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Gold Injection into the Booster: Beam Survival as the Length of the Tandem Current Pulse is Varied

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Study Period: January 24, 1997; 14:10 - 14:20	
Participants: C. Gardner, et al.	
Reported by: L. Ahrens	
Machine: Booster	
Beam: Au^{32+}	
Tools: Booster injection current transformer, Tandem pulse width control	
Aim: To measure injection/early acceleration efficiencies as the Tandem pulse width is varied.	

Summary

To gain insight into the phenomena at work during injection/early acceleration in the Booster, a single parameter, the width of the current pulse from the Tandem, is varied while recording the resulting beam current in the Booster. Efficiencies for : "the stack" (the peak of the stack), fast loss (measured somewhat arbitrarily 0.8 ms from the start of the Tandem pulse) and slower loss (measured after an additional 3.5 ms) are determined. The results are presented as "marginal" efficiencies for a) the first 275 μs of beam, b) the next 100 μs of beam ending at 375 μs from the start, c) the next 100 μs slice ending at 475 μs, and d) the final 100 μs slice ending at 575 μs. For this set of data, the first slice has poor stacking efficiency and excellent long survival efficiency, the other three slices have good stacking efficiency and steadily deteriorating long term survival efficiency.

The "raw" data from this study (four scope "dumps" for four Tandem pulse widths) are shown in Figure 1. The Booster injection transformer output with the "beam off" response subtracted is the "highest" trace. Forget the next (fuzzy) trace - this is the current in one of the quadrupole strings. Then comes one of the injection bump magnet currents - which is relevant in that it gives a time reference frame of sorts. Finally comes the current from Tandem - showing the width and current level. (These traces are copied from Booster/AGS Start-up Book III for 1997 Iron/Gold pp. 33, 34). In the analysis, the calibration for the two current transformers is taken to be (10 μA per Volt) for the transformer in the line, and (3.45 x 10^8 ions per Volt) for the Booster injection current transformer. The pulse width variation is accomplished by moving only the late end of the tandem pulse, without any other retuning. The labeling for the time slices in this study note is shifted by 25 μs from the log book trace labeling; 600 μs in the log corresponds to 575 μs here.

Intensities at the three times during a given Booster cycle - stack peak, fast loss, and slow loss - are then "read off" from the traces for each of the four pulse widths. That data, translated into ions is displayed in Figure 2. In order to interpret data in a "marginal" way - to subtract the 275 μs numbers from the 375 μs numbers - to learn what the net effect of 100 μs more beam was - , it is necessary to "renormalize" each run to what it would have been had the Tandem current remained constant during the study. The assumption here is that at this 10% level, things are linear. Figure 3 then results. Now one can ask how the time dependence of the surviving Booster current changed with each additional slice. Figure 4 gives this. The change in the Tandem input is also included, although by the normalization maneuver just described, these are now equal for the three later slices. One sees that the gain at the peak with each additional slice is nearly constant, the fast loss improves and then degrades a bit, and the slower survival steadily degrades. Figure 5 is just another way of showing the same thing. Here the efficiency for each step (stack up, fast loss, slower loss) is shown for each of the time slices, including the initial wider (275 μs vs. 100 μs) slice. The most prominent features are the relatively poor efficiencies for the initial slice stacking, and for the final slice long survival.

Conclusions and Comments

The poor efficiency of the stacking for the early slice is not surprising. This part of the injection is very sensitive to subtle tuning, and would change from day to day. One thing that must have been true during the study situation is that a lot of Tandem beam was being lost in the Booster during these initial hundreds of μs. The stacking efficiencies for the other three slices is quite high - 85%-90%. The fast survival efficiency is slightly lower, and apparently degrades slightly in the last bin. One should take these number with a grain of salt - perhaps errors in the reported percentages of 5% - you see the raw data. The trend seen in the final bin - the longer term survival - is stronger, and reflects one well-known reality of our intensity problem. More beam in does not yield proportionally more beam out. Whether the increasing loss rate is due to the higher intensity in the Booster for later slices, or due to something flawed about the beam being injected in the latter part of the injection process is not answered here.

It would have been very interesting to simply inject say 100 μs of beam - the first 100 μs of beam from Tandem - at 100 μs steps across the Booster injection period. How would the stacking of that 100 μs of beam look? Would it always stack like the first 100 μs here - i.e., very poorly ? Would its long term survival a) always look about the same - suggesting that with no intensity there is no effect, or b) would its long term survival show similar behavior to what we see with the full beam - suggesting that the late beam corrupts the Booster. We should look.

