Linac

1. Present Status

1.1 Electron Gun

We measured the characteristics of the electron gun in order to predict the lifetime of its thermionic cathode. The measurement results are shown in Fig. 1.

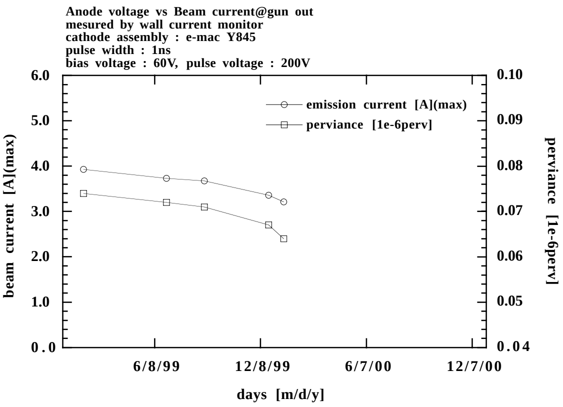

Fig.1. Curves of deterioration of beam current and perveance of electron gun.

The reductive curves of the perveance of the electron gun predict that the cathode assembly will be replaced within one year.

1.2 Beam Energy Stability

In 1998, we reduced the RF power and phase drifts by stabilizing the temperature drift of the atmosphere and cooling water. In addition, a readjustment was made to the de-Qing efficiency of the klystron modulator in order to reduce the PFN voltage fluctuation. As a result, beam energy stability was greatly improved and good reappearance of the injection current was obtained [1].

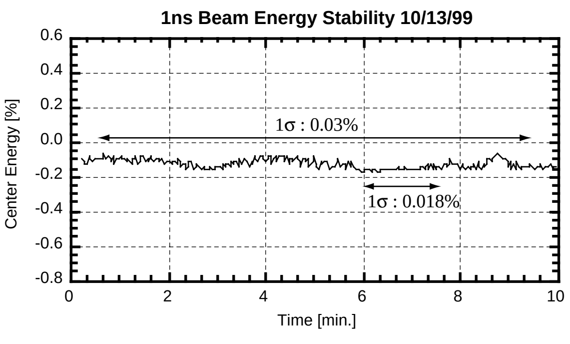

Fig. 2. Energy variation of 1-ns beam.

In 1999, an accurate evaluation of the beam energy variation was made by analyzing a beam spot image on a screen monitor mounted in the 1-GeV chicane section. As shown in Fig. 2, the energy fluctuation was ±0.018 % (rms) for a short term, and ±0.03 % (rms) for a long term (10 minutes).

2. Improvements

2.1 Injector

The electron gun holds a thermionic cathode with a control grid. After a long time operation of the gun, barium atoms evaporate from the heated cathode and accumulate on the grid, resulting in increase of the emission current from the grid. This grid emission spoils the purity of the single bunched beam of the storage ring, since it cannot be regulated by a grid control voltage. Therefore a beam deflector for kicking only the grid emission was designed and constructed. We started an experiment of the deflector system in the machine laboratory.

2.2 RF System

In the case of 1-ns beam injection into the New SUBARU storage ring, beam injection loss has to be minimized since radiation caused by the beam loss is severely regulated at New SUBARU. Therefore, the beam energy spread, including the energy fluctuation in a long term, has to be less than ±0.3 %. As a result, the maximum beam current has been limited to 200 mA. In order to narrow the beam energy spread caused by beam loading and consequently to extend the upper limit of the injection current, introduction of an energy compression system (ECS) is determined.

A design for the ECS [2] is based on the conventional type developed at the Mainz 300-MeV linac. According to the calculated result, the beam energy spread or fluctuation will be kept within ±0.3 % (full width) even for a high current injection at 5 A.

The ECS is composed mainly of four chicane magnets and an accelerating structure. The chicane section was completed in January 1999 and has been used for a beam energy analyzer as mentioned above. The accelerating structure and RF components will be installed in the summer of 2000.

