SUMMARY OF PROTON STACKING 2/96

Mike Church 5/28/96

This is a summary of the proton stacking studies which took place on 2/24/96 - 2/27/96 at the end of Collider Run 1b. The minute-by-minute details can be found in Pbar logbook 26 pages 21-41. Device settings can be found in the protected D1 S/R file 696.

Operational details:

Figure 1 shows the stack size as a function of time throughout the studies period. After polarity reversal, the only significant hardware problems were D:VT801 (replaced) and A:H205 (wrong polarity). Beam on target (M:TOR109) ranged from 2.5-2.8E12/pulse; typical yield into the Debuncher was D:FFTTOT/M:TOR109=12000-14000, which is about 6.2 times the normal antiproton yield. In order to keep the Debuncher stochastic cooling systems running near maximimum power it was required to gate them off for the first 80 msec of each pulse in order to keep them from tripping off. It was also found that stacking efficiency was slightly lower with DRF2 on (in either polarity), so it was left off. This is not understood.

Tuneup of all systems took place over the 1st ~24 hours of stacking, with stacks purposely being dropped after reaching stack sizes of 30-50 mA. The "standard" stacking tuneup was done on all systems. Also, significant tuning was done to all major stacktail and core momentum parameters (attenuators and trombones). The only major changes made from the settings used during the final part of Run 1b were the following:

A:CPT101 980 psec --> 1020 psec
A:SHT101 1040 psec --> 1120 psec
A:SPFT03 231 psec --> 240 psec.

Figure 2 shows the stack momentum profile. Because of the excessive backstreaming from the stacktail, A:FFTTOT was not a reliable measure of beam injected into the Accumulator. Therefore, measurements of D/A efficiency (A:FFTTOT/D:FFTTOT) and Stacktail efficiency (1.E6*A:STCKRT*T:SCLEN/A:FFTTOT/A:PULSES/3600.) must be interpreted

with some suspicion. Figures 3-9 show plots of various performance parameters as a function of stack size. In addition, 2 to 3 stacktail TWT's were left off for most of the studies period because they caused excessive transverse heating of the core. This limited A:SPPSUM to about 1000W. (The trip level on each TWT was set at 100W to protect the kicker tanks.) It was determined after the studies that some of the spigots on the tanks corresponding to TWT's 10,15,16 were bad. In addition, the core 4-8GHz vertical core cooling system was not doing any cooling (as determined by studies performed on 2/9/96) due to a hardware problem; and a hardware problem was discovered in the 4-8GHz horizontal core cooling system after the studies.

Results:

The maximum stacking rate attained was 12.2 mA/hr at a 1 mA stack with all $29's in the timeline and a 5 second repetition rate. A:SPPSUM was 1050W, with all TWT's on except #10 and #16. The maximum stacking rate attained at a 2.4 second repetition rate was 9.7 mA/hr. The stacking rate was found to be independent of stack size up to about 40 mA. This was determined by dropping the stack by setting a vertical trim in the Accumulator, and then immediately continuing stacking at 0 mA. The primary limitation at small stack sizes was the total stacktail power available to push beam off the stacking orbit towards the core. It was found that reducing the total stacktail power below the level allowed by the TWT trip limit always reduced the stacking rate at small stack sizes. At large stack sizes, it was found that the cycle time had to be gradually increased in order to maintain a high stacking rate. At 200 mA, the stacking rate was 7 mA/hr at a cycle time of 7.5 seconds. The ratio of maximum stack rate at 0 mA/maximum stack rate at 200 mA is approximately the same for proton and antiproton stacking.

A measurement was made (F. Bieniosek) of the yield into the Debuncher as a function of delay time on the lithium lens pulse (Figure 10). The difference between proton and antiproton data in the shape of the yield vs. delay curve is a possible indication that the angular phase space distribution of protons from the target is different than antiprotons from the target.

A measurement was made (J Morgan) of the transverse beam size in the D/A line as a function of Debuncher cooling time (Figure 11).

Trapped ion studies and transverse beam transfer function measurements

were made at a stack size of 217 mA (S Werkema). A strong coherent line was observed at 79 MHz at the 127-Q line which had not been observed before (Figure 12). The cause of this coherent line and its implications require further study.

Conclusions:

The goal of this study was to demonstrate that the current Accumulator stacktail system could stack over 10 mA/hr if provided with enough incoming particle flux. It did this despite known hardware problems. Prior to these studies, typical antiproton production efficiency had been in the range 12-14 (E-6 pbars/proton on target). During record-breaking stacking in the Spring of 1995, antiproton production efficiency had been over 16. This study provides a firm basis to extrapolating to a stack rate of over 20 mA/hr (at small stacks) for the planned MI upgrades -- that is, decreasing η by a factor of 2 and increasing the stacktail bandwidth by a factor of 2.

