SPring-8 Linac

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1.Introduction

The 1.2GeV linac of SPring-8 consists of a thermionic gun, a bunching system and 26 accelerator columns. To avoid the ion trapping in the storage ring, the linac can provide a positron beam with an energy of 900MeV. The linac produces three kinds of the pulse length from 1nsec, 10-40nsec and 1μsec. These correspond to the storage ring's requirements for multi-bunch and single bunch operation modes. The linac rf-frequency is 2856MHz with a maximum operation rate of 60Hz. Operation of power supplies was started early in 1996 and beam operation began on August 1,1996. In 1997, the linac was operated steadily, providing electrons into the booster synchrotron--except for a summer shut-down from July 12 until August 31.

2.High-power Klystron System

High power microwave is produced from 13 sets of 80MW klystrons with 200MW modulators. The SPring-8 linac ran for over 10,000 hours between its first operation, in early 1996, and March 31, 1998. During 1997, only one klystron and two thyratrons were replaced. The klystron replacement became necessary after a cooling water leak from a beam dump connector, and one thyratron was suffered from a grid spike problem and another thyratron was replaced because of a deterioration of anode delay time and jitter. The other klystrons and thyratrons have continued to operate normally. Table 1 summarizes the operated time of the linac klystrons and thyratrons.

Table 2 shows typical operation parameters of PFN voltage, accelerator column energy gain and total energy. The pulse transformer ratio is 1:12 for the gun and the booster system and 1:16 for the main klystron system. The booster system supplies microwave to two pre-bunchers and one buncher, as well as the driving system that distributes low-power microwave to each main klystron. The $2\pi/3$ traveling-wave mode accelerator column has a length of 2.835m. Energy gain is calculated without correcting for power loss in the waveguide between a klystron and the accelerator column.

Table 1. Operated time of klystron and thyratron on March 31, 1998.

Names	LV(heater) on-time(hours)	HV on-time (hours)	Thyratron type	Klystron type
Gun	12,529	8,405	F241	
Booster(#1)	13,170	10,213	F175	
(present)	14,378	11,221	F175	PV2012
H0	12,885	8,902	F351	E3712
H1	12,733	9,094	F351	E3712
H3	12,901	9,040	CX1937A	E3712
H5	12,687	9,084	F351	E3712
M2	12,813	9,024	F351	E3712
M4(#2)	11,262	7,673		E3712
(present)	12,744	8,833	F351	E3712
M6	13,130	9,131	F351	E3712
M8(#1)	9,817	6,690	F351	
(present)	12,662	9,035	F351	E3712
M10	13,027	9,266	F351	E3712
M12	12,828	9,165	F351	E3712
M14	12,771	9,165	F351	E3712
M16	12,815	8,820	F351	E3712
M18	13,152	9,041	F351	E3712

Note #1;Thyratron replacement

#2;Klystron replacement

Table 2. Typical parameters of PFN voltage and energy gain

Names	PFN Voltage (kV)	Klystron Power(MW)	Energy (MeV)	Total Energy (MeV)
Gun	32			
Booster	25	7.3	10.0	10.0
H0	33	9.5	26.5	36.5
H1	45	54.7	93.8	130.3
H3	38	25.1	63.6	193.9
H5	45	55.6	93.7	287.6
M2	45	56.9	93.6	381.2
M4	37	19.6	56.2	437.4
M6	45	54.7	93.9	531.3
M8	45	62.7	99.5	630.8
M10	45	56.9	93.6	724.4
M12	45	62.5	98.1	822.5
M14	42	45.4	85.5	908.0
M16	35	15.1	48.9	956.9
M18	37.9	24.9	63.3	1020.2

3.Beam Status

The linac provides to the booster synchrotron with 40nsec pulse-length and 100-150mA electron beam. Figure 1 shows the beam current for a typical injection, with a beam current was 115mA and injection duration of 1070sec. Beam current fluctuation is less than ±2.5%.

After fine adjustment of the beam operation, the energy spread becomes ±0.6%. The beam loading in the accelerator column is about 1% at the condition of 120mA and 40nsec beam, so that it may be a main source to determine the energy spread at this beam condition. Center energy fluctuation is ±0.2% and is mainly caused by PFN voltage fluctuation, along with the jitter of modulator trigger and thyratron trigger, and microwave phase fluctuation. Each PFN voltage fluctuation at the flattop has been within its design specification limit of ±0.5%, including the ripple due to pulse forming network and flat-top droop. Observed beam energy is more stable than the PFN voltage. This is because shot-by-shot reproducibility of the PFN voltage at a typical beam timing can be achieved at levels smaller than the PFN voltage flatness of ±0.5%.

Some drift has been observed in the beam current, the beam energy and other machine data. The drift time-constants are about several-tens minutes and one day[1]. The shorter time drift is caused by variations in the cooling water temperature, which can vary about 3-4 degrees over 25-40 minutes period. This cooling water is used for magnets, power supplies and klystrons without a precise temperature control. Observations reveal that the phase and output-power of klystrons coincide with the cooling water temperature drift. The long time drift is related to room temperature. Although controlled by an air-condition, the room temperature can vary by about 4 degrees in the course of a day, affecting the solid waveguide and electric circuits in the microwave driving system.

4.Other Activities

A modulator test set is under construction in order to carry out high power klystron test and to examine thyratron characteristics. The modulator incorporates an inverter circuit in place of a charging power supply composed of an IVR, a rectifier and a de-Qing circuit. The PFN condensers are 2-pararrel and 16-series. PFN inductance is remotely adjustable. A pulse transformer ratio of 1:17 has been selected. The thyratron mount can easily accommodate different types of thyratron made by different makers.