2.3 Beam Monitor

A beam position monitor (BPM) is an essential device for the diagnosis of a beam passing through a linac. We have been involved in the R&D of a single-pass BPM since 1995. After constructing a few kinds of pilot models, we decided to adopt an electrostatic strip line type. The resonant frequency of 2856 MHz was chosen for the strip line, since the BPM has to detect three types of beams with the pulse widths of 1ns, 40ns and 1μs.

The signal processing circuit for the BPM was requested to have a wide dynamic range, since the 1-ns beam current ranges from 20 mA to 2 A. Finally we concluded that the logarithmic detection method, which was originally capable of processing wide dynamic range signals, was the first choice for our case.

A prototype circuit comprises 2856-MHz bandpass filters, logarithmic detectors and peak-hold circuits. The following ADC's take four output signals to convert them into x-y positions. The position resolution is estimated about 10 μm from the noise level of the logarithmic detector. The circuit has just been completed and will be tested by the spring of 2000. We will begin operation of the BPM system from the autumn of 2001.

2.4 Beam Transport

In 1998, two new beam-transport lines were built: the L3 line to an experimental hole and the L4 line to the New SUBARU. Due to the great length of the L4 beam line (150 m), Twiss parameter matching of the transport line has to be made accurately in order to realize high injection efficiency.

First, transverse beam sizes are measured with three wire scanners and four screen monitors which are installed between the end of the final accelerator guide and the first bending magnet. Then Twiss parameters at the entrance of the 1-GeV chicane are calculated from the obtained seven beam sizes [3]. These parameters give the optimum excitation currents of quadrupole magnets at the upstream side of the first bending magnet. In addition, beam emittance also results during this process. The measured emittance values are summarized in the section of machine operation.

This matching process is carried out when the linac operation starts or when the operation parameters are changed, resulting in high injection efficiency greater than 90 %.

3. Other Activities

3.1 RF Gun

Work on a photocathode RF gun study started in 1996. A high-power RF test of the gun's RF cavity started in November 1998 and the first photoelectrons by the irradiation of UV laser pulses was observed in February 1999. High-power RF of up to 18 MW was fed into the cavity and the electric-field gradient on the cathode reached 127 MW/m. The maximum beam energy was 2.9 MeV and the charge per bunch was 2 nC. The minimum normalized beam emittance of 17πmm•mrad was obtained when the 10-ps pulsed laser was injected on the cathode plain holding the maximum electric fields of 90MV/m, and then 0.8 nC beam bunches were extracted [4].

A beam simulation code has also been developed as a comparison for the experimental results. The present code is a three-dimensional particle tracking code which treats all actions between each electron in order to solve the space charge effect. The simulated results provided a good explanation for the experimental values of the emittance and their dependence on an initial phase of the RF power fed into the gun's cavity [4]. Therefore we consider that this code is useful for the design of our second phase.

3.2 Klystron Modulator

A thyratron, a kind of vacuum tube, which contains a hydrogen reserver, has been widely used as a switching device for a klystron modulator. The reserver needs voltage adjustment of its heater to maintain the tube's performance and then determines the tube's life when the hydrogen dries out. Thus the thyratron is the bottleneck in the development of a reliable and compact modulator. Therefore, to avoid this problem, we have developed a solid-state switching device which is able to replace the thyratron.

A pilot model, in which ten IEGT's (Injection Enhanced Gate Transistor) are stacked, is now in production. An IEGT has a structure similar to an IGBT, which is widely used for high-power control, except that an IEGT has the advantage of smaller power loss. The pilot model is expected to have a practical specification of 32 kV / 4000 A and tests will begin from the summer of 2000.

References

[1] T. Asaka *et al.*, Proc. 18th Particle Accelerator Conf. (New York, 1999) 3507.
[2] T. Asaka *et al.*, in this volume.
[3] K. Yanagida *et al.*, Proc. 24th Linear Accelerator Meeting in Japan (Sapporo, 1999) 82.
[4] T. Taniuchi *et al.*, in this volume.