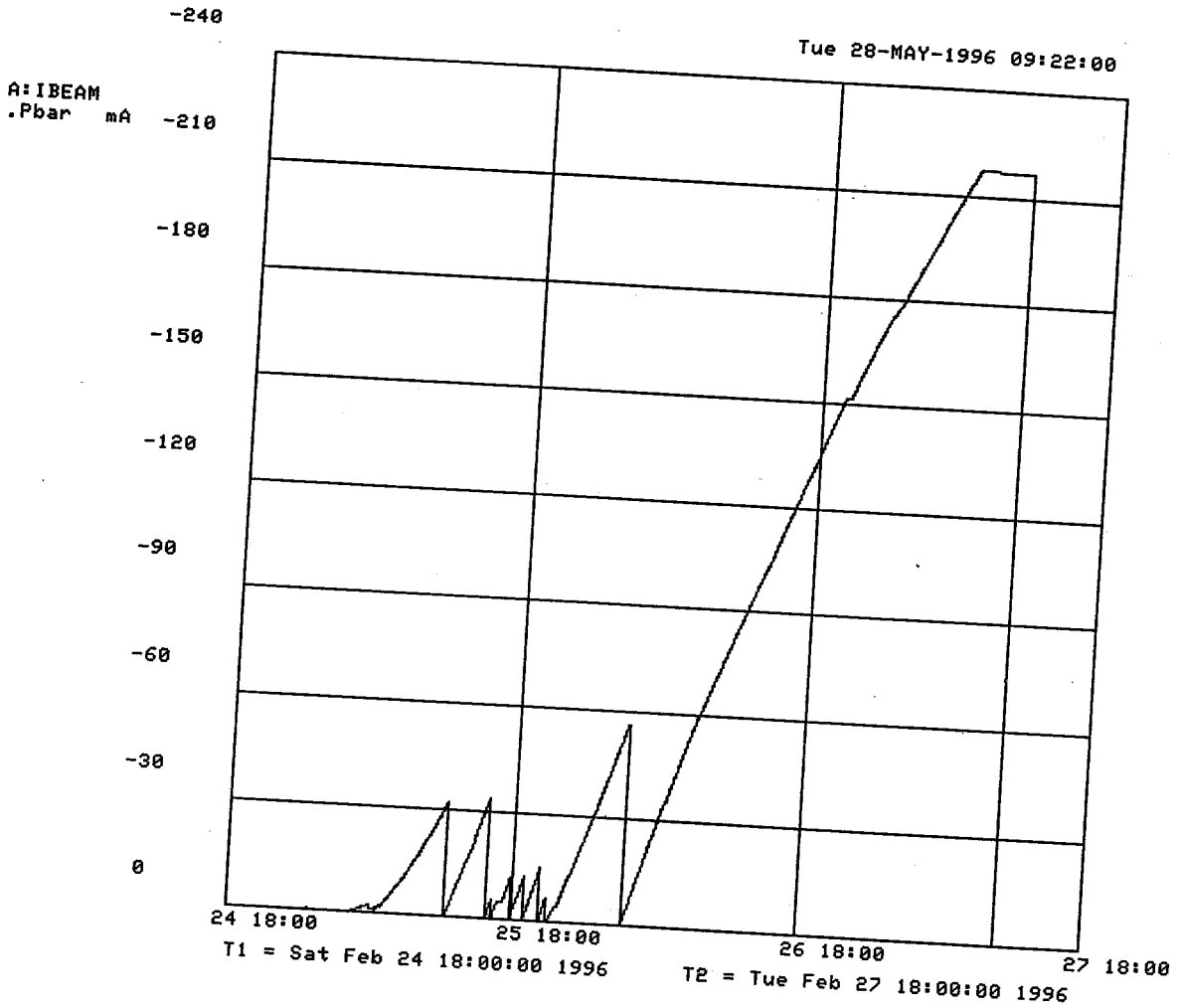


FIGURE 1: STACKRATE VS. TIME

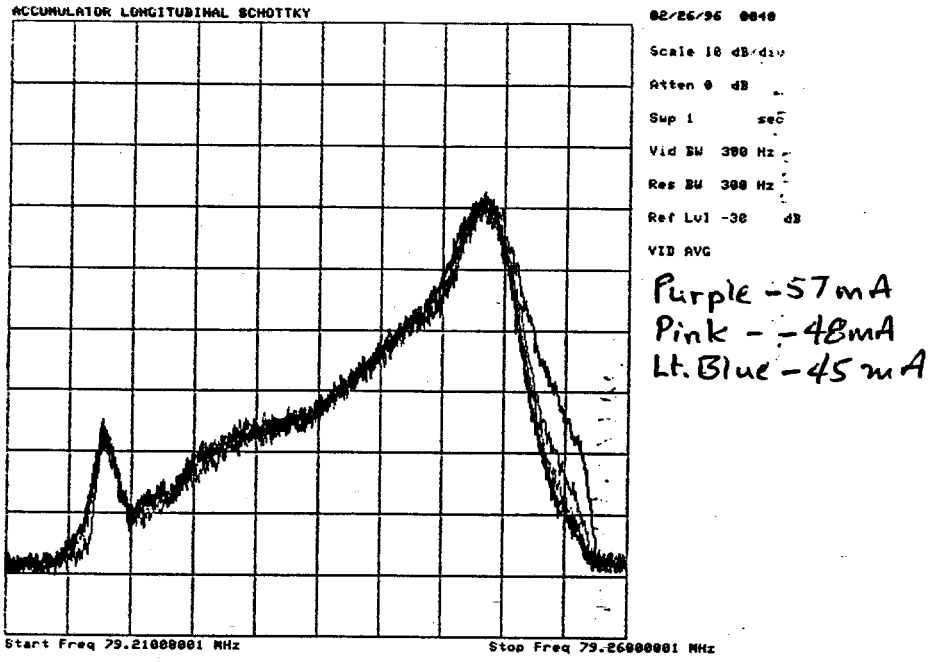


