Vertical Beam Damper

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The beam damper is a wide band feedback system for damping coherent betatron oscillations. Separate systems have been installed to suppress radial and vertical oscillations. This report describes the commissioning of the vertical system.

The purpose of the beam damper is to remove betatron oscillations caused by injection errors and to suppress the spontaneous growth of oscillations caused by the interaction of the beam with its image charges in the vacuum chamber wall. These functions are illustrated in Figures 1 and 2.

The vertical position of the beam is detected at location 3211. It is delayed by approximately one revolution, amplified, and applied to deflecting electrodes at location 3194. The vertical betatron oscillation phase advance at the normal tune of the accelerator is such that a position error at the pickup is transformed into an angle error at the deflector. During the experiments described here the gain of the damper was 3.6 x 10^{-6} radians/cm - 10^{12} protons. This was determined from electrical measurements.

At an intensity of 3 x 10^{12}, this gain should cause a decrease of betatron amplitude to 1/e in about 20 revolutions. To measure the gain using the beam we used the Q-kicker to excite an oscillation. This is shown in Figure 3. We measured a damping time of 30 revolutions.

During the entire cycle of the machine no vertical oscillation signals were observed within the 2 KHz to 2 MHz band-pass of the damper. When the beam is bunched at 200 MHz a small amount of octupole stabilization is required to suppress a violent high frequency transverse instability. This instability is not understood at this time.
Figure 1: The beam damper has been turned off. The upper trace shows the signal from the vertical position detector while the lower trace shows the beam current. In this picture the beam was unstable because of image forces from charges induced in the vacuum chamber walls. The coherent growth seen in the top trace continued until a significant part of the $3 \times 10^{12}$ protons injected had been lost.
Figure 2: The beam damper is on. The position detector signal shows the rapid cooling of the betatron oscillations caused by an injection steering error. The beam is stable.
Figure 3: The damping of an induced betatron oscillation. In the upper trace the damper has been operated at a normal gain setting. The oscillation decreased to $1/e$ in about 30 revolutions. In the lower table the damper gain has been reduced by a factor of 10. Most of the decay of the coherent oscillation in this case is caused by tune spread. Note the difference in sweep speeds in the two traces.