Status of PLS 2-GeV Linear Accelerator*

W. Namkung, I. Ko, M. Cho, J. Bak, C. Ryu, S. Won, T. N. Lee
Pohang Accelerator Laboratory, POSTECH
P. O. Box 125, Pohang, Korea 790-600

Abstract

The Pohang Light Source (PLS) project uses a 2-GeV electron linear accelerator as a full energy injector to its storage ring. The linac operates at 2,856 MHz with 11 klystrons of 80-MW output power and 10 pulse compressors. The 3.07-m long accelerating column is a SLAC-type constant gradient structure with conflat flanges. A distributed pumping system is adapted for the linac vacuum. The RF drive system uses the first klystron as a booster for the remaining 10 klystrons. Tunnel structure has been finished, and the gallery building is under construction. The construction of 60-MeV preinjector has been finished on February 28, 1992, and this preinjector is under normal operation. We present the updated design parameters and the construction status of the PLS 2-GeV linac.

1 INTRODUCTION

The PLS 2-GeV linear accelerator is a full-energy injector to the storage ring which will be served as a light source of various researches [1]. The 150-m long linac consists of 11 klystrons and modulators, 42 accelerating columns, 10 pulse compressors, and various components. It is placed at the underground tunnel located 6 meters below the klystron gallery floor.

About 200-m long tunnel and half of the gallery building is completed at present time. The first section of 2-GeV linac, called the preinjector, has been completed, and it is under normal operation [2].

The main linac is to be completed by July 1994, while the installation is to be carried out during July 1992 – December 1993.

2 TECHNICAL DESCRIPTION

2.1 General Description

The nominal beam energy of the linac is 2 GeV and the operating frequency is 2,856 MHz. The maximum repetition rate of the linac is 60 Hz. However, when the linac is served as an injector of the storage ring, the repetition rate will be 10 Hz due to the limitation on the injection system of the storage ring. The higher repetition rate will be useful for the machine test or other purposes in the future.

*Work supported by Pohang Iron & Steel Co. and Ministry of Science and Technology, Korea

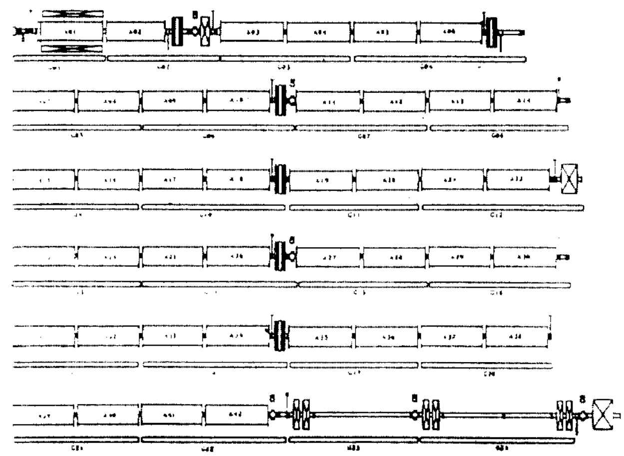

Figure 1: Layout of PLS linac.

The normalized emittance for the electron beam of the linac is 0.015 π MeV/c cm rad. It corresponds to 7.5×10^{-8} π m rad at 2 GeV. The energy spread of the electron beam is $\pm 0.6\%$ at FWHM. Major parameters are summarized in Table 1.

Table 1: Major parameters of PLS 2-GeV linac.

Beam Energy	2 GeV
Energy Spread	0.6 %
Machine Length	150 m
RF Frequency	2,856 MHz
Max. Repetition Rate	60 Hz
E-gun Current	> 2 A
E-gun Pulse	2 ns
Emittance	0.015 π MeV/c·cm rad
Klystron Output Power	80 MW max.
Number of Klystron	11 (=1+10)
Number of Pulse Compressor	10
Number of Accel. Column	42
Length of Accel. Column	3.072 m
Number of Quad. Triplet	6
Number of Support & Girder	22

2.2 Preinjector

The preinjector is the first 60 MeV section of the PLS 2-GeV linac. This consists of a triode type e-gun, S-band prebuncher and buncher, two accelerating columns, and various components. The preinjector is powered by a 25 MW klystron. Its installation has been started on July 27, 1991, and the first commissioning is completed on December 7, 1991 when the 61.2 MeV electron beam is obtained. The preinjector is under normal operation after the completion of the second commissioning, which is emphasized on computer control system, on February 28, 1992. The preinjector is used to train PLS personnel for their experiences on machine operation.

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

2.3 Beam Transport

The 60 MeV electron beam from the preinjector is accelerated to 2 GeV by 10 high-power klystrons and 10 pulse compressors. The klystron provides 80 MW maximum output power, and each klystron feeds four accelerating columns. Ten pulse compressors are employed to obtain higher accelerating gradient. When the klystron power is 64 MW and the energy gain factor of the pulse compressor is 1.5, the achievable beam energy is 2 GeV.

The 3.07-m long accelerating column is the SLAC-type constant gradient structure and the operating mode is $2\pi/3$. The filling time is 0.83 μs. A maximum cumulative phase excursion of 2.5° will be allowed for each accelerating column.

In order to have a higher beam break-up threshold, some accelerating columns have four supplementary holes with 9 mm or 11 mm diameter around the center aperture of the disk. Only the cavities from no. 2 to no. 6 have such holes. Out of total 42 accelerating columns, 12 columns have 9-mm holes and another 12 columns have 11-mm holes. The accelerating columns are arranged such that three kinds of columns (no supplementary hole, hole with 9 mm diameter, hole with 11 mm diameter) are inserted to distort the resonant condition of the HEM_{11} mode in the region where the HEM_{11} mode has a phase velocity equal to light velocity.