Two beam transport lines are under construction at the end of the linac. These will transfer an 1GeV electron beam from the linac to New-Subaru facility and an experimental hall. The beam will bend to the left by an angle of 30 degrees (the synchrotron is to the right) and go into a new tunnel, which is under construction. Beam transport line to New-Subaru incorporates a double-bend-achromatic lattice while the line to the experimental hall is a triple-bend-isochronous-achromatic lattice. All of accelerator components in the transport lines have been designed and are now being manufactured. The installation of beam transport lines will start in July 1998 and beam commissioning will begin in September, 1998.

To improve the beam quality such as a low emittance and a high peak current for FEL experiment based on a single pass spontaneous emission[2], a rf gun was studied and a single cell test cavity was fabricated[3]. A experimental arrangement of rf gun is under construction. This will measure the dark current at the condition of the high accelerating field, check the cavity design code, and clarify technical problems in operating the rf gun. About 30MW of the microwave power at a frequency of 2856MHz is available along with a YLF laser with 4th harmonics for the rf gun experiment.

References

[1] T. Asaka et al. "Stability of the RF system at SPring-8 Linac", In this annual report.

[2] K. Yanagida, et al. "Study of Linac Based Single Pass FEL", In this annual report.

[3] T. Taniuchi, et al. "Photocathode RF Gun Development for SPring-8 Linac", In this annual report.

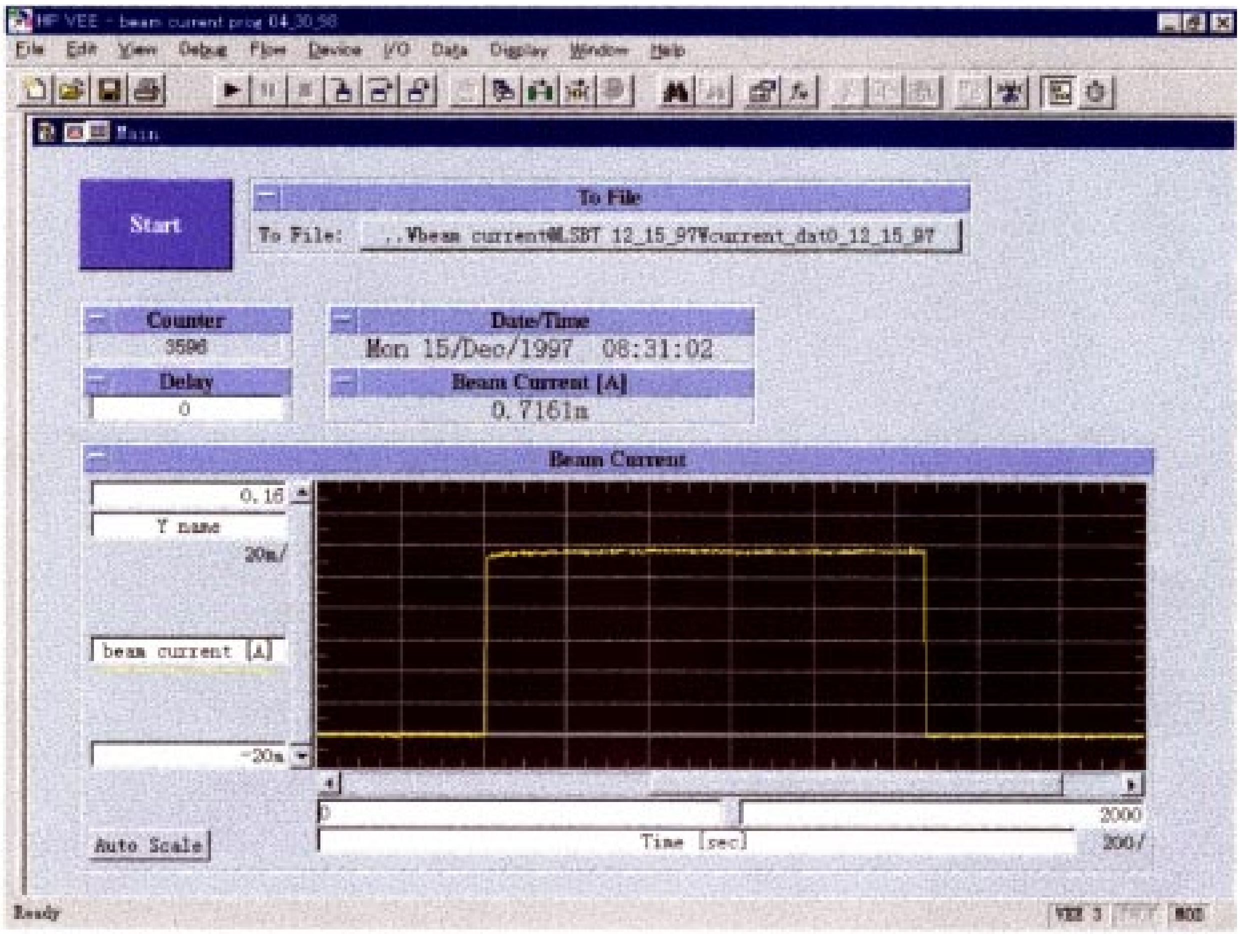

Fig.1, Linac output current injected into the synchrotron.