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RF Capture of Prebunched Linac Beam at Zero B

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Reported by E. Raka

Subject RF CAPTURE OF PREBUNCHED LINAC BEAM AT ZERO $\dot{B}$

OBSERVATIONS AND CONCLUSION

Purpose

To study rf caputre of an intensity modulated beam (at the injection rf frequency of ≈ 2.5 MHz) from the linac at zero $\dot{B}$ so that energy modulation of the linac is not required.

Procedure

The AGS was already set up for d.c. magnet excitation (see AGS Studies Report No. 154). The linac setup is covered in AGS Studies Report No. 156 (forthcoming). Then the phase and frequency of the rf signal sent to the linac and to the accelerating stations (still only six out of ten unshorted) was optimized for injecting successive turns into the center of the rf bucket. Most measurements were made with a large bucket area compared to the linac longitudinal emittance. However, some observations were made at low (≈ 58 kV) rf voltage.

Observations and Conclusion

Photo 1 shows the F-20 current XFMR at 0.2 V/div and 200 μsec/div with "pre-bunched" injection for ≈ 250 μsec. Total protonsn from the linac was 1.3×10^{13}; 1 CBM $9^{+} \times 10^{13}$; 3 CBM $4\text{-}5 \times 10^{12}$. The rf sum signal was 2.2 volts. We see the presence of bunch shape oscillations at twice the synchrotron frequency due to a mismatch between the linac energy and the rf frequency. The latter was 2.508 MHz for Photo 1, while for Photo 2 it was changed to 2.510 MHz giving almost a perfect match. If we assume the injected beam occupies only a small part of the bucket, then we can use the bunch shape frequency seen in Photo 1 to calculate the effective rf voltage. The frequency is ≈ 10.6 KHz whch gives a V_{rf} = 183 kV or about 83 kV/volt of rf sum signal. From this one obtains a bucket area of 1.16 eV sec and a bucket full width of about 4.6 MeV. This is to be compared with 0.8 MeV width for the 90% linac energy spread.

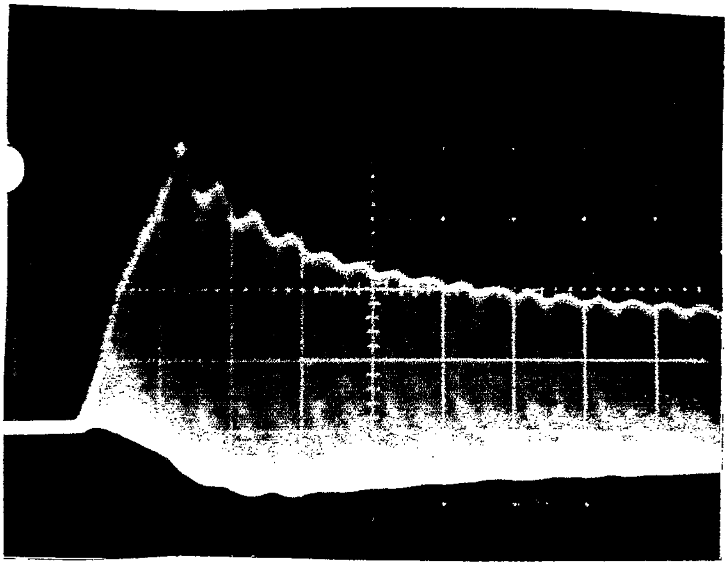
Photo 3 shows the wideband pick-up electrode signal at ≈ 5 μsec intevals or every revolution at 100 mV/div vertical gain. The linac amplitude modulation is activated and one sees successive turns at injection time. Photo 4 is the same except that the AGS rf is on at the level of Photos 1 and 2 as well as the linac "pre-bunching". Photo 5 starts 100 μsec later than 3 and 4 and is ≈ 25 μsec or five turns per sweep. The vertical scale is now 500 mV/div, but the rf conditions are the same as Photo 4. Finally, in Photo 6 we have the same trigger and gain as Photo 5 but there is no prebunching just AGS rf voltage on and still ≈ 1.3×10^{13} total protons from the linac.

Now Photos 3-5 indicate that the beam from the linac in the "pre-bunched" mode is more than 100% amplitude modulated. That is, there appears to be very little or no beam for about half the ≈ 400 nsec spacing between the bunches. This is also borne out by the smooth bunching pattern seen in Photos 1 and 2. Thus, we indeed seem to be injecting a small linac longitudinal area into a large AGS bucket. For a 180° wide "bunch" with 0.8 MeV energy spread the area is 0.16 eV sec! Although there is a large mismatch into the bucket which results in some dilution, i.e. the widening of the bunch as seen on the last traces in Photo 5, this takes place smoothly since one is in the linear region. This is why Photo 2 shows essentially no evidence of filamentation.

