Linac

1. Introduction

Operation of the linac's power supplies was started in 1996, and beam operation began on August 1, 1996. In 1998, after operation for one and a half years, the beam's stability was intensively examined and improvement was carried out during the summer shutdown [1].

Two new beamline for experiments and for beam injection into the storage ring New SUBARU, called L3 and L4 respectively, were completed [2] (see the photogravure section). The electron beam injection into the New SUBARU started in October 1998.

2. Operation and Failure

The linac was operated without any big problem during the year. Operation statistics for the year will be summarized in another subsection.

The cumulative usage hours of klystrons and the PFN voltages are shown in the following table.

Cumulative usage hours of klystrons and PFN voltages.

Name	LV-on time (hours)	HV-on time (hours)	Klystron type	PFN volt. (kV)
Booster	18545	15044	PV2012	25.0
H0	17341	12781	E3712	39.0
H1	17209	12980	E3712	43.6
H3	17398	12915	E3712	43.2
H5	16509	12440	E3712	43.5
M2	17216	12905	E3712	43.2
M4	5260	4889	E3712	43.5
M6	17517	13020	E3712	43.5
M8	17044	12890	E3712	42.0
M10	17394	13151	E3712	43.5
M12	17211	13052	E3712	42.0
M14	17117	12936	E3712	42.0
M16	17152	11050	E3712	43.1
M18	17561	12873	E3712	43.5

No klystron had failed during the year, however, two thyratrons were replaced: one because of a deterioration in anode-delay time and the other because of jitters, respectively. Electrical discharges in the high voltage circuit of the klystron modulators caused a small amount of damage to the modulators.

3. Improvements

In order to achieve high stability beam injection into the storage ring, the linac's RF equipment was examined for the causes of the drift of RF power and phase [1]. This investigation provided the following findings:

1) The phase drift of the high power klystron drive system, which depends on the environmental temperature, was 10.0 deg. / 4.0 ˚C at the downstream end of the 70 m-long waveguide through one day.
2) The variation in the klystron-cooling-water temperature was 3.0 ˚C with a period of 25 minutes, which caused the phase drift (1.2 – 2.4 deg. / 3.0 ˚C) of the klystrons.
3) The random variation in the power and phase of the klystrons resulted from the fluctuation in the PFN voltages at the klystron modulators due to inadequate adjustment of the de-Q'ing efficiency.

After analyzing these findings, the following improvements were made during the summer shutdown in order to reduce the RF power and phase drifts [1]:

1) The waveguide of the high power klystron drive system was covered with a heat insulator, and the air-conditioner was adjusted, so that a phase drift smaller than 3 deg. at the downstream end of the waveguide was achieved.
2) An inverter control system was introduced to regulate the coolant-temperature, and thus the phase stability of the klystrons was kept within 0.5 deg.
3) Readjustment was made to the de-Q'ing efficiency of the klystron modulators, resulting in a PFN-voltage stability of ± 0.2 % (1σ) for each klystron was achieved.

After the above improvements, the beam injection stability was achieved within a beam current fluctuation of ± 0.7 % (1σ) and a center energy fluctuation of ± 0.1 % (1σ) at the beam transport line as shown in Fig. 1.

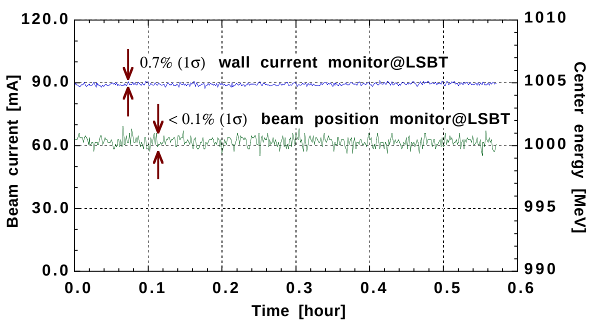

Fig. 1. Variation in current and center energy of injected beam.

