Installation and Commissioning of PLS Preinjector Linac*

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Abstract

The Pohang Light Source (PLS) preinjector is a 60-MeV electron linac. It consists of two accelerating columns and one 25-MW klystron. The installation of the preinjector has started from July 27, 1991. In the tunnel, all components up to a 3-dB divider have been installed by September 24, 1991. Any vacuum leak more than 1.5×10^{-10} Torr-l/sec has been removed. The components in the gallery has been installed by November 24, 1991. The commissioning has been finished on December 7, 1991 by achieving 61.2 MeV electron beam. The construction of this preinjector linac is a major collaboration between Pohang Accelerator Laboratory, Korea and Institute of High energy Physics, Beijing, China.

1 INTRODUCTION

The 2-GeV Pohang Light Source (PLS) consists of the storage ring as a light source and a full energy linear accelerator as an injector [1]. The preinjector linac is the first 60 MeV section of the PLS 2-GeV linac [2].

Table 1: Major parameters for 60-MeV preinjector

Electron Energy	60 MeV
Energy Spread	0.8 %
Beam Pulse Width	2 ns
Repetition Rate	15 – 60 Hz
Pulsed Beam Current	> 1 A
Emittance	0.015 π MeV/c·cm
RF Frequency	2,856 MHz
Number of Klystron	1
Number of Accelerating Column	2
Length of Accelerating Column	3.05 m
E-gun voltage	80 kV
E-gun Current	> 2 A

The preinjector, as shown in Figure 1, consists of an electron gun, S-band prebuncher and buncher, two accelerating columns, 28 focusing solenoids, one quadrupole triplet, and various components. This is powered by a 25 MW klystron in the first phase. Later, this will be replaced with more powerful klystron to drive 10 klystrons in the downstream. Both the amplitude and the phase of the RF electric field of the bunchers can be adjustable independently in order to optimize the bunching condition.

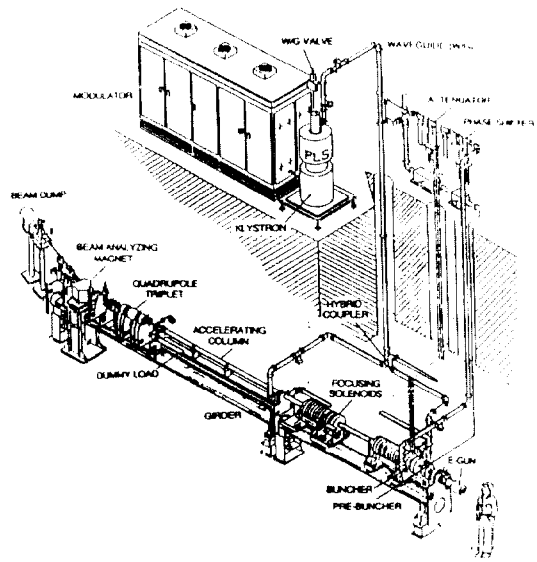

Figure 1: PLS Preinjector Linac

The major parameters for the preinjector are summarizes in Table 1.

The preinjector is one of the institutional collaboration programs between Pohang Accelerator Laboratory, Korea and the Institute of High Energy Physics (IHEP), Beijing, China.

2 INSTALLATION

A tunnel structure of about 20-m wide and 60-m long has been completed by the end of July 1991. It is just four months after the ground breaking ceremony which has been held on April 1, 1991. Especially the penetration holes connecting the tunnel and the gallery through 3-m thick concrete have been finished within ±5 mm tolerance. By this time, construction work for the gallery building has not been started, so the installation work has been divided to two parts: tunnel work and gallery work.

2.1 Tunnel Work

The installation of tunnel components has been started on July 27, 1991 [3]. The straightness of two accelerating columns is measured by using an optical telescope before and after the installation has been taken place. The

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maximum displacement of 0.78 mm is measured at the horizontal plane of second accelerating column.

