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Longitudinal Impedance Measurements VII

E. Raka

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Collider Accelerator Department

Brookhaven National Laboratory

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Subject Longitudinal Impedance Measurements

OBSERVATIONS AND CONCLUSION

Purpose:

To repeat once again the measurement at 5 GeV in order to compare with the previous two results at this energy. Also to study the operation of the frequency synchronization loop and finally to investigate more closely the spectrum of the dipole mode in order to determine if it is a Legendre or Sinusoidal oscillation.

Procedure:

A flat top on time comb F was set-up for a Gauss clock reading of 9890-9900. With a synchronization frequency of 4,381,000 cps this corresponds to an energy of 5.09 GeV. The radial loop between the I-7 radial position and the flat top voltage was also closed shortly after the frequency loop. Excitation of the dipole and quadrupole modes at h = 13 ,14 was employed as usual. Observation of the quadrupole mode was made around 25 f_o and 26 f_o while observation of the dipole mode was made around 25 f_o, 26 f_o, 85 f_o and 110 f_o.

The synchronization loop gain was varied from .3 to 1 times the maximum available while the operation of the loop and the output of a frequency discriminator whose sensitivity is 160 ∿/volt was observed. The input of the latter is the synchronization frequency plus 455013 ∿ its center frequency. These tests were made without rf excitation of course.

Results:

At 5.09 GeV and $\approx$ 4.25 x 10^{12} protons/pulse the observed frequency difference $f_q-2f_d \approx -11$ cycles for a $V_{ext} \approx$ 232 kV at h = 13. Here f_d = 490 ∿ and f_q = 969 ∿; this yields a Z/n $\approx$ 50.5 Ω with a V_{eff} = 213 kV. For h = 14 excitation and V_{ext} = 269 kV the observed difference was f_q-2f_d = 1044–1056 = - 12 ∿ with f_d = 528 ∿ f_q = 1044 ∿. This gives a Z/n $\approx$ 53.7 Ω and a $V_{eff} \approx$ 247 kV. The bunch length for the lower voltage was 30 nsec and for the higher V_{ext} 31 nsec. One obtains a phase space area of $\approx$ .56 eV sec for both cases.

These results are in very good agreement with those obtained in early October. An attempt was made to measure the frequency shift as a function of intensity but at > 6 x 10^{12} the machine reproducibility was not stable enough for an accurate determination of this effect.

The amplitude of the dipole mode at h = 13 for a fixed low excitation level was measured at 25 $f_o + f_d$ using the linear gain or the spectrum analyzer. With the same excitation level the maximum amplitude was also measured at 85 $f_o + f_d$ and found to be about six times larger. At h = 14 the test was repeated with fixed excitation and observation at 26 $f_o + f_d$ and 110 $f_o + f_d$. The amplitude was found to be essentially the same for these two points. Now the square of these amplitudes should be related to the form factor for the mode present at the particular values of $f\tau_e$ used. Since τ_e = 31 nsec for the h = 13 points and 30 nsec for the h = 14 points, the observations were made at $f\tau_e$ = .283 and .961 and .284 and 1.21 respectively. The results do not correspond to either the Legendre or sinusoidal form factors and must be repeated more accurately.

Finally the effect of increasing the gain of the frequency synchronization loop indicated that it was somewhat unstable at maximum gain (a limit of $\approx$ .75 max. was calculated for the $f_d \approx$ 500 ∿ present at 5 GeV). At .9 max the frequency ripple is $\approx$ 8 cycles pp at $\approx$ 360 ripple with however some 60 ∿ structure that almost doubles this. Similar ripple could be seen on the radial position signal, i.e., mostly 360 ∿ plus a 60 ∿ beat structure. However at this gain the bunches can be strongly perturbed by the closing of the loop when the momentum is not exactly the value corresponding to f_{synch} i.e. the jitter in the reproducibility of the Siemens power supply. Hence, the gain was reduced to .5 for the impedance measurements.

The synchronization loop has been modified slightly so that it will lock on with greater input frequency (momentum) variations. This is a mixed blessing since the wider acceptance window results in larger phase transients when the loop is closed and these can perturb the bunches enough to render the controlled excitation of coupled bunch modes meaningless. The result is a less efficient use of the available study time.

Discussion:

As mentioned above, the previous values for Z/n at 5 GeV were reproduced quite well but unfortunately there was not time to go to another energy. This must still be done since the values obtained are, as pointed out in Studies Report 116, not consistent with the assumptions made about the nature of the low frequency Z/n in the AGS.