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Longitudinal Impedance Measurements II

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Subject Longitudinal Impedance Measurements II

OBSERVATIONS AND CONCLUSION

Introduction:

As in the previous run the goal was to drive some of the potentially unstable coupled bunch resonant modes in the neighborhood of h = 12. Exciting both dipole and quadrupole oscillations and measuring accurately their frequencies along with a determination of the unperturbed bunch length will then permit a calculation of the imaginary part of the coupling impedance at a given energy.

Procedure:

The intensity was reduced to $\approx 2.5 \times 10^{12}$ and transition adjusted for no phase space dilution. Then a 1 sec. flat top was added to the magnet cycle and fast extraction set up at the end of this time. Next the frequency synchronization loop was closed on the flat top and it functioned perfectly. That is the beam frequency was synchronized to a stable external oscillator at 4,454,861 C.P.S. in a phase lock loop. Then a small amount of rf excitation was added to the 9 accelerating stations at the 13th and 14th harmonics ± the phase oscillation frequency and twice the phase oscillation frequency ($\approx$ 180, 360 C.P.S.). The E-20 WBPU was fed to the HP spectrum analyser which was tunned to $\approx$ the exciting frequency with bandwidths 30-300 cycles (no sweep). One then looked for a growing amplitude of one of these lines during the .2-.3 second period of the rf excitation. Fine tunning of the excitation frequency in step of 1 or 2 cycles/sec. permitted accurate determination of the resonant frequency of a given mode.

Observations:

Considerable time was lost adjusting the radial control loop to carry the beam through the flat top and to set up the fast extracted beam, so data was taken only during the last 90 minutes of the run.

Excitation of the dipole mode at the upper and lower sideband of the 13th harmonic yielded a clean reproducible linear growth of the resonances. The upper sideband or n = 1 coupled bunch mode exhibited a slow exponential additional growth after the excitation was removed while the lower sideband or n = 11 mode decayed in the expected manner when the excitation was removed.

Similar growth was observed when the quadrupole mode was driven at h = 13 but both signal decayed after the excitation was removed. This is not understood since it was expected that the quadrupole mode for the upper sideband would also be unstable. Finally the dipole mode sidebands at h = 14 were driven but this time the rate of growth during excitation was not linear. A fast initial rise was followed by a rapid decrease in slope which continued to decay with time. After removal of the excitation the upper sideband actually exhibited a slight decay while the lower sideband showed a slight growth. This again is a result that needs further investigation.

Results:

In any event a very accurate measurement of the coherent dipole frequency was obtained; 178.5 ± .5 C.P.S., from both h = 13 and 14 excitation. The quadrupole frequency from the h = 13 excitation was 351.6 ± .7 so that Δf the incoherent dipole frequency shift is $2\left|f_q - 2f_d\right|$ or 10.8 C.P.S. This along with the $\approx$ bunch length of 19 nsec and a V_{rf} = 262 Kv as determined from the beam energy and f_d results in a $Z/n \approx 36\ \Omega$ inductive at 27.4 GeV.