Supports and girders, accelerating columns, solenoids are installed in series. The installation of other centerline components including two beam current monitors (BCT), one beam profile monitor (BPRM), the prebuncher and buncher, one quadrupole triplet are followed. The beam analyzing station which consists of one 24° bending magnet, one beam profile monitor, and a beam dump are connected to the centerline later. The waveguide components up to 3-dB divider are finished by September 24, 1991. Any vacuum leak more than 1.5×10^{-10} Torr-l/sec is removed. The vacuum pressure inside the accelerating columns and the waveguide network is kept under 1×10^{-8} Torr. The vacuum pressures measured after the completion of the installation are listed in Table 2.

Table 2: Vacuum pressures at various locations

Vacuum Region	Pressure (Torr)
E-gun	2×10^{-9}
Accelerating Column	5×10^{-8}
Klystron Window	8×10^{-9}
Bunching System	8×10^{-8}

The triode type e-gun is started its operation on October 17, 1991. The pulsed beam of 2.4 ns, 3.5 A is obtained with the cathode voltage of 80 kV.

2.2 Gallery Work

Due to the complicate structure of the gallery building, the beneficial occupancy of the gallery has been delayed to the end of October, 1991.

A 25 MW klystron and its modulator are installed and tested in early November. Measured parameters for the klystron and modulator are summarized in Table 3. Various gallery components including 29 power supplies for various magnets, 6 ion pump power supplies, various vacuum gauges and controllers are installed during November, 1991.

Table 3: Parameters for klystron and modulator

Pulse High Voltage	270 kV
Pulse Current	295 A
Pulse Width	3.3 μs
Pulse Risetime	0.7 μs
Pulse Falltime	1.2 μs
Duration of Input RF Power	3.0 μs
Repetition Rate	15 Hz (operation)
Pulse flatness	$\pm 1\%$
PFN Impedance	6.4Ω
Klystron Output Power	24 MW

The waveguide components from the klystron to the 3-dB divider, and phase shifters and attenuators for the buncher system are also installed during this period.

The phase lengths from the klystron to the high power load of each accelerating column are measured with a network analyzer. The phase difference of these paths is below measurable range, so there is no need of tuning the waveguide system.

The computer control system which is based on Intel 310 and BITBUS network is installed in the control room. Three iSBC 88/40 and iSBX 344 are used to control magnet station (MG), beam monitoring station (BM), and modulator and klystron supporting station (MK). For the interlock system and parameter display, iRCB 44/10 is used via BITBUS network.

For man-machine interface, two IBM PC compatible computers are used. The communication between these PCs and the Intel 310 is made through RS-232 ports. The menu selection of the main control software can be done with a touch panel screen.

The Manchester encode/decode method is used for the communication between the MG station and magnet power supplies in order to minimize electromagnetic interferences (EMI) generated mainly by the modulator.

The BM station controls two BPRMs, two beam loss monitors. There are two BCTs used in the preinjector. One is located immediate downstream of the e-gun, and the other is placed near the end of the preinjector. These are connected directly to Textronix 7104 oscilloscope in the console with very-low-loss coaxial cables.

The timing system consists of various synchronizers, frequency dividers, and variable time delay modules. This system is installed on the top of the BM station.

The travelling wave tube (TWT) is used to drive the klystron. The peak output power from the TWT is about 270 W, and about 160 W of peak power is actually used to drive the klystron. The TWT rack is located inside the control room, but it uses a separate ground from other control equipments so the EMI problem can be avoided.

By November 24, 1991, all components in the gallery and the tunnel are connected, and the calibration of magnet power supplies and BCTs are finished.

2.3 Cooling Station

A small but dedicated cooling station has been built for the preinjector because the major cooling station for 2-GeV linac is not available until the end of 1992.

The cooling station produces two kinds of low conductance cooling water; the normal cooling water for magnets and waveguides, and the precision controlled cooling water for accelerating columns. The precision-temperature water control system must guarantee the wall temperature of the accelerating columns within ± 0.2°C centered at 45°C. The cooling system including pipe work was completed on November 8, 1991.