1/24/97 2 μg foil, vary source width:

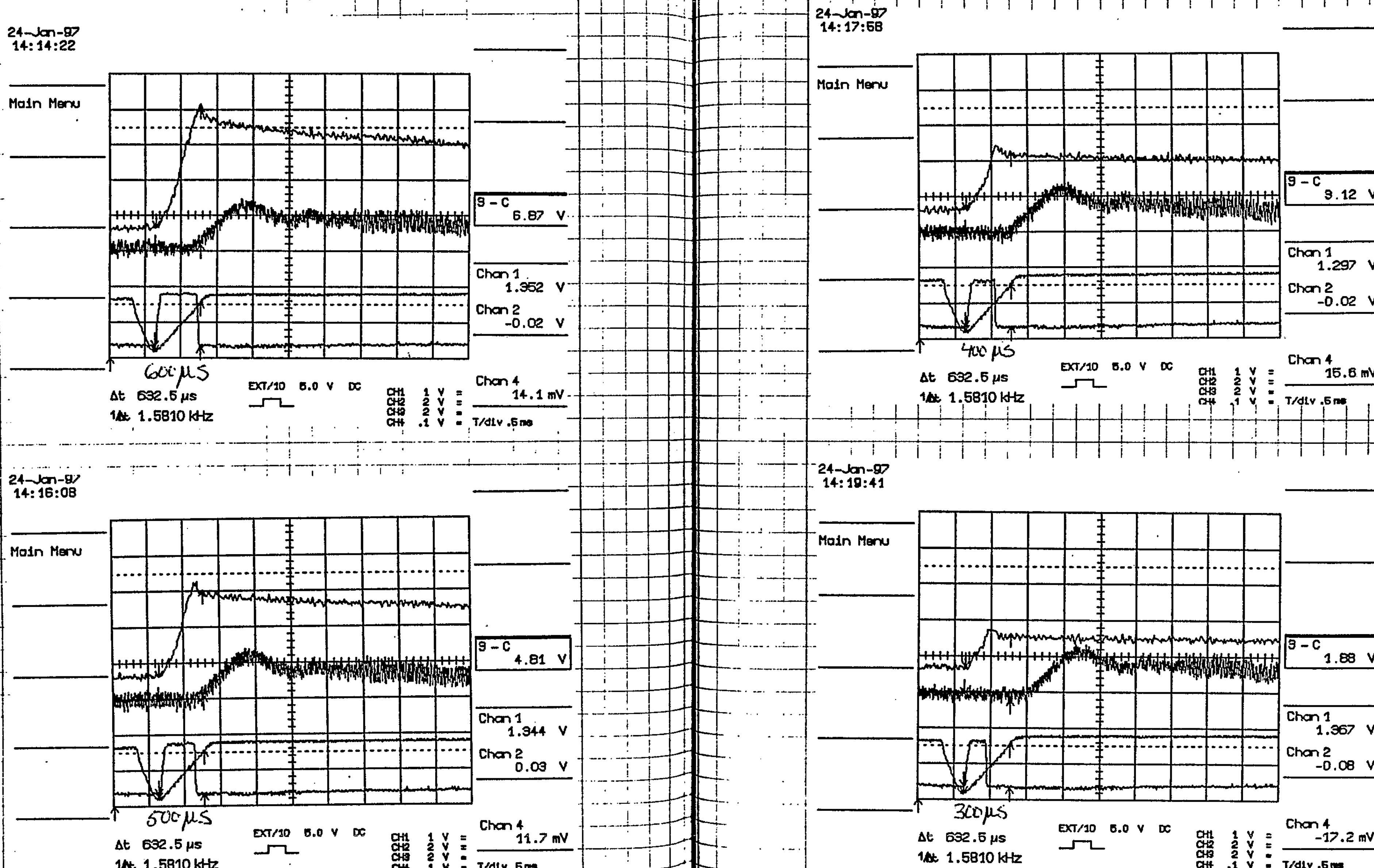

Figure 1

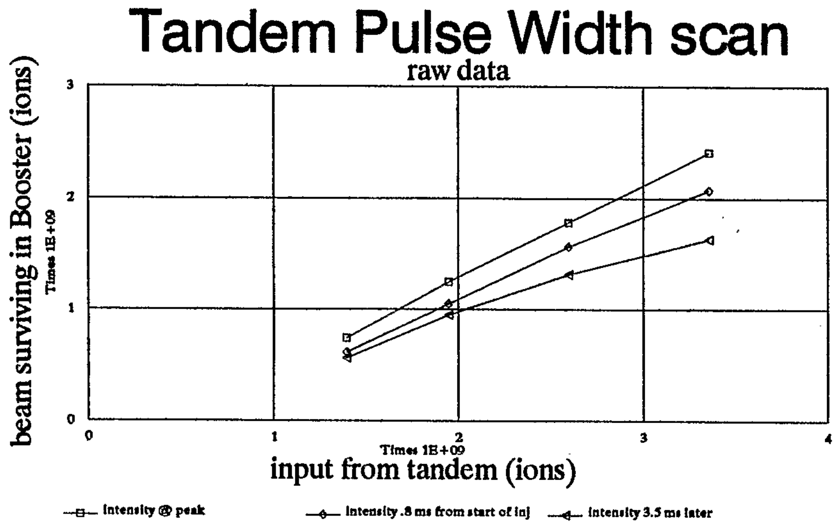

Figure 2