Table 2: Specifications of the klystron.

Output Power	80 MW
Pulse Width	4 μs
Repetition Rate	60 Hz (max.)
Gain	52 – 53 dB
Maximum Drive Power	500 W
Beam Voltage	400 kV
Beam Current	500 A
Perveance	2 $\mu Perv$
Maximum Magnetic Field	1.2 kG

A total of 44 accelerating columns are already ordered to the IHEP, and first 12 units will be shipped by April 1, 1992. The installation of these columns and other components will be started on July 1, 1992.

2.4 Klystron and Modulator

The 80-MW maximum output klystron required to make 2 GeV beam will be Toshiba E3712 model. The first two units will be shipped by July 1, 1992. The specification of this klystron is summarized in Table 2.

The 200-MW modulator will be manufactured by PLS personnel. A prototype of the 150 MW modulator is already assembled and tested [3]. The specification of the 200-MW modulator is also summarized in Table 3.

The klystron and modulator for the preinjector will be replaced to a high power unit in order to drive 10 klystrons in the downstream.

Table 3: Specification of the modulator.

Peak Power	200 MW
Output Pulse Voltage	23.3 kV
Pulse Transformer Ratio	1:17
Repetition Rate	60 Hz (max.)
Pulse Length	4.4 μs
Pulse Risetime	0.8 – 1.0 μs
Pulse Falltime	1.5 – 2.0 μs
Pulse Height Deviation	$\pm$0.5 %
PFN Impedance	2.8 Ω
Thyratron Current	9.5 kA
Anode Voltage	47 kV

2.5 Waveguide System

The design of waveguide system is completed after minor change is made. This change provides more working space in the access way of the machine tunnel. All required components are ordered and will be delivered on time to start the installation work on July 1, 1992.

An 800-W solid state amplifier is already delivered and tested. This will be used as a booster amplifier for the first klystron.

2.6 Control System

The PLS control system adopts the VME system on SUN Sparkstations. This system will provide a highly distributed control system for the linac and the storage ring. The computer control system of the preinjector is, however, based on an Intel 310 computer and BITBUS network. Along with two IBM PC compatibles as the man-machine interface, the preinjector control system is in normal operation. The modification of this Intel system to the VME system is being taken place.

2.7 Mechanical System

There are 6 quadruple triplets used in the linac to guide the 2-GeV beam. Five sets of quadruple triplet are already ordered. Three of them which have 44-mm aperture are same as the one used in the preinjector. The two quadruple triplets located at the high energy end is required strong field gradient, so these triplets have an aperture of 32 mm.

The girders are made with extruded aluminum tubes which are about 7-m long. Four sets of girders and supporters are to be shipped by June 1, 1992. These will be used to install eight accelerating columns within this year.

The cooling system for the preinjector is completed and the PC- based cooling control system is under operation. The quartz crystal oscillator is used as a temperature sensor.

2.8 *Alignment System*

The linac alignment is based on a laser alignment system. This system is adapted for better alignment accuracy and systematic checking for the periodic realignment of the linac.

The Fresnel zone plate (FZP) is used as a target of laser alignment system. One FZP mounted on an actuator is placed at the upstream end of each girder pipe. The laser source is located at the downstream of the linac and the image processing device is placed behind the e-gun. The focal length of each FZP is determined by the location of the target. The girder pipe is evacuated to 10^{-2} Torr to minimize the environmental effects such as air refraction.

The prototype of FZP with a focal length of 7.23 m is fabricated by photoetching method. The FZP material is Sandvik 38 and the frame is SUS 304. The thickness of the FZP is 38 μ and the minimum opening is 80 μ. The prototype of the FZP actuator is also fabricated and the durability test is finished.

2.9 *Beam Transfer Line*

The beam transfer line (BTL) provides a beam pass from the 2-GeV linac to the storage ring. The design of this 98-m long BTL [4] is improved and the number of focusing quadrupoles are reduced from 26 to 24. Also the maximum field gradient of the quadrupoles is reduced to 10 T/m, so the magnet design is changed to an air-cooling type. This change removes most of cooling pipes in the BTL tunnel.

3 CONVENTIONAL FACILITY

3.1 *Linac Building*

Since the ground breaking ceremony which was held on April 1, 1991, a lot of progress is made in the construction of the linac building. About 220-m long tunnel structure, which is located 6-m below the ground level, is completed and the finishing work is being taken place. About half of the gallery building is also completed. The whole linac building will be completed by Spring next year.

3.2 *Cooling Station*

The linac cooling station is located just outside the linac building near the 1 GeV outlet. The ground work of the station building is just started and the pump station will be completed by October 1992. The cooling station will be functioned by computer control system at the end of this year.

4 REFERENCES

[1] PLS Project, Design Report (Revised Edition) of Pohang Light Source, Pohang Accelerator Laboratory, Pohang, Korea, 1992.

[2] W. Namkung et al., "Installation and commissioning of PLS preinjector linac", paper submitted to this conference.

[3] M. Cho et al., "Design of 200-MW pulse modulator for PLS 2-GeV electron linac", paper submitted to this conference.

[4] I. Ko and M. Yoon, "Design of beam transfer line and injection system of Pohang Light Source", Proc. 1991 IEEE Particle Accel. Conf., pp2700-2702, 1991.