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Tuning the AGS for Minimum Phase Space Dilution at Transition: Preliminary Study of Transverse Instabilities After Transition

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Observations and Conclusion

The beam intensity was lowered by reducing the Linac pulse width to 53 μs and tuning capture to obtain 2.8-3 x 10^{12} accelerated to full energy. The integrator "on" time was increased to 2540 (254 msec from injection peaker) command so that it came on at ≈ 305 msec from t_o, i.e. after transition. Next, 12' were added to the delay cable in the low level rf system to make the radial error signal almost zero at transition. Then the transition phase and timing were adjusted to give essentially no longitudinal dilution in passing the transition energy.

This is accomplished by putting in less than the nominal $2(\pi/2 - \phi_s)$ phase jump required for no radial excursion. Hence, the beam moves rapidly outside while the radial loop acts to limit the amount of radial motion by providing the additional phase shift needed (the sign of the loop correction being reversed at transition). In this manner, transition is crossed sooner since the acceleration rate is increased while the γ_{tr} is lowered because the latter decreases with increased radius.

A transition phase command of 1300 and transition time of 1567 (GC/10) resulted in a 4 mm outward jump as seen at L-7 a horizontal β_{min}. There was no beam lost and no blowup of the bunches at transition. Photographs of the bunches at injection peaker +470 msec ≈ 22.8 GeV/c on the wall current monitor gave widths of 25 nsec at the base. The sum of the gap voltage was ≈ 2 volts or ≈ 260 kV from which one calculates a bunch area of 1.02 eV sec. This is within 10% of the area calculated at injection for the same voltage and hence is consistent with no significant dilution at transition. Figure 1 shows the bunches where the time scale is 5 nsec per small box.

Next, the Linac pulse width was increased to obtain 5.2-5.4 x 10^{12} accelerated to transition. With a radius shift at -195 before transition there was some loss at transition for the previous phase and time settings. After considerable manipulation, the best results were obtained with no phase jump (except ≈ 15° from the radial error signal) and 1555 GC/10 on the transition time with a radius shift of -250 before transition. This gave < 5 x 10^{11} transition loss and essentially no blowup. The radial excursion at L-7 was then ≈ 1.35 cm. Figure 2 shows the L-20 current transformer on an expanded vertical scale, the output of a phase detector showing the difference between the beam and the vector sum of the rf cavity voltage and finally the radial error signal.

Figure 3 shows the bunches again at the same time in the cycle as Figure 1. The width at the base is essentially the same but there is obviously some oscillation going on within the bunch. Since the bunch shape damper was turned on just after transition for this case, in order to control any n=0 quadrupole oscillations, the motion must be due to other modes. This point was not pursued. Since the base widths are still ≈ 25 nsec long, the bunch area is still ≈ 1 eV sec as before.

Next it was decided to investigate if the bunches at 5.2 x 10^{12} were succeptible to transverse instabilities after transition. During most of the above running, the beam was being extracted normally in the FEB mode. With a radius shift at 307 msec of -100 and a further shift to -137 (525 ms) prior to extraction, no transverse growth had been experienced at these low intensities. However, when the shift at 307 was increased to -125, H-5 trips began to occur and at -150 they were always present. Next, the shift was reduced to zero at 307 and more trips occurred. In the latter case no beam was extracted and sometimes a loss would occur prior to extraction. For the inside case, some beam would be extracted but the bunches were badly torn. Using the IPM to measure sizes at 320 and 520 msec from t_o we determined that the loss associated with the radius at -125 to -150 was also associated with transverse growth in the vertical plane while the loss at zero (we did not go further outside at 307) was associated with growth in the horizontal plane! These results are consistent with observations made many years ago, i.e. see AGS Studies Report No. 57 (3/15/74). They also should make it possible to investigate the transverse instabilities in a more controlled manner.

