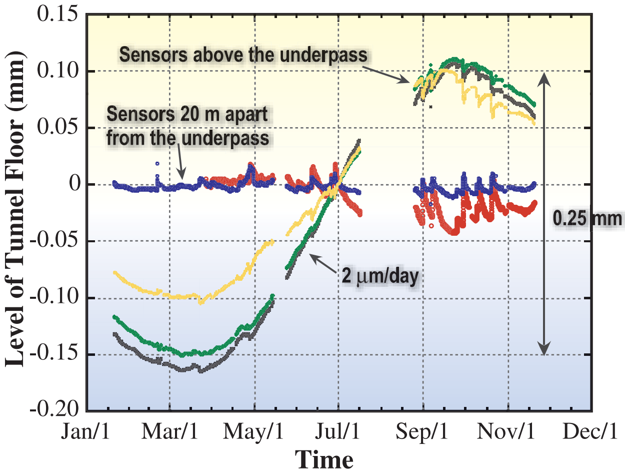

Fig. 10. Long-term movement of the tunnel floor above the vehicle underpass. The level changes by 0.25 mm from late March to September 2004. The rate of change is 2 µm/day.

Developments and Upgrades of Linac

Improvements towards top-up operation [9]

The SPring-8 linac has been improved since 1998 in order to provide beams with the stable energy and current; the energy stability has since been enhanced to 0.01% rms [10]. Temperature fluctuations in the klystron gallery, however, have not been negligible since 2002 when electric power saving of the linac began. We reduced the RF repetition rate from 60 Hz to 10 Hz for electric power saving in 2002 and accordingly observed remarkable room temperature drift in winter when the outdoor air temperature was low. These temperature variations caused the RF phase variations, as we experienced before 1998. The beam energies during acceleration from a buncher system to the end accordingly varied slightly, resulting in a distortion of the beam trajectory. We therefore investigated this room temperature issue to stabilize the trajectory fluctuations. The final beam energy, however, was stabilized by an energy compression system (ECS). The long-term energy stability was measured using BPM and OTR monitors. Figure 11 presents the beam energy variations before and after the ECS during a period of two days. The plotted energies before show the accidental reduction; the compensated energies, however, maintained the stability of 0.14% (p-p) throughout the measurement. Thus the ECS is effective in maintaining both shot-by-shot and long period beam energy stability.

The Linac is equipped with a bending magnet which switches a beam from the transport line for the New SUBARU storage ring to one for the booster synchrotron. In order to perform simultaneous top-up operation of the two rings, the previous block-type bending magnet was replaced with a fast-response bending magnet which could be momentary excited at short intervals. The new bending magnet must repeatedly turned on and off at short intervals to inject the beams frequently into both the synchrotrons. In order to achieve fast response and a small residual field, a 50A400 silicon steel plate 0.5 mm thick was chosen for the lamination-type yoke of the new magnet. The measured residual field was about 10 gauss, one-third of the previous field. A fast-response power supply was also fabricated for the new bending magnet. This power supply can excite the new magnet at 0.9 T with the rise/fall time of 200 ms.

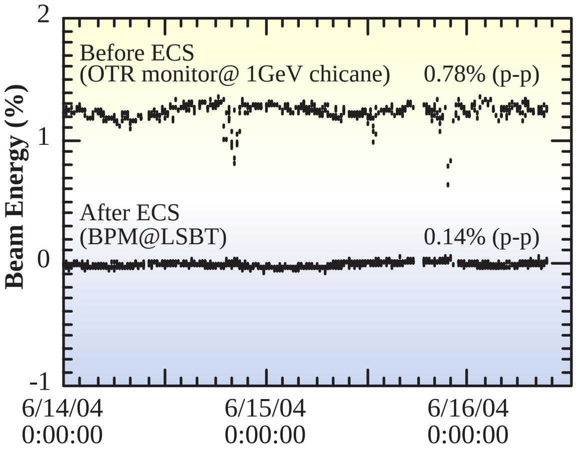

Fig. 11. Variations of the beam energy before and after ECS.

Study of high gradient acceleration

It is quite important to investigate high gradient acceleration for the development of RF guns, because an RF gun must stably maintain a high gradient of more than 100 MV/m in its RF cavity to reduce the beam emittance. The linac group has collaborated with KEK to study high-gradient acceleration with S-band accelerating structures.

It has been reported that a high-pressure ultrapure water rinsing (HPR) technique is very effective in improving the field gradients for accelerating structures. We have investigated the effectiveness of the HPR process to flush contamination in a traveling-wave accelerating structure. Results of the investigation at KEK revealed that the HPR treatment considerably accelerated the RF conditioning process of the accelerating structure and raised the possible maximum accelerating gradient [11].

In order to know what kind of phenomena has been promoted by RF conditioning and to understand the basic mechanism of RF discharge, we have diagnosed the RF breakdown by fast spectrographic analysis of atomic lines and quadrupole mass spectroscopic analysis [12]. Our results show that the HPR process may not completely flush carbon compounds and may cause water molecules to be injected into copper surfaces. We consequently proposed an alternative treatment, that is, a chemical etching method of dissolving contamination on copper surfaces such as dust and copper oxides [13].

We determined the optimum etching thickness by etching test pieces. The optimum value obtained, at which the surface roughness did not increase, was 0.3 mm. One RF gun cavity, which was RF-conditioned before, was processed by chemical etching with controlled etching time so as not to exceed the optimum etching thickness. The treated cavity was RF-conditioned at an RF gun test bench. Figure 12 presents results of RF conditioning of the cavity. Before the treatment the cavity could hold a maximum gradient of only 76 MV/m on a cathode after 3.3×10^7 shots of RF conditioning. The etching treatment, however, considerably accelerated the RF conditioning process and increased the gradient to 183 MV/m after 1.9×10^7 RF shots. The maximum gradient finally reached 187 MV/m. The measured quantum efficiency of the copper cathode reached 8.6×10^{-3} %.

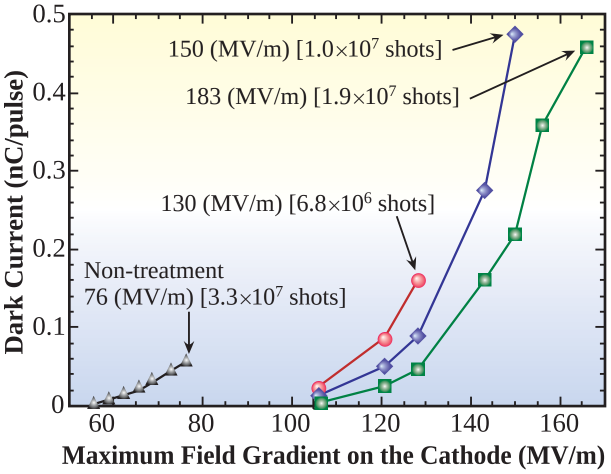

Fig. 12. Effect of RF conditioning of an RF gun cavity are expressed as variations of the dark current and the attained gradients on the cathode. The dark current at the gradient of 183 MV/m is not plotted because it was unstable.

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