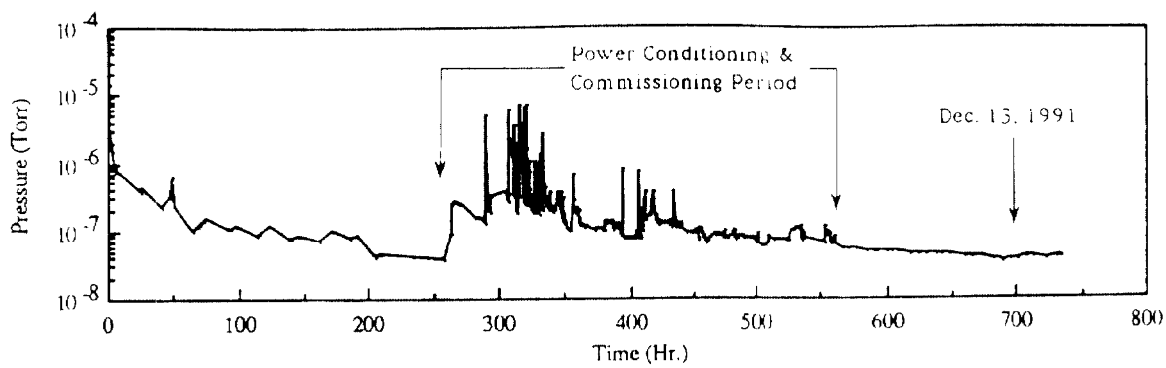

Figure 2: Vacuum pressure history of the preinjector linac

3 COMMISSIONING

The power training of RF components like accelerating columns and waveguide components is started immediately after the all components have been installed. The vacuum pressure history during commissioning period is shown in Figure 2.

The first electron beam is accelerated through the preinjector on November 29, 1991. The first commissioning is completed on December 7, 1991 when the 61.2 MeV electron beam is obtained.

The second commissioning is started from February 16, 1992 and completed on February 28, 1992. The main object in this period is to operate all system including modulator high voltage control and various interlocks with the main computer.

The achieved beam energy and the corresponding klystron output power is shown in Figutre 3. The measured beam parameters are listed in Table 4.

Table 4: Measured beam parameters

Beam Energy	61.2 MeV
E-gun Current	2.2 A
Beam Current at BCT2	1.3 A
Beam Pulse Width	2 ns
Energy Spread	0.64 %
Klystron Output Power	24 MW
Repetition Rate	15 Hz

The preliminary result of the emittance measurement is also obtained. The normalized values are: $\epsilon_{x,n} = 0.12$ MeV/c·cm, $\epsilon_{y,n} = 0.03$ MeV/c·cm. These data will be refined, and will be reported elsewhere.

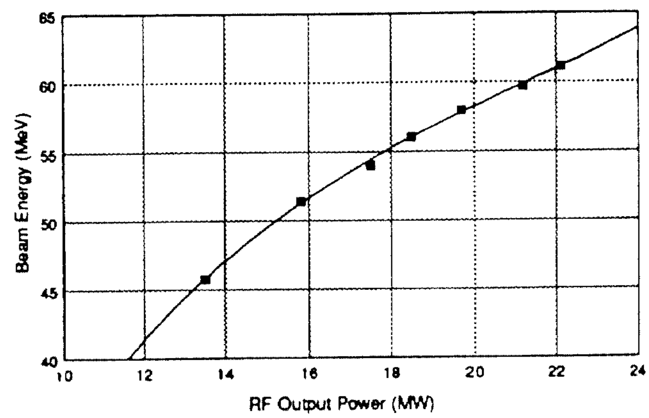

Figure 3: Achieved beam energy and klystron output power

4 FUTURE PLAN

As a front-end of 2-GeV linac, this preinjector will be improved in several places. First, to drive 10 klystrons from K2 to K11, the preinjector klystron will be replaced to a high power unit such as SLAC 5045 or Toshiba E3712 klystrons.

The computer control system of the PLS storage ring and 2-GeV linac is based on the VME system. The preinjector control system based on the Intel BITBUS system will be replaced in the near future.

5 ACKNOWLEDGEMENT

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6 REFERENCES

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