It is planned to try and further speed up the passage through transition by jumping the phase in two steps rather than using a single step plus the radial loop response. One jumps by $(\pi/2 - \phi_s)$, then clamps the radial loop. After the required outward excursion is made, another jump of $(\pi/2 - \phi_s)$ is made along with a radius shift that nulls the unclamped output of the radial loop.

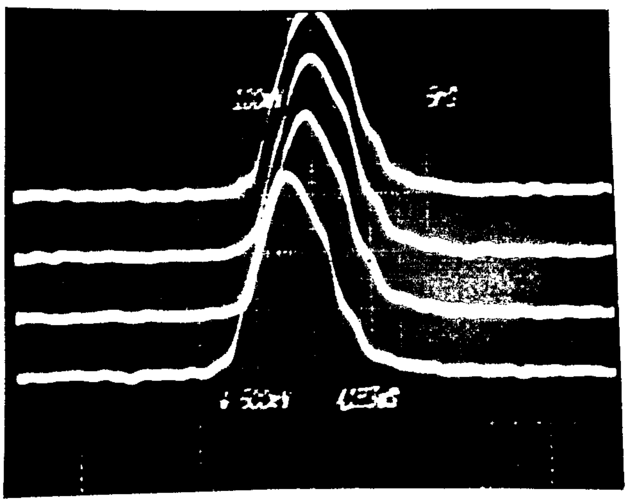

Fig. 1 Wall Current Monitor
10 nsec/div 3×10^{12}

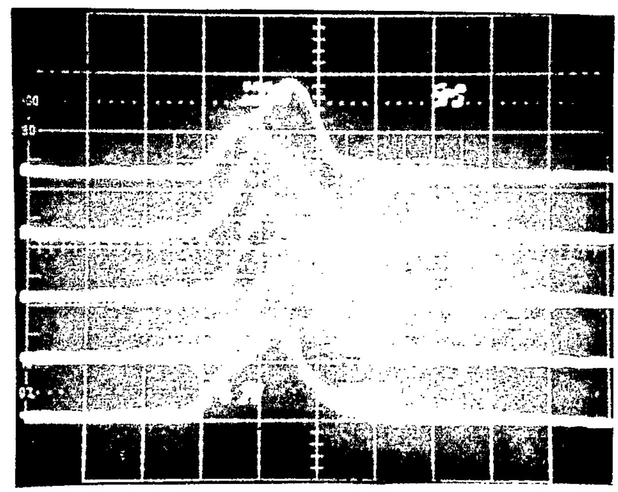

Fig. 3 Wall Current Monitor
10 nsec/div 5.2×10^{12}

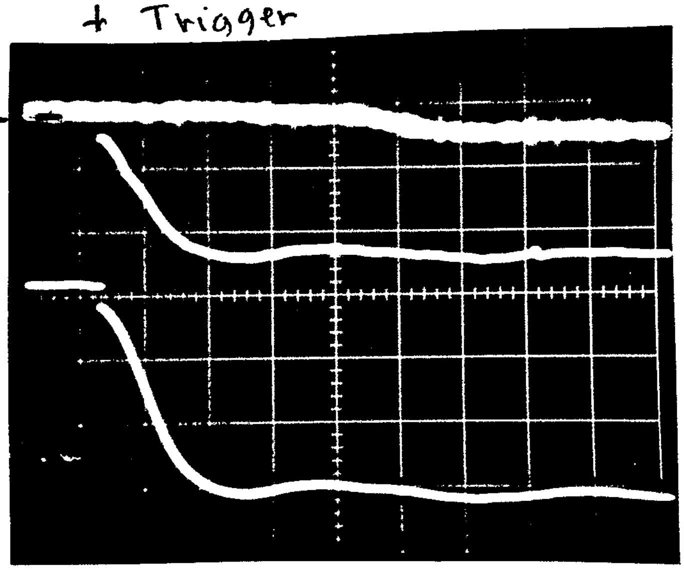

Fig. 2 1 msec/div 5.2×10^{12}

mvh