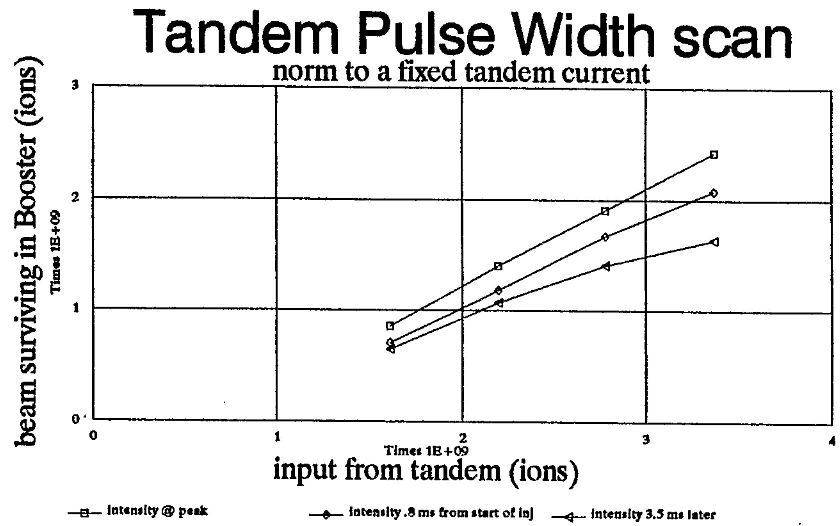

Figure 3

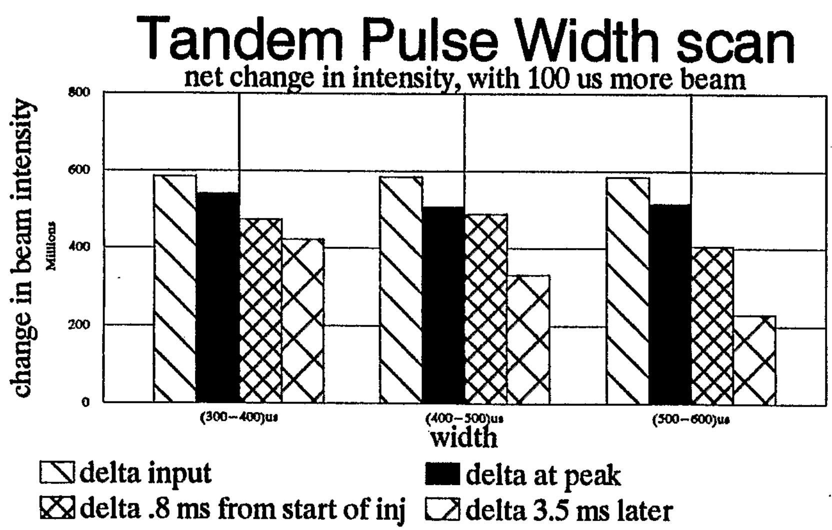

Figure 4

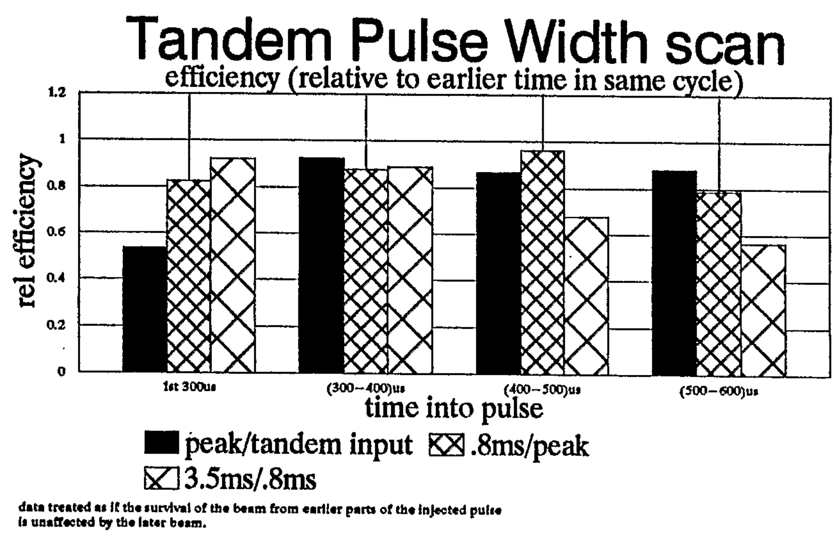

Figure 5