FIGURE 2: STACK PROFILE

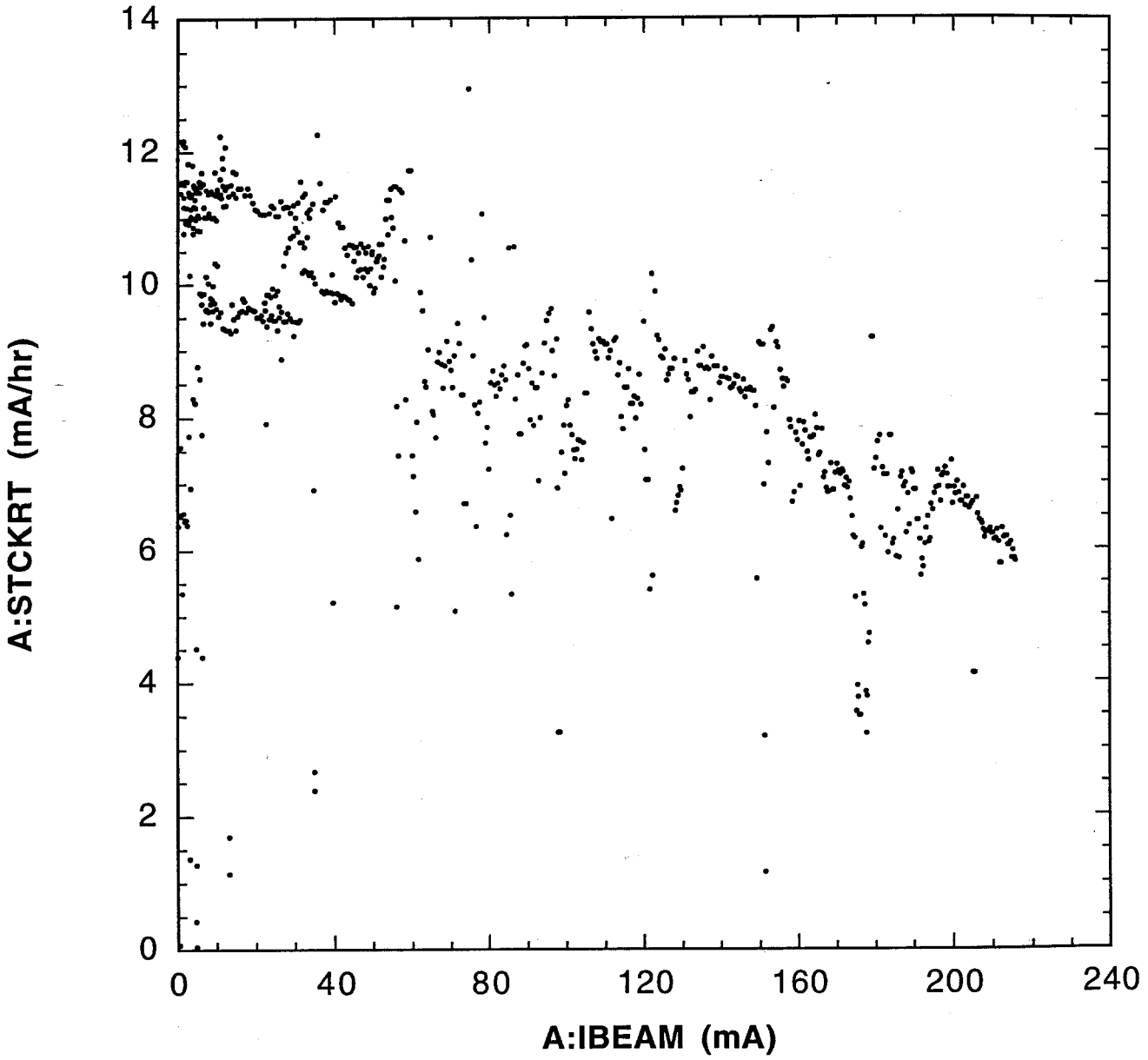


FIGURE 3

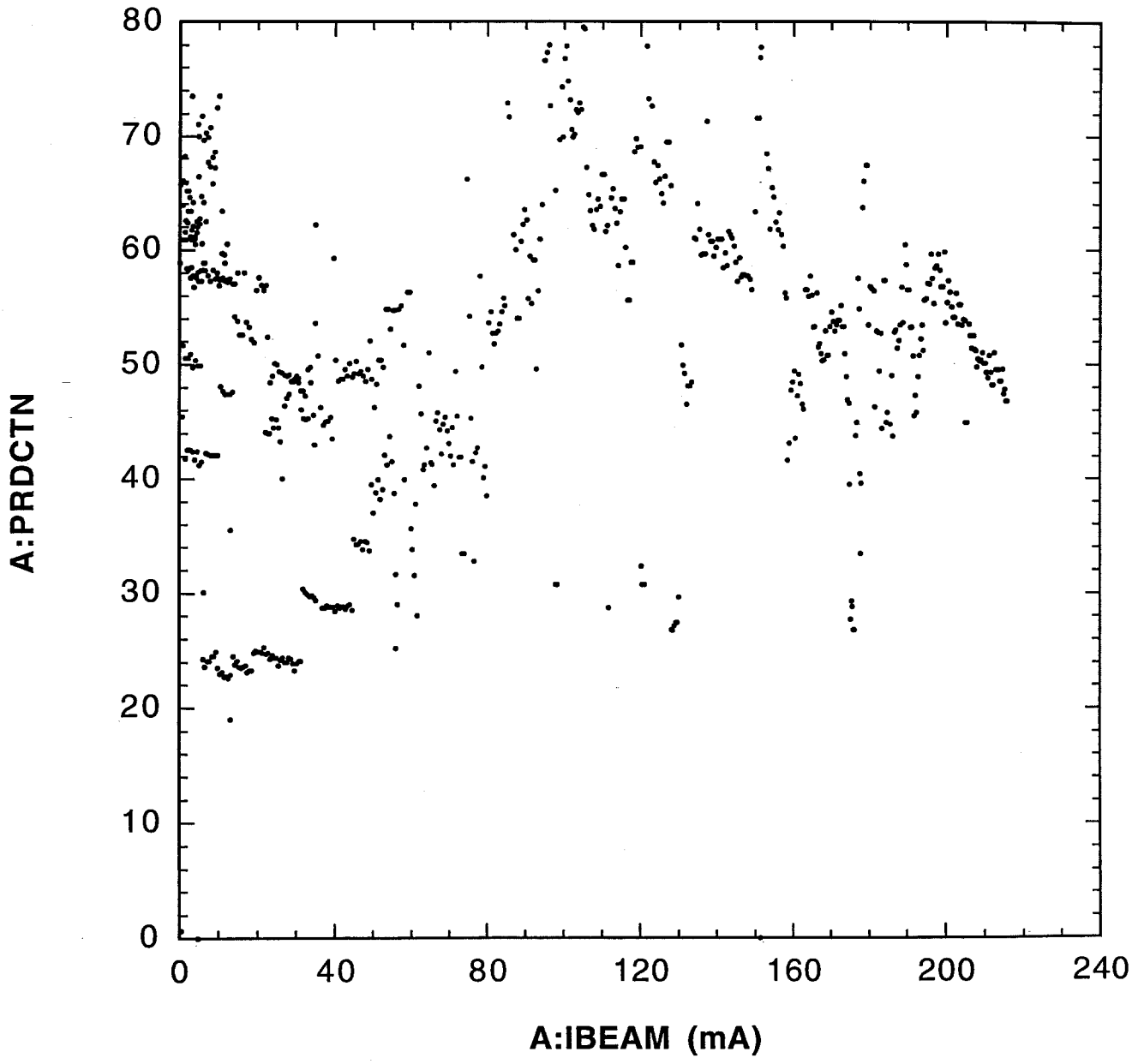


FIGURE 4