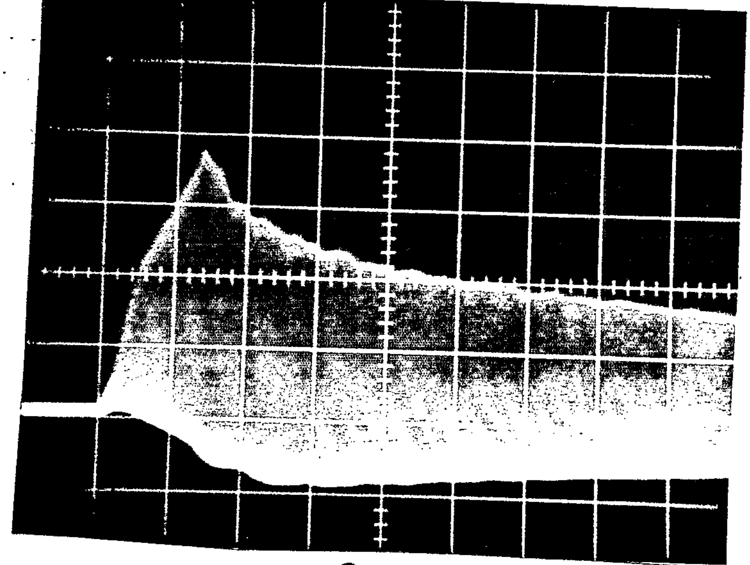
Now as the rf level was dropped, the smooth bunches seen in Photos 1-5 develop more structure. As the bucket becomes smaller, more non-linar motion takes place since a larger fraction is populated. The level was reduced to about 0.7 volts on the rf sum signal or ≈ 58 kV where the bucket area is ≈ 0.66 eV sec and the bucket height is 2.6 MeV. The 1 CBM went up to 10.4×10^{12} and the 3 CBM to $> 7 \times 10^{12}$ while the peak amplitude of the bunches decreased 25-30%. This increase in intensity was most likely due to the smaller amplitude synchrotron oscillations for a given initial phase error in the low volage bucket. Also, of course, the space charge tune shift is less since the phase dilution is greater.

The voltage was not reduced further nor were any photos taken due to lack of time. It seemed likely that some additional reduction was possible with either more beam captured or at least the same amount retained. However, if one attempts to lower the voltage to obtain a much better match to the low linac energy spread, the beam induced cavity voltage could become a problem. Also, to obtain a better match to the AGS buckets, one should be able to control the amplitude modulation over a wide range. Finally, if this scheme were to be tried with $\dot{B} \neq 0$, it would be necessary to modulate the linac energy as well as the rf frequency.

At present this method of rf capture does not promise any significant advantage over the standard scheme of adiabatic capture or the idea of stacking in momentum space by modulation of the lianc energy proposed several years ago.



1



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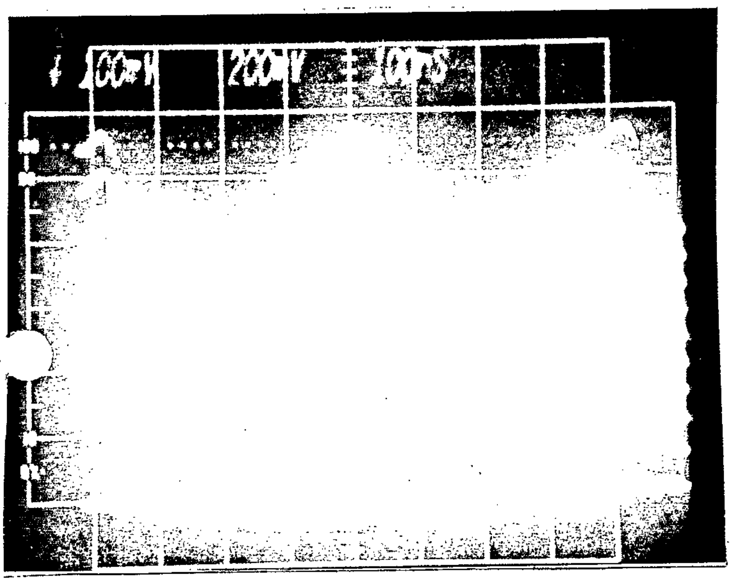

