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RF Capture at Zero B

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Experimenters E. Gill and E. Raka

Reported by E. Raka

Subject Rf Capture at Zero $\dot{B}$

OBSERVATIONS AND CONCLUSION

Purpose

To investigate rf capture at zero $\dot{B}$ where for the same bucket area the space charge effects should be about 25% less than normal (for the same intensity and a uniform distribution). Also, to measure the tune spread of a coasting beam as a function of intensity in order to estimate space charge effects.

Procedure

In order to obtain zero $\dot{B}$, it was necessary to connect the magnet to an external d.c. supply. After checking polarity and a little tuning, a circulating beam was achieved with 105.56 amps (1689 out of 4000 = 250 amp). All ten rf stations were "shorted" during the first part of the studies. Then six were unshorted for capture tests.

While the changeover to d.c. excitation of the magnet took place, some modifications were made in the AGC loop for the rf system. Photo 1 shows the rf sum (lower trace) and the AGC control voltage with all ten stations on synthetic sweep, i.e. no beam. The time scale is 0.5 msec/div; rf $\sum$ 0.5V/div; AGC/volt/div). The AGG program, not shown, was level 1 @ 120, level 2 at 1250 and the slope fast compared to 100 µsec. Then a factor of two increase in the d.c. gain of this loop was restored in the control chassis (the reduction having been instituted in 1980). The result is shown in Photo 2 where now level 2 is at 1050. It was further discovered that a factor of two reduction was present in the input circuits at the rf building. This was removed and the result is shown in Photo 3 (level 2 still 1050). The purpose of this exercise was to restore the loop response to its original state so that subsequent rf capture studies where control of the rf amplitude is critical could be made and compared to past results.

Observations and Conclusions

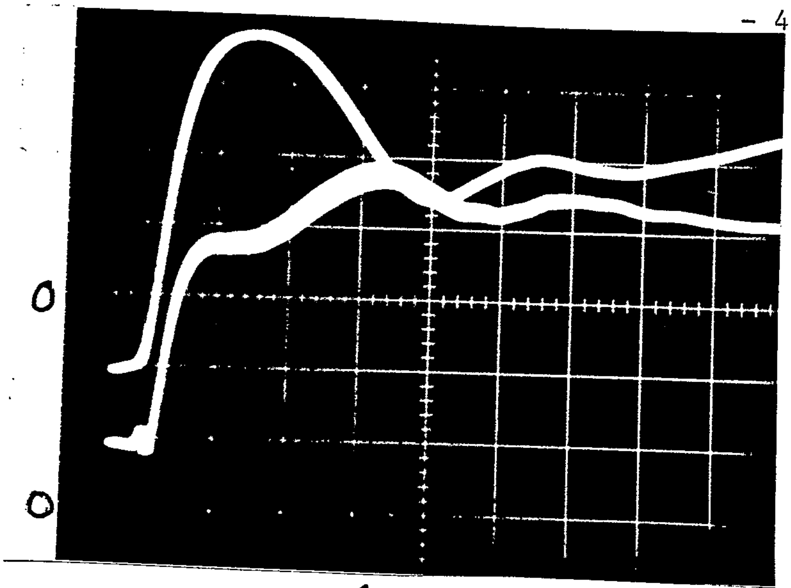
Once a circulating beam was obtained it was immediately discovered that even at 2-3 x 10^{12} protons injected, coherent transverse instabilities were present. Above about 3 x 10^{12} they could produce beam losses and hence erratic survival. The narrow band feedback damping systems were functioning but were unable to control the blowup.

To some extent this behavior was anticipated and a low current supply was connected to the vertical sextupoles. From past experience (4/25/71), it was expected that the vertical chromaticity would be reduced to near zero for $\dot{B} = 0$ at 200 MeV. It was found that 5-6 amperes enabled one to inject 6-7 x 10^{12} without blowup, but above this range the horizontal instability was quite strong. One could observe the blowup on the IPM quite easily. A further increase of current in the vertical sextupoles to $\approx$ 14 amps enabled one to inject around 10^{13} but again, the horizontal blowup became uncontrollable. Also at this high current, the injected current began to fall off some. During this time some tuning of the correction multipoles took place, but it finally became clear that a stable high intensity beam circulating for many milliseconds could not be achieved. Hence, the goal of measuring incoherent tune shifts of a d.c. beam at various intensities was not achieved.