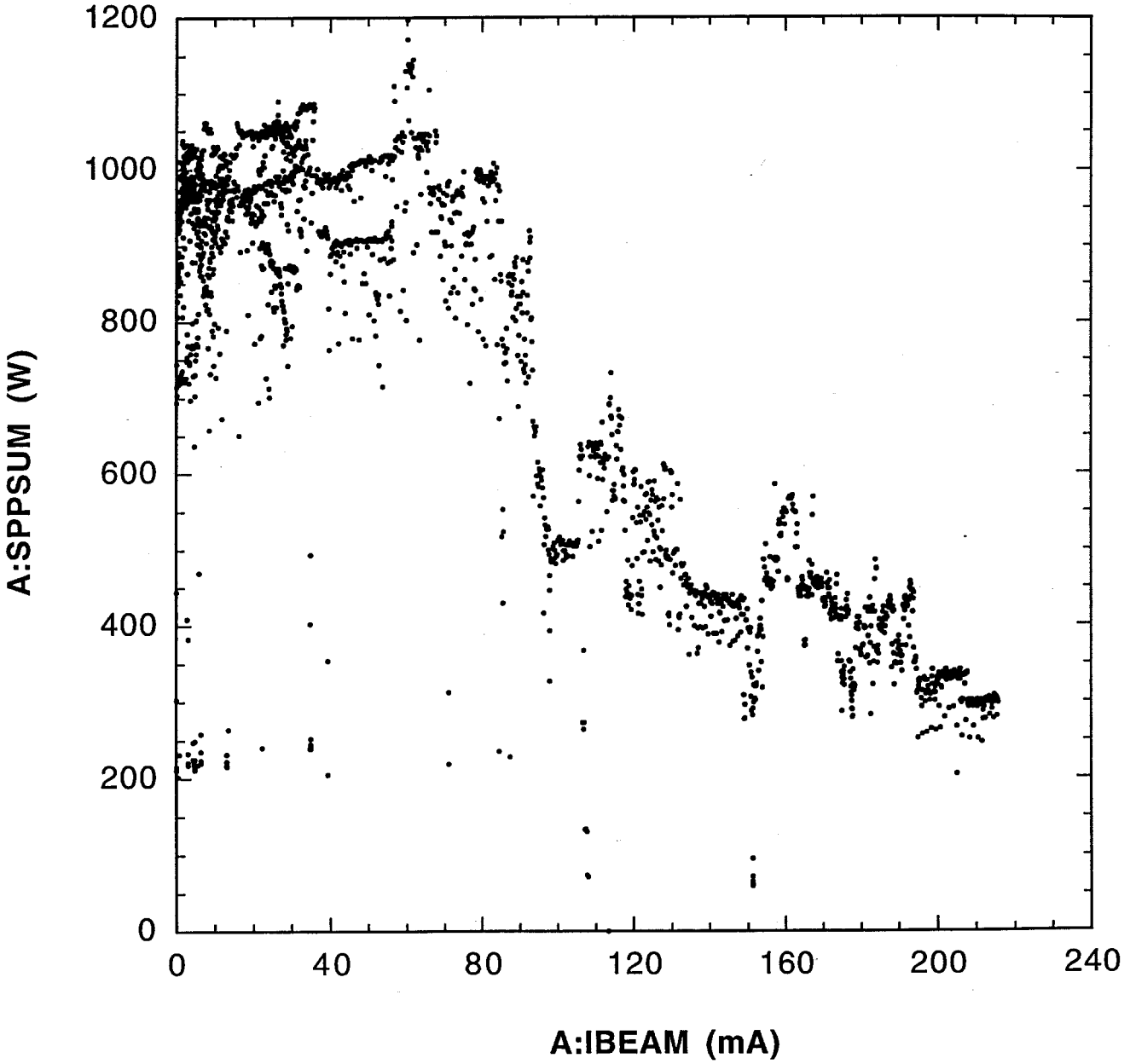

1200
1000
800
600
400
200
0
A:SPPSUM (W)
0
40
80
120
160
200
240
A:IBEAM (mA)