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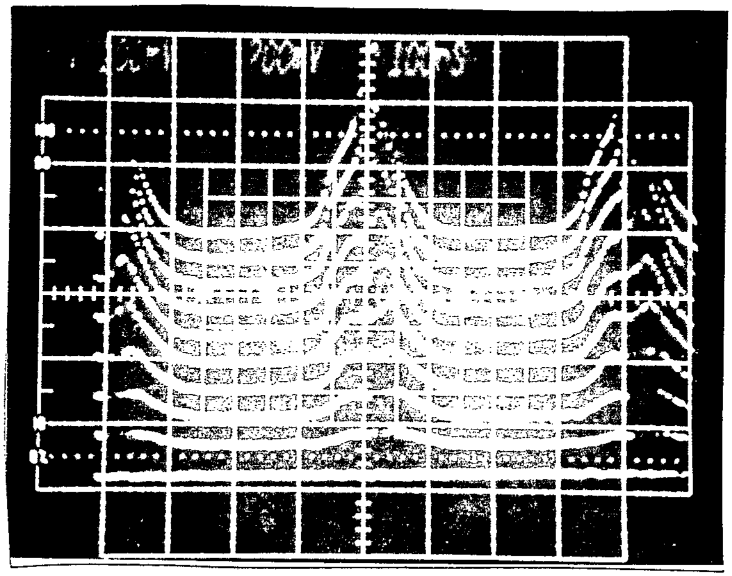

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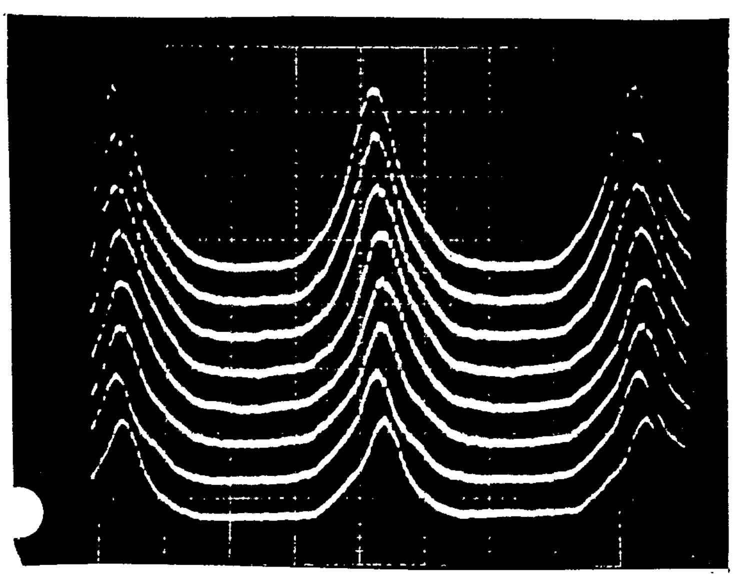

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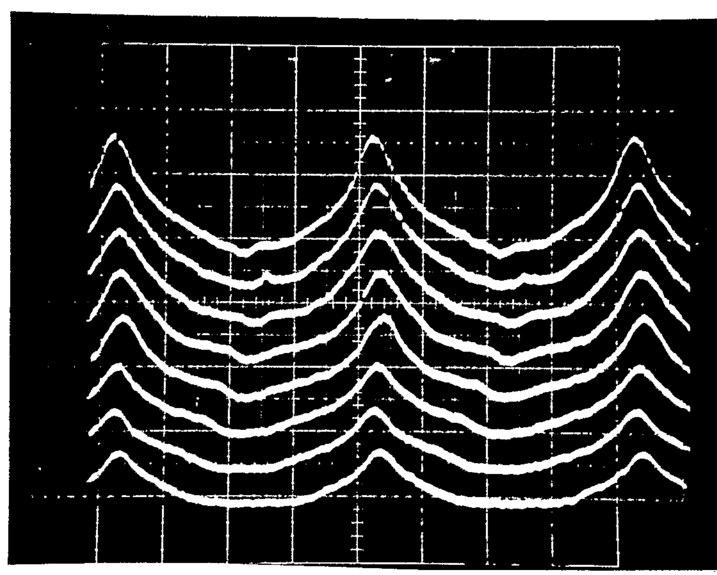

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