Developments and Upgrades of Linac

Improvement of Electron Gun System

The SPring-8 linac has been equipped with only one electron gun system, i.e., a high-voltage inverter-type pulse power supply, a pulse transformer, a high-voltage deck and an electron gun. That is, when any of these parts fail, the linac cannot inject beams into the booster synchrotron until the failure is fixed. In particular, the replacement of a cathode assembly requires at least three days to complete the processes of mounting a new cathode assembly, and the evacuation and activation of the cathode. Therefore, the construction of a backup system has been an important issue for enhancing the reliability of the electron gun system and to reduce the downtime of the beam injection in the case of a gun failure.

We have thus carried out the following improvements:

1) Development of a reliable high voltage pulse power supply.
2) Composition of a twin electron gun system.

New high voltage pulse power supply

The previous pulse power supply often caused discharges at the high-voltage terminal of the inverter power supply. In addition, it was difficult to maintain the pulse power supply because it was designed many years ago. The new power supply was completed in 2005 and it has been operated in a test stand for almost one year to confirm its performance and reliability. At the end of 2006, we replaced the previous power supply system with the new one. Figure 24 shows the pulse transformer tank and the high-voltage deck installed in the accelerator room.

The new system has the following features:

1) A pulse transformer with a step-up ratio of 1:30 decreases the primary voltage and accordingly solves the discharge problem. The inverter power supply now feeds a voltage of only 12 kV to the PFN to generate a pulse voltage of 180 kV at the terminal of the electron gun.
2) The FL-net, which is a standard universal network used in factory automation, was adopted as a new network connecting PLCs with a higher-level control system. All the linac PLCs used for local control of devices will be connected to the FL-net instead of the current network.
3) A larger high-voltage deck was installed to enhance functionality, expandability and serviceability.

The high-voltage pulse applied to the electron gun has a long rise/fall time of approximately 3 μs because the large step-up ratio enlarges the stray capacitances of the secondary circuit. However, the short flat top of the pulse caused by the long rise/fall time does not limit operation since in practice we use short pulse beams with pulse widths of less than 40 ns. The voltage stability of the inverter power supply is about 0.05% rms, which is sufficiently stable for the injector linac.

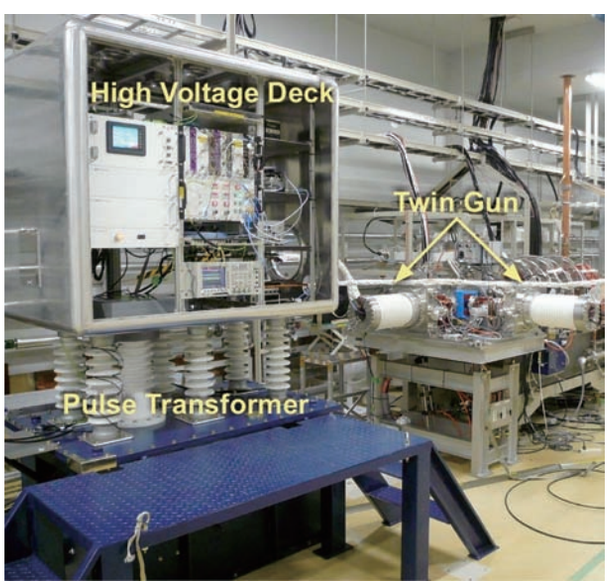

Fig. 24. New high-voltage station installed in the accelerator room.

Twin electron gun system

We had considered a couple of ideas that could realize a twin gun system: duplicating the present electron gun or doubling the present injector part including the gun and the buncher system, for example. We eventually decided to build only a backup gun and its power supply as early as possible. The following issues were taken into account in designing the backup gun.

1) The original performance of the main gun has to be maintained after the installation of the backup gun, whereas the performance of the backup gun for temporary operation, the beam current for example, can be inferior to that of the main gun.
2) The cathode of the backup gun has to be being pre-heated during the linac operation to immediately generate electron beams in case a failure of the main gun occurs.

A 90° bending magnet was installed to inject beams from the backup gun orthogonally mounted to the main gun, which was relocated upstream to make space for the bending magnet. The pole pieces of the bending magnet were designed to focus beams from the backup gun. A magnetic lens was installed for each gun to reduce the beam divergence caused by the space charge effects. A beam profile monitor and a coaxial type beam absorber to measure beam currents have also been installed for diagnosis of the backup gun's beam. Figure 25 shows the almost completed twin electron gun.

The backup gun will be soon tested and be ready for operation. The additional high-voltage power supply system for the backup gun will be constructed in 2008; hence, the complete twin gun system will start operation in 2009.

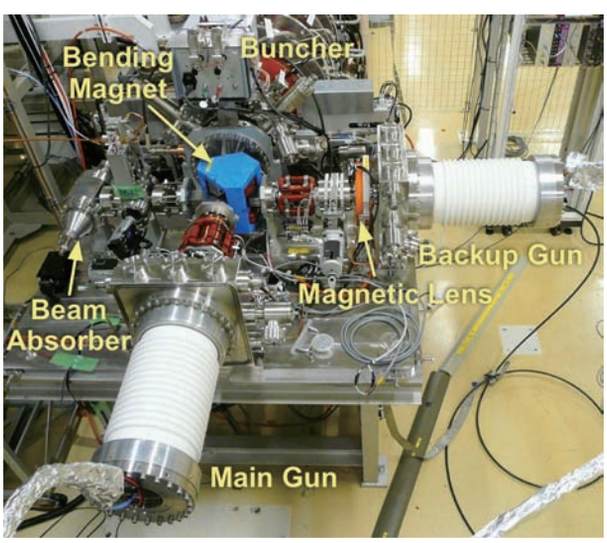

Fig. 25. Twin electron gun.

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