FIGURE 5

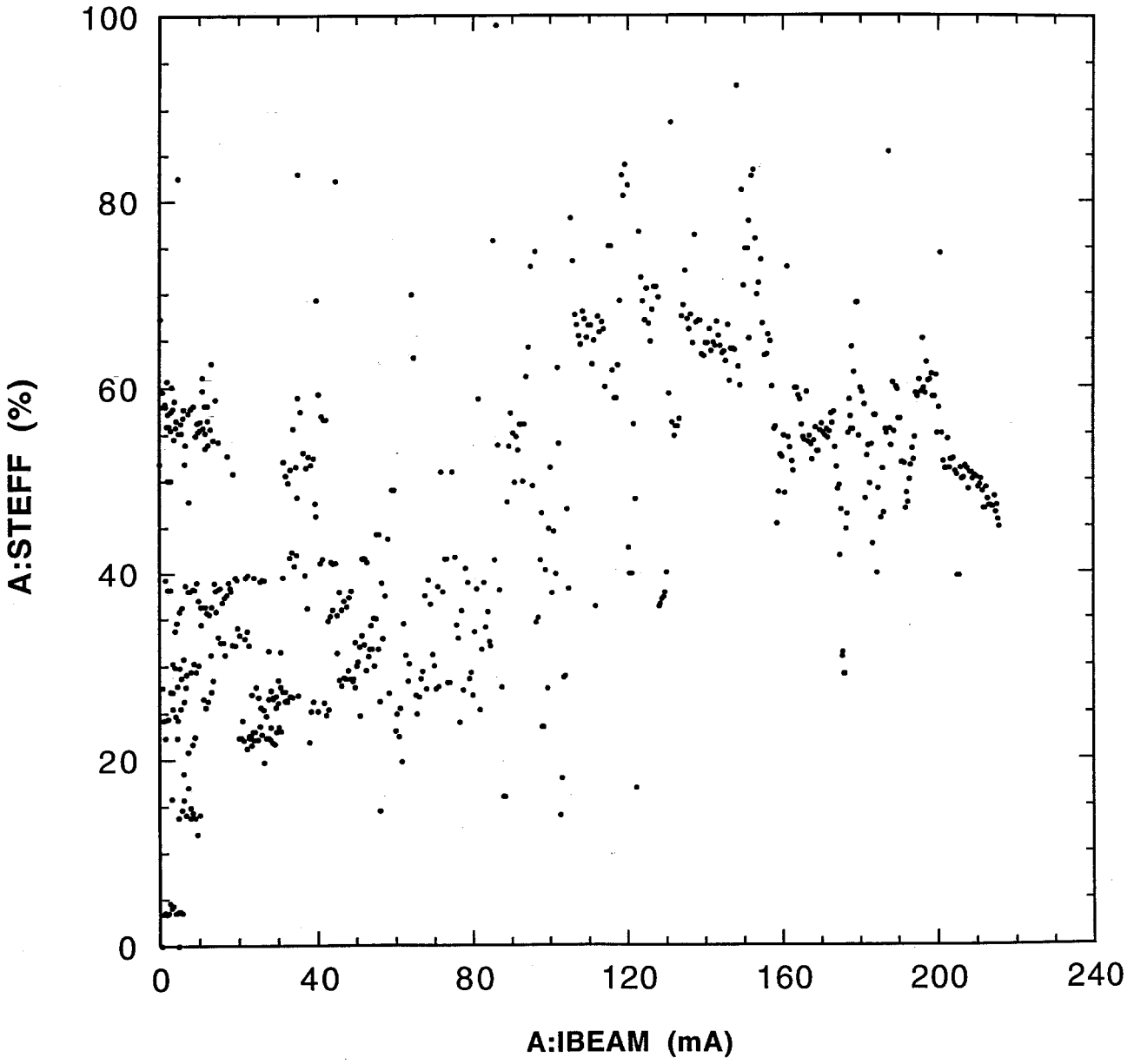


FIGURE 6

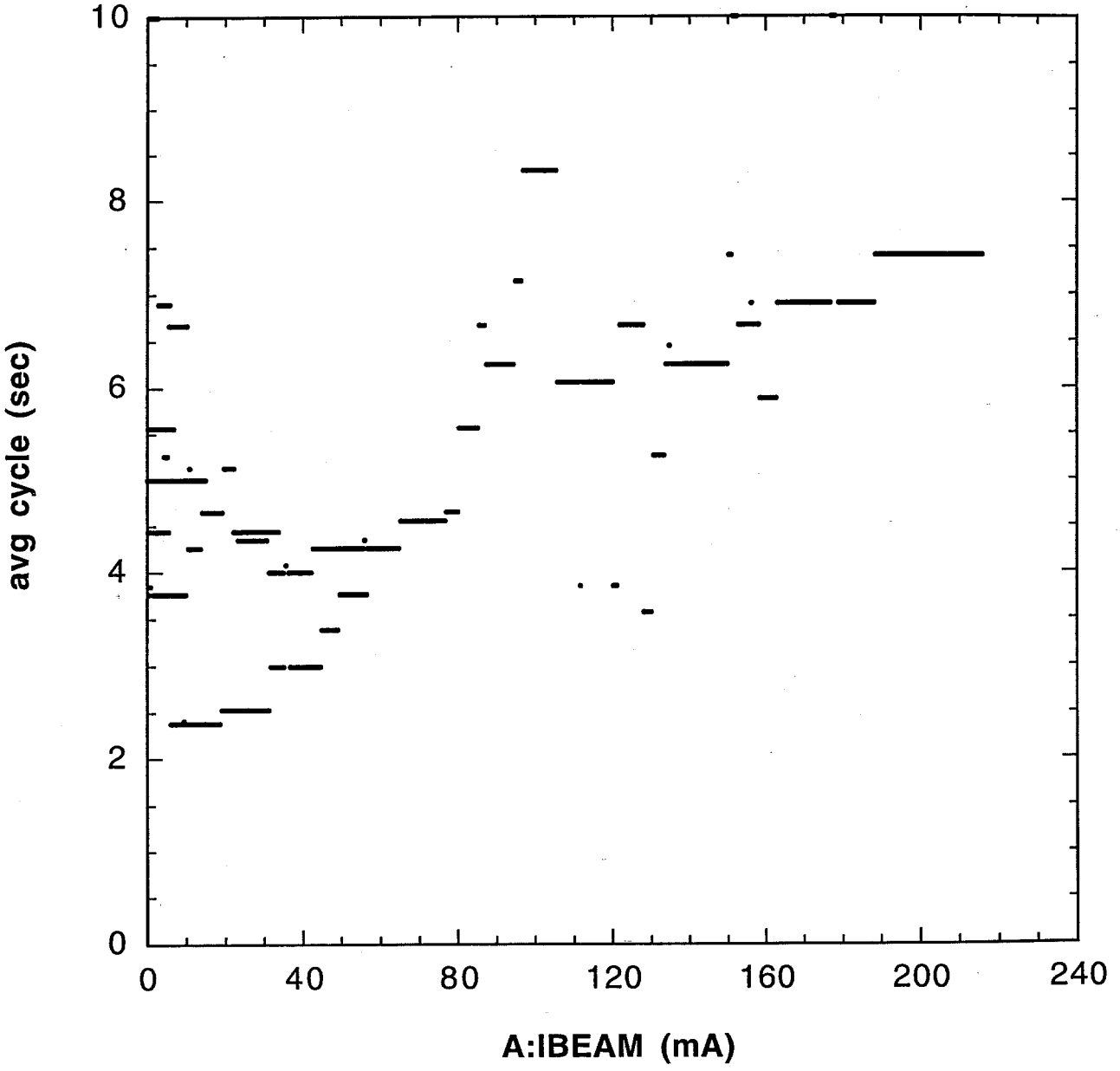


FIGURE 7

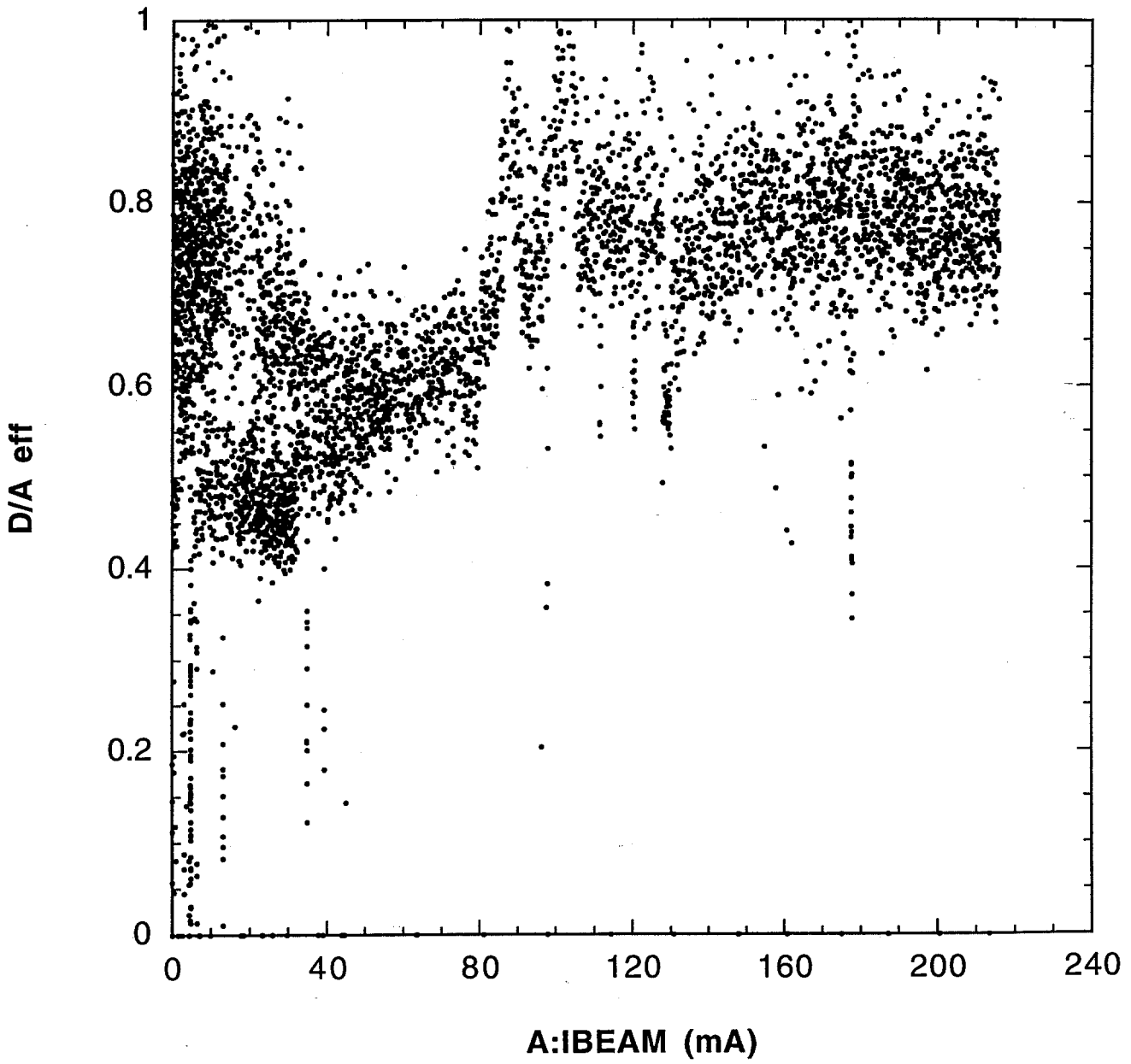