At one point six of the rf cavities were unshorted as a check on the procedure. It was observed immediately that the instabilities became controllable! The reason for this behavior was quickly traced to the fact that the beam was self-bunching on the rf cavity impedance. This increases the momentum spread in the beam and hence the tune spread, thus stabilizing the transverse coherence. The strong self-bunching is due to the much smaller momentum spread now available from the linac, i.e. ≈ 0.22% (see AGS Studies Reports 144 and 147). This small momentum spread is most likely the reason for the transverse instabilities being much more difficult to control than had been anticipated.

Finally, the six rf stations were used to capture the beam and some additional tuning of the multipoles was carried out. However, the capture process was not optimized as to the best value of level 2 or the slope of the voltage program. No further studies were carried out as the scheduled time had already been exceeded by two hours.

The principal result of this study, in retrospect, was the realization of how the reduced linac momentum spread in the H^- mode can impact on the AGS operation.



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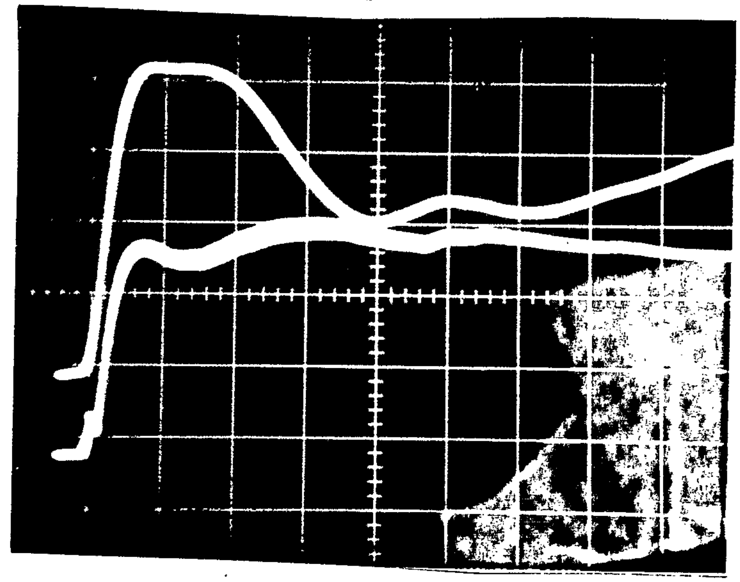

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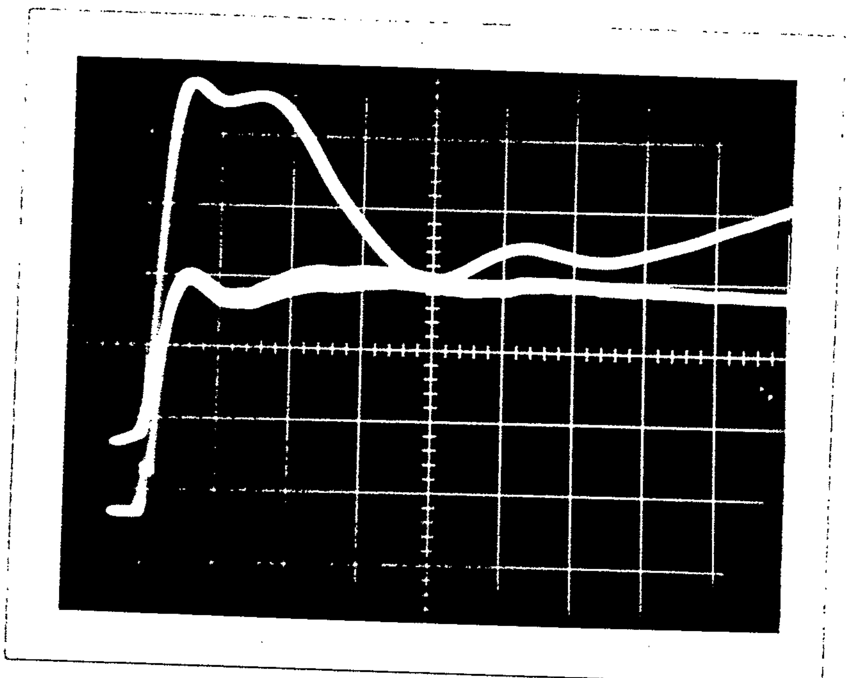

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