



Brookhaven
National Laboratory

BNL-103992-2014-TECH

AGS.SN114;BNL-103992-2014-IR

Longitudinal Impedance Measurement IV

E. Raka

July 1978

Collider Accelerator Department
Brookhaven National Laboratory

U.S. Department of Energy

USDOE Office of Science (SC)

Notice: This technical note has been authored by employees of Brookhaven Science Associates, LLC under Contract No.EY-76-C-02-0016 with the U.S. Department of Energy. The publisher by accepting the technical note for publication acknowledges that the United States Government retains a non-exclusive, paid-up, irrevocable, world-wide license to publish or reproduce the published form of this technical note, or allow others to do so, for United States Government purposes.

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or any third party's use or the results of such use of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof or its contractors or subcontractors. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

Date 7/16/78 Time 0000-0500 Experimenters E. Raka, E. Gill
 Subject Longitudinal Impedance Measurement IV

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 $13f_o + f_q$ 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 $13f_o - f_d, f_q$. 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 $483 \sim$ and between the upper and lower quadrupole frequencies was $969 \sim$. Thus $f_d = 483/2$, $f_q = 969/2$ and $2(f_q - 2f_d) = +3 \sim$. However since the error on the individual measurements was about $\pm 1 \sim$ the final result is $3 \pm 3 \sim$. 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 $z/n = 15.7 \Omega$. 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 $\approx .9$ eV sec while that for the 27.4 GeV run was $\approx .69$ 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.