FIGURE 8

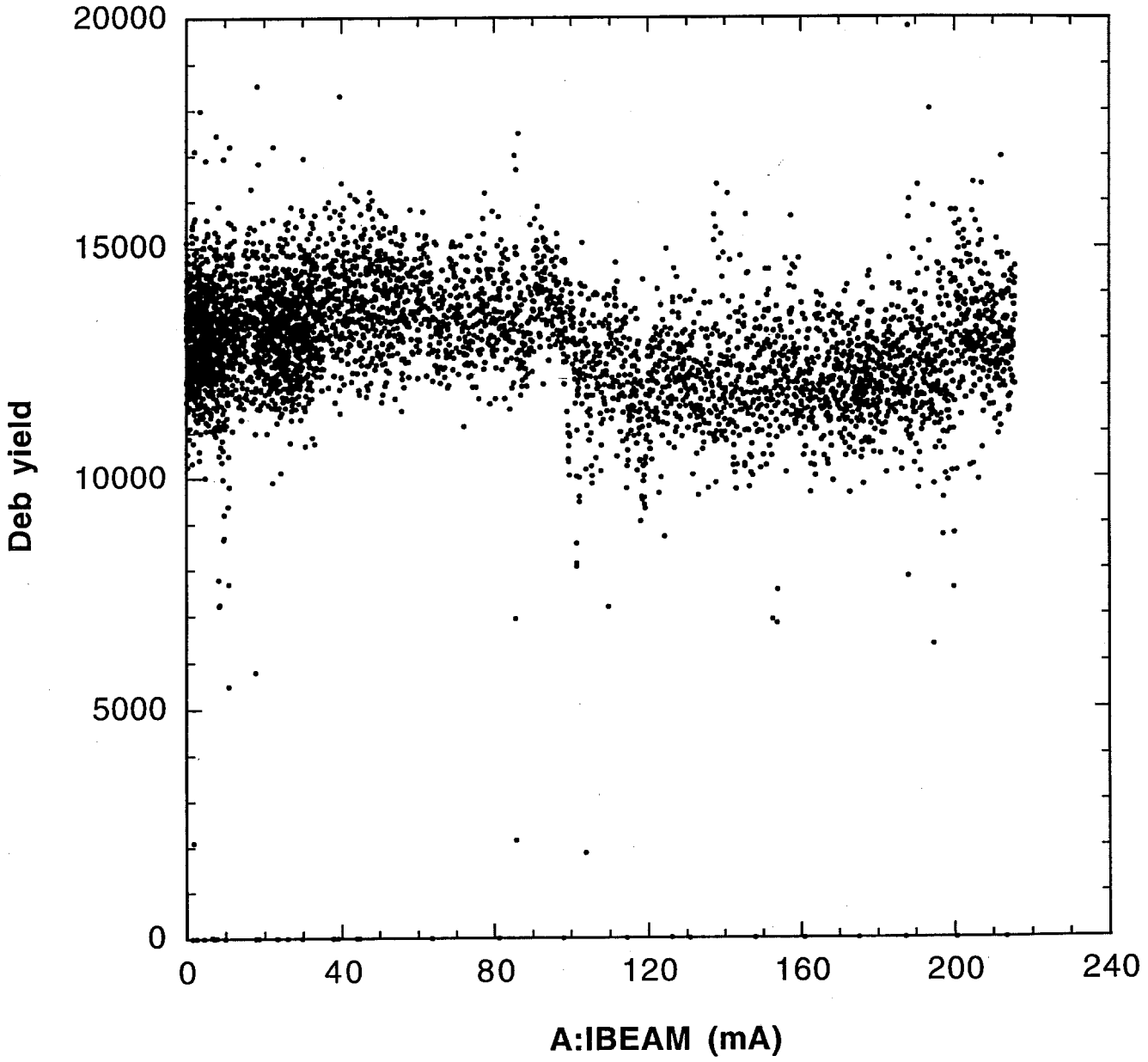
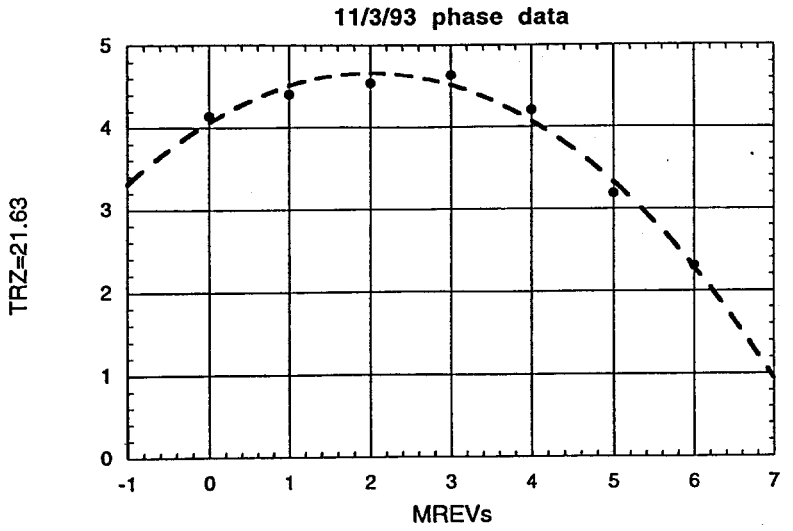

20000
15000
10000
5000
0
