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Effect of Cavity Tuning program on Capture Efficiency

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Purpose:

To investigate the effect on capture efficiency of different modes of operating the cavity tuning program. Also to study the capture process itself.

Results:

During the past three months the main cavity tuning supply has been cycled between its output at 2.5 MHz and 4.725 MHz (on the flat top to prevent rebunching) rather than returning to zero current from its value at the start of flat top (4.45 MHz). The latter condition was present when intensities $> 6 \times 10^{12}$ were obtained. Now, however, if this mode of operation is used the capture efficiency is reduced by 15-20% even after optimizing the various rf parameters.

A slight readjustment of the slope of the tuning program from its present value is required to obtain satisfactory acceleration when the "off frequency" (4.725 MHz) is removed. The initial vernier current is reduced by $\approx$ 130 amps relative to the case when the main current is not returned to zero.

The difference in acceleration efficiency occurs in the first 2 msec, but the reason for the poorer capture was not discovered. No appreciable differences can be seen in the individual station voltages during the capture process, however, the detailed action of the tuning servos during this time were not monitored. Another minor effect of this mode of operation was that the available voltage $\approx$ 100 msec after injection, where the $\dot{B}$ changes rapidly due to switching from the F to the P bank, was just enough smaller so that some beam was lost. (One could not obtain a higher voltage since apparently the amplitude clamp was acting here.)

In the off frequency mode of operation, the following experiment was made. The rf amplitude was held constant at level 2 ($\approx$ 3 kV gap) and the starting oscillator rise trigger and slope adjusted so that capture was obtained under programmed conditions (since switching to beam control was delayed until 1 msec from injection). A small amount of modulation was present on the rf sum signal and the maximum intensity was $2^{+} \times 10^{12}$. Then the normal rf amplitude program was tried, i.e., rising from level 1 $\leq$ 1/5 level 2 in 200-300 μsec. The beam started to bunch shortly after injection when the gap voltage was still low and large modulation appeared on the rf sum signal. Capture was very poor and did not improve if one switched to beam control just after injection.

One can draw the following conclusions from this; the minimum gap voltage is too high and the gap impedance seen by the beam is too high to ever approach the conditions required for satisfactory adiabatic capture.

The present mode of capture has been arrived at empirically and consists of running the cavities below the beam frequency (12 f_o) before injection and then increasing the starting oscillator frequency at much faster rate than the nominal $\dot{f}$ as the beam is injected. One switches over to beam control after bunching starts, which occurs during the rise of the gap voltage from level 1 to level 2. This rise takes place in a time corresponding to about one cycle of small amplitude phase oscillations at the voltage of level 2. One could obtain intensities of almost 5×10^{12} with this same beam that gave only $2^+ \times 10^{12}$ using a fixed voltage and a frequency program.