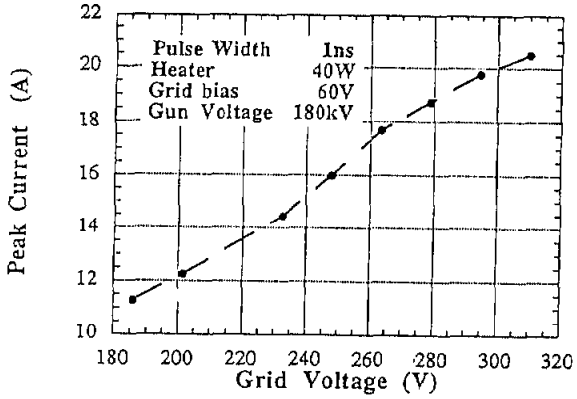
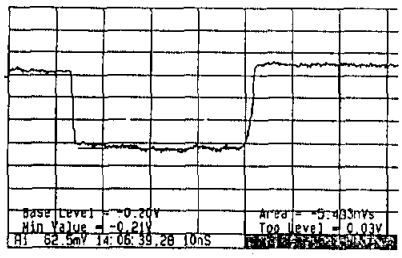
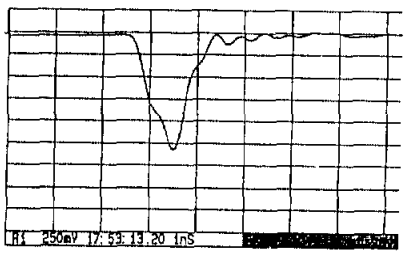


Figure 4. Emission current characteristics versus grid voltage



Short Pulse Mode 40 nsec



Single Pulse Mode 1 nsec

Figure 5. Typical gun emission of short and single pulse modes

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,

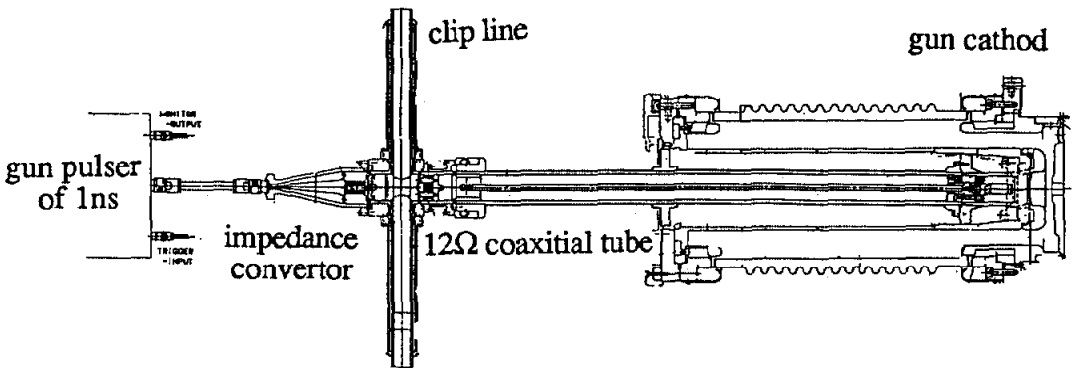


Figure 2 Layout of pulse transport line

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, 26 high power klystron's drive power is supplied with this wave guide line divided by directional coupler.

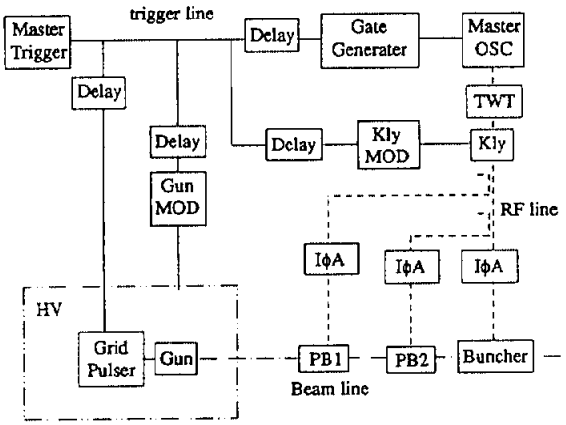


Figure 6. Diagram of RF system

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 singlepulse beam mode is shown in Figure 7.

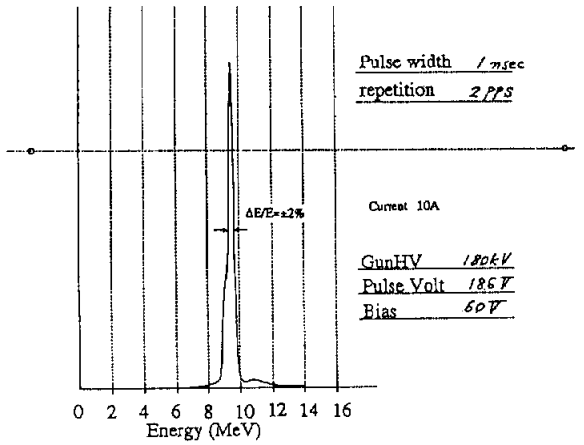


Figure 7. Energty spectrum of single pulse beam

E. Monitor

Several types of the beam monitors are prepared for a long pulse and a short pulse. The monitors are grouped into five types, which are for beam profile, currents, energy, emittance and bunch length. The profile monitors are the traditional fluorescent monitors, Demarquest AR995F, with CCD camera. It uses the operation of beam transport. The current of a long pulse is measured by Peason current transformers, and that of a short pulse is measured by wall current monitors and an amorphous-core type current transformer. The gun emission current tests about the wall current monitor show a good characteristic of the time response of less than 250 psec, that is good enough to observe a beam current of a single pulse. The cross section of the wall current monitor is shown in Figure 8. The set of a bending magnet of 90 degrees and a Faraday cup after a Q triplet measures the energy spectrum at a point after the buncher, with electron energy to be 9 MeV. Before the bending magnet of energy analyzer, there is another bending magnet of 8 degrees defraction. This beam line is used for the bunch length monitor using the streak camera by Cherenkov light radiation.

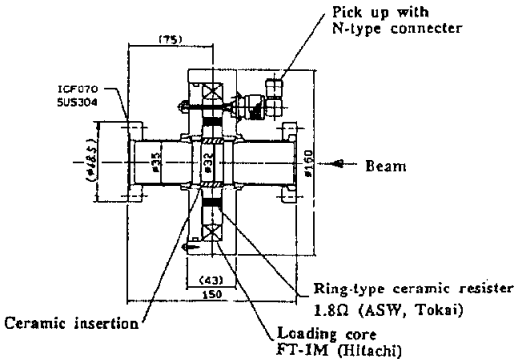


Figure 8. The cross section of wall current monitor.

III. CONCLUSION

The preinjector system of SPring-8 linac has been temporarily installed in Tokai Establishment, 700 km the East of Harima Garden City. We are testing the performance of the preinjector system, electric gun, bunching section, modulator and klystron system, monitors, control system and total beam characteristics. In result, the performance of preinjector system is enough to fill the request of the SPring-8.

Further experiments will be continue to examine the endurance for the long term of operation on SPring-8 injector, especially the life time of the gun cathode.

IV. Reference

[1] R. F. Koontz, "CID Thermonic Gun System", SLAC-PUB-2824, Oct. (1981)