Deb yield
0
40
80
120
160
200
240
A:IBEAM (mA)

FIGURE 9



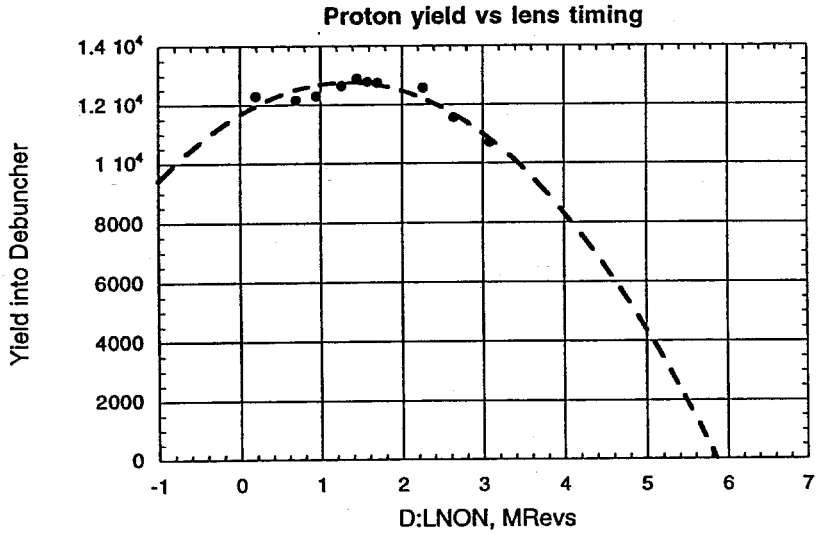
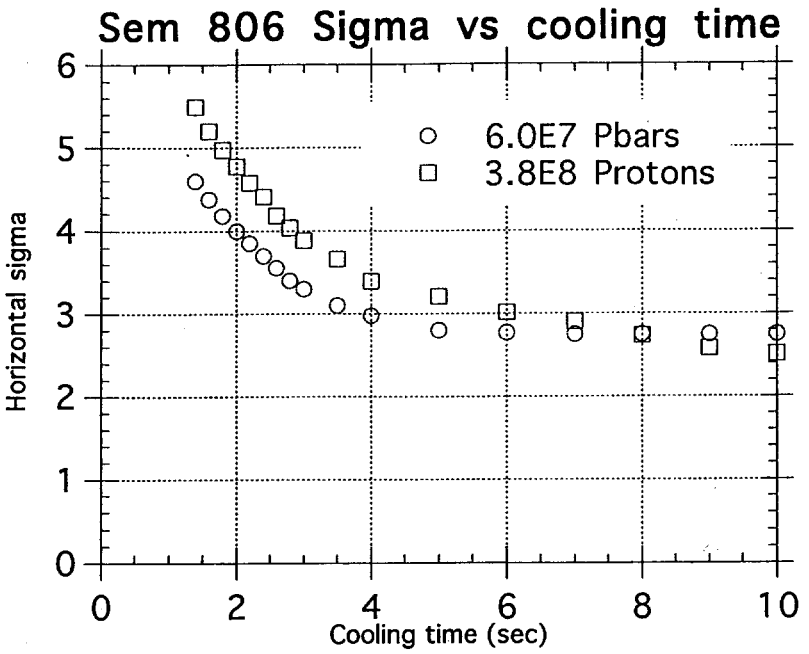


