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Longitudinal Impedance Measurement IV

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OBSERVATIONS AND CONCLUSION

Purpose:

To measure the longitudinal coupling impedance at ≈ 7 GeV by exciting coupled bunch oscillations around h = 13. Specifically the coupled bunch modes n = 1, 11 and within the bunch modes m = 1 (dipole) and m = 2 (quadrupole).

Procedure:

A flat top was set-up at E = 6.637 GeV using time comb "F". The frequency synchronization loop was closed at f = 4,412,406 cps. At the same time the radial control loop on the flat top voltage was closed with a gain of five (see Studies Report 110). This provided a very stable reproducible momentum at 2.8×10^{12}.

Next the n = 1 coupled bunch dipole and quadrupole modes were identified by adding to the rf drive at the acceleration stations $13f_o + f_a$ or $13\ f_o + f_q$ where f_d is the dipole or phase oscillation frequency and $f_q \approx 2f_d$. Then the n = 11 or lower sidebands were excited i.e., at $13\ f_o - f_d, f_q$. These measurements were then repeated very carefully starting at ≈ 200 msec into the flat top with low excitation levels of 200 msec duration. Photos were taken of the growth and decay pattern of each line.

Finally, an attempt was made to excite the n = 2 m = 1 mode at $(14f_o + f_d)$ with no success.

Observations:

The difference between the upper and lower dipole frequencies was 483 ~ and between the upper and lower quadrupole frequencies was 969 ~. Thus $f_d = 483/2$, $f_q = 969/2$ and $2(f_q - 2f_d) = +3$~. However since the error on the individual measurements was about ± 1~ the final result is 3 ± 3~. The sign of the incoherent frequency shift is positive the same as at 27.4 GeV (Studies Report 109), but since we are below transition energy this means that the impedance is of opposite sign i.e. capacitive (or negative inductive). If we put in the observed bunch length of 26.5 nanosec and the external rf voltage determined from the energy and f_d we obtain a z/n = 15.7 Ω. This is larger than expected particularly since the sign of the impedance is negative reactive. Thus our error is large in determining the magnitude of the z/n near an expected null in this impedance. Another contributing factor was the abnormally large bunch length and hence area during this run. Since the calculated z/n is $\sim$ to $\Delta f_s \ell^3$, small errors in Δf_s are magnified when the bunches are large. The area here was ≈ .9 eV sec while that for the 27.4 GeV run was ≈ .69 eV sec.

It was noted that the lower dipole (n = 11) mode which is potentially unstable was still Landau damped at the 2.8×10^{12} intensity. One could clearly observe, however, that the threshold for growth was close.

Conclusion:

The sign of the impedance at the energy used (6.63 BeV) is most likely that of a capacity but its magnitude is clearly uncertain. One will have to make measurements at other energies further away from transition and with smaller bunches to obtain more accurate values.