A dispenser cathode assembly Y796, which is able to generate a high current 1-ns pulsed beam of up to 18 A, had been used as the linac electron gun [3], for production of positrons was assumed. The Y796 electron gun was controlled by adjusting grid bias voltage or heater power. In addition, an iris was inserted at the downstream of the anode in order to reduce current. Finally, we obtained the beam current of 200 mA for a 40-ns pulse width and 2 A for a 1-ns pulse width. During the summer shutdown, the cathode assembly was replaced with an assembly Y845 [4], which was appropriate for a lower emission to generate a stable beam because there is no need for a positron beam.

The trigger system of the linac was modified and improved as follows (see the photogravure section). A new trigger circuit for the injection into the New SUBARU was installed. This circuit made the timing signals from the synchrotron and the New SUBARU selectable. Trigger signals for instrumentation, such as waveform observation by means of an oscilloscope, were prepared so as to take data of waveforms synchronized with beam pulses.

The transmission line to the gun grid had a short stub to convert a step function signal to a short pulse. It had to be replaced with a normal line without a stub when a semi-long beam pulse was required. In this configuration, a short-pulse generator, which is able to generate a 250-ps pulse width, replaced the short-stub method. Therefore, selection of a beam pulse width of 40 ns or 1 ns can be easily made by switching two pulsers held in a high voltage deck.

A chicane, which is located at the downstream side of the last accelerator guide, was completed in January 1999. The chicane comprises four bending magnets, a quadrupole magnet, a vacuum chamber, and beam monitors as illustrated in Fig. 2. This was built for monitoring the beam energy during the injection into the synchrotron and as part of an energy compression system (ECS) that will be installed in the near future.

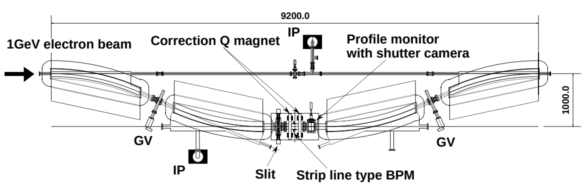

Fig. 2. Top plane view of the chicane.

4. L3/L4 Beam Transport Line [2]

The L3 beam transport line, which transfers an electron beam to an experimental hall, was built for investigation of the beam and for study of beam physics. The L4 line transports an electron beam to the New SUBARU storage ring. An achromatic lattice is adopted for the former while an isochronous-achromatic lattice is used for the latter.

Design of both beam transport lines started in the summer of 1997 and their construction began in the spring of 1998. Commissioning of the beamlines started in September 1998 and was completed successfully in a few days.

5. Other Activities

A high power compact pulse modulator [5] was constructed in order to test 80 MW klystrons or different types of thyratrons as well as to provide R&D tools for the development of the next generation modulator. Typical specifications are 190 MW peak power, 390 kV peak beam voltage, 60 pps pulse repetition and 2.2 μs flattop pulse width with less than ± 0.15 % of the beam voltage. As advances over conventional modulators, the following new technologies are introduced: a 40 MHz inverter high voltage power supply, a command charging method, and a remote-controlled tunable slug for the PFN coil. The new modulator is now being tested.

A photocathode RF gun study started in 1996, and the first single-cell model was assembled with RF equipment such as waveguides or a klystron in the summer of 1998 (see the photogravure section). Conditioning of the gun's RF cavity started in November [6]. High power RF up to 18 MW was fed into the cavity and the electric field gradient on the cathode reached 127 MW/m. An experiment extracting photoelectrons by irradiation of UV laser pulses will be carried out in February 1999.

Construction has begun on a test bench for the electron gun assembly, which is equipped with a high voltage generator, solenoid coils, a beam chamber, a vacuum pump, and beam monitors. We will examine the performance of the new gun, such as transfer characteristics, before mounting it on the linac.

References

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[2] S. Suzuki *et al.*, SPring-8 Annual Report 1998, (1998).

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[4] T. Kobayashi *et al.*, SPring-8 Annual Report 1998, (1998).

[5] T. Hori *et al.*, Proc. 19th Int. Linear Accelerator Conf., 576 (Chicago, 1998).

[6] A. Mizuno *et al.*, SPring-8 Annual Report 1998, (1998).