FIGURE 10: Debuncher Yield vs. lens pulse delay



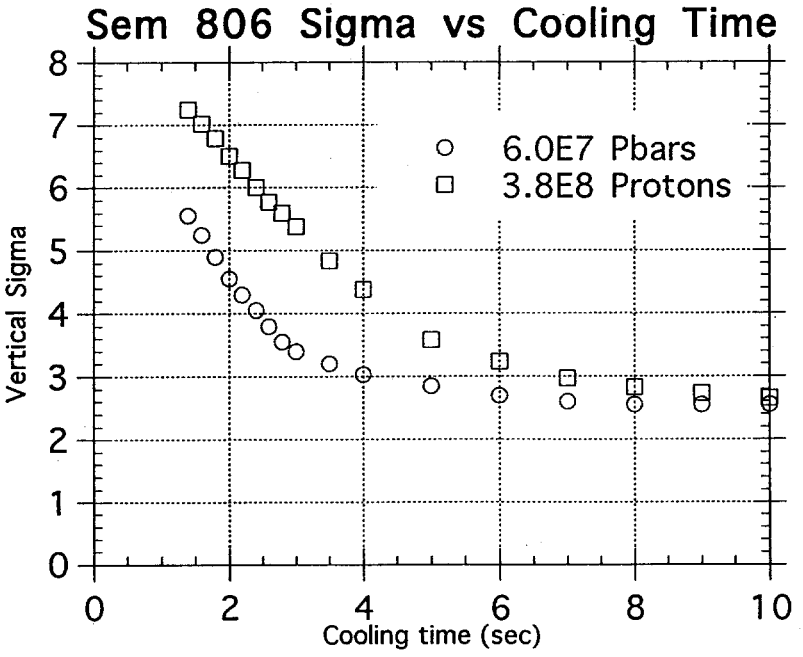


Figure 11: Transverse beam size in D/A line vs. Debuncher cooling time.

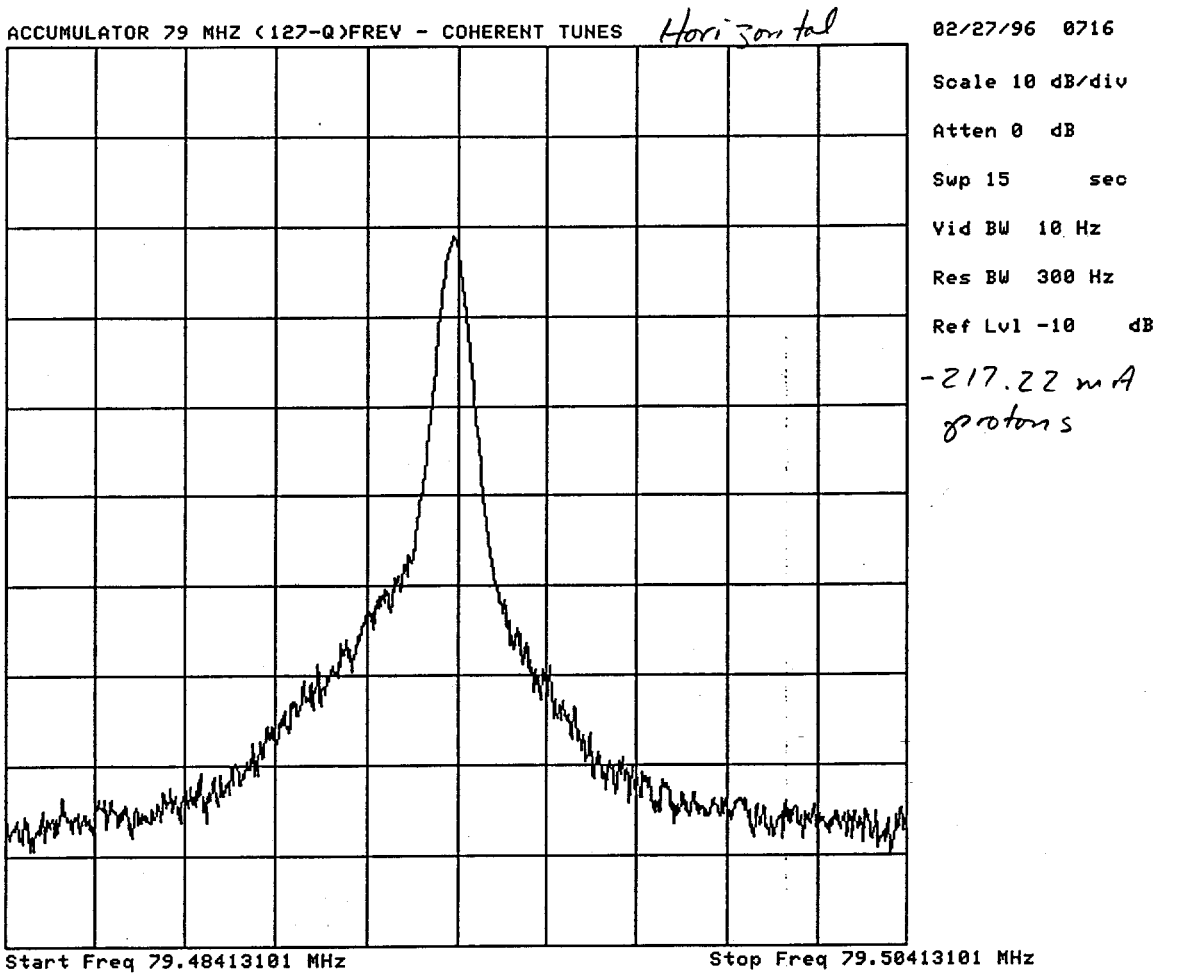


FIGURE 12: TRANSVERSE COHERENT INSTABILITY LINE IN ACCUMULATOR