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ATA PROBE BEAM EXPERIMENT

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DISCLAIMER

ATA PROBE BEAM EXPERIMENT*

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SUMMARY

The philosophy of these tests is to measure the motion of a low current, small diameter electron beam in the accelerator before running high current. By using low current, we can study particle motion in the applied fields without any extra complications associated with the self-forces of high currents. With the steering magnets off, we have measured the transverse drift of the probe beam. Also, we have used the probe beam to optimize the current in the steering magnets to compensate for the drift. There have been concurrent efforts to locate the source of the error field which is presumed to cause the drift. So far, the source has not been established but the search is continuing.

All of the results reported here are obtained with the wire zone installed between beam bugs 20 and 25, and with a 0.6 cm diameter hole plate on axis just upstream of beam bug 25. The main measurements are beam center of mass transverse position from the beam bugs. Using the Tektronix computer system, the beam bug current and transverse positions (x and y) are plotted at 512 times during 50 ns. These time resolved plots are available in hard copy form but for the present purpose we have calculated the time average positions and plotted these vs beam bug number.

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Fig. 1 presents the results of two runs with identical parameters: uniform 750 Amp/Turn in the focusing magnets and all steering off (starting at station 25). The beam current is about 100A. There is some loss of current. for the first six or eight stations starting from 25 indicating that the beam is not in equilibrium as it leaves the wire zone. The two runs are very similar and show that the center of mass drifted east about a cm in the first six spaces, then drifted more slowly for a few spaces and finally drifted another cm east in the downstream region.

We model the beam as having a center of mass which undergoes cyclotron motion about a guiding center with the guiding center following a magnetic flux line. (In principle, ∇B drift can move a guiding center across flux lines, but this seems unlikely in this case.) The flux line motion is given by

$$\frac{B_x}{B_Z} = \frac{x}{N\,L}$$

where B_Z is the axial field, B_x is the horizontal component of error field, x is the horizontal displacement of the flux line, L is the length per beam bug space and N is the number of spaces. (There is a similar equation for Y.)

Solving,

$$B_x L = \frac{XB_Z}{N} \quad .$$

In the first six spaces starting with station 25, $B_x L = \frac{1\text{ cm} \times 2900\text{ Gauss}}{6}$ = 483 Gauss cm east per beam bug space.

L is about 370 cm, so the average error field is about 1.3 Gauss. The local error field could be much larger.

By observing the effect on the probe beam, the steering magnets were found to have a strength of 50 Gauss cm per amp. (This is about one half the vacuum field strength. They are weakened by the magnetic ferrite rings of the beam bugs which are located inside the steering coils.) So the current needed in the first six horizontal magnets is

$$I_H = \frac{-483}{50} = -9.7\text{ Amp} \quad .$$

The steering currents calculated by this method were used and Fig. 2 gives the resulting beam positions. The beam is closer to the axis on Fig. 2 than on

Fig. 1. The plan is to move the steering magnets away from the magnetic beam bug rings and then do the probe beam experiments again - this time forming the probe beam by installing a small diameter tube collimator at the injector output.

The Z-wise fluctuations of the position plots suggest that the radius of curvature of the center of mass motion about the guiding center is about 0.5 to 1 cm in the downstream region. It would be nice to reduce this because with τ dependent γ, this results in τ-wise beam sweep.

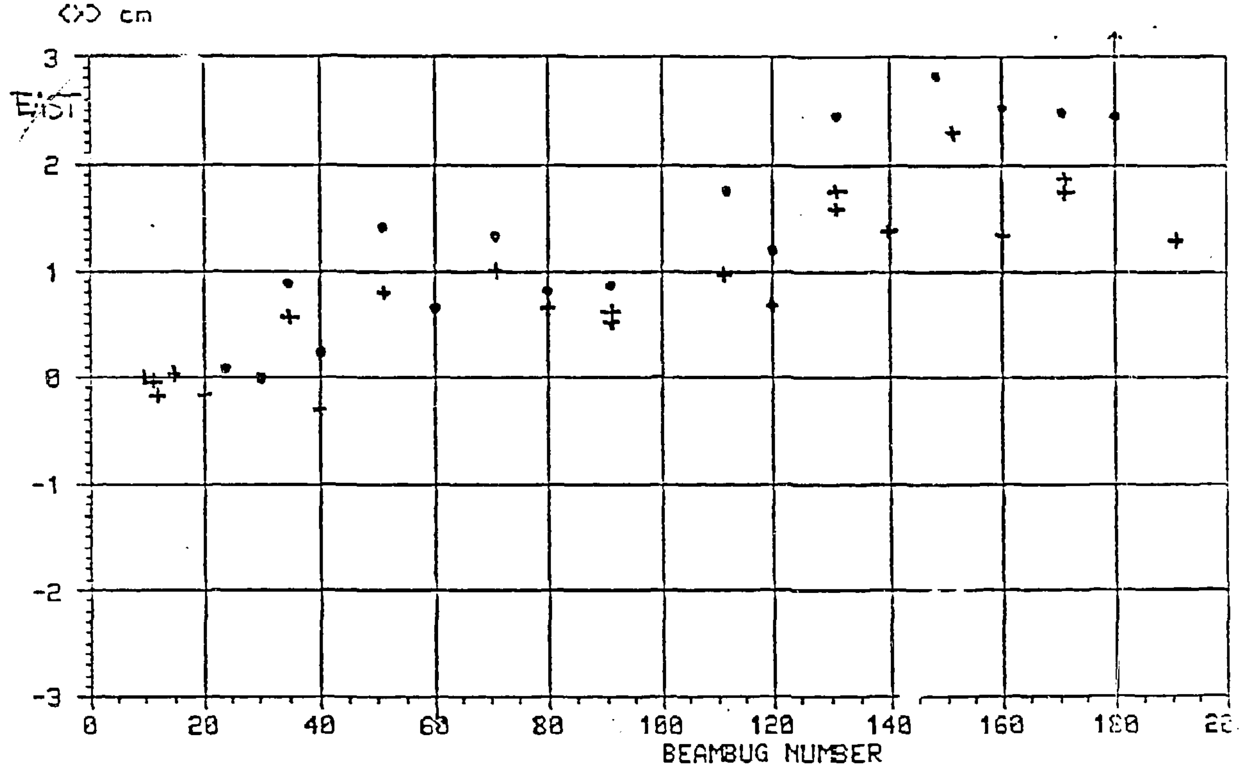
Probe beam comparisions were also done switching off the pulsed accelerator power starting at station 25. This caused no significant change in the drift with flat B_Z and no steering. This shows that the pulsed power is not the source of the error $B_\perp$. Also, the drift was independent of the magnitude of B_Z, which is consistent with the model and the assumption that the focusing magnets are the source of the error field.

Figure 1

Analysis date = 21-FEB-84   Analysis program = BUGANN.MES

B09201.ATA - 5-JAN-84 - WIRE ZONE,.6 CM DIA HOLE, 750 A/T, NO STEERING
B09202.ATA - 5-JAN-84 - WIRE ZONE,.6 CM DIA HOLE AT 24,25,FOCUS 750 A/T,NO STE

B09203.ATA - 5-JAN-84 - WIRE ZONE,.6 CM DIA HOLE AT 24,25,FOCUS 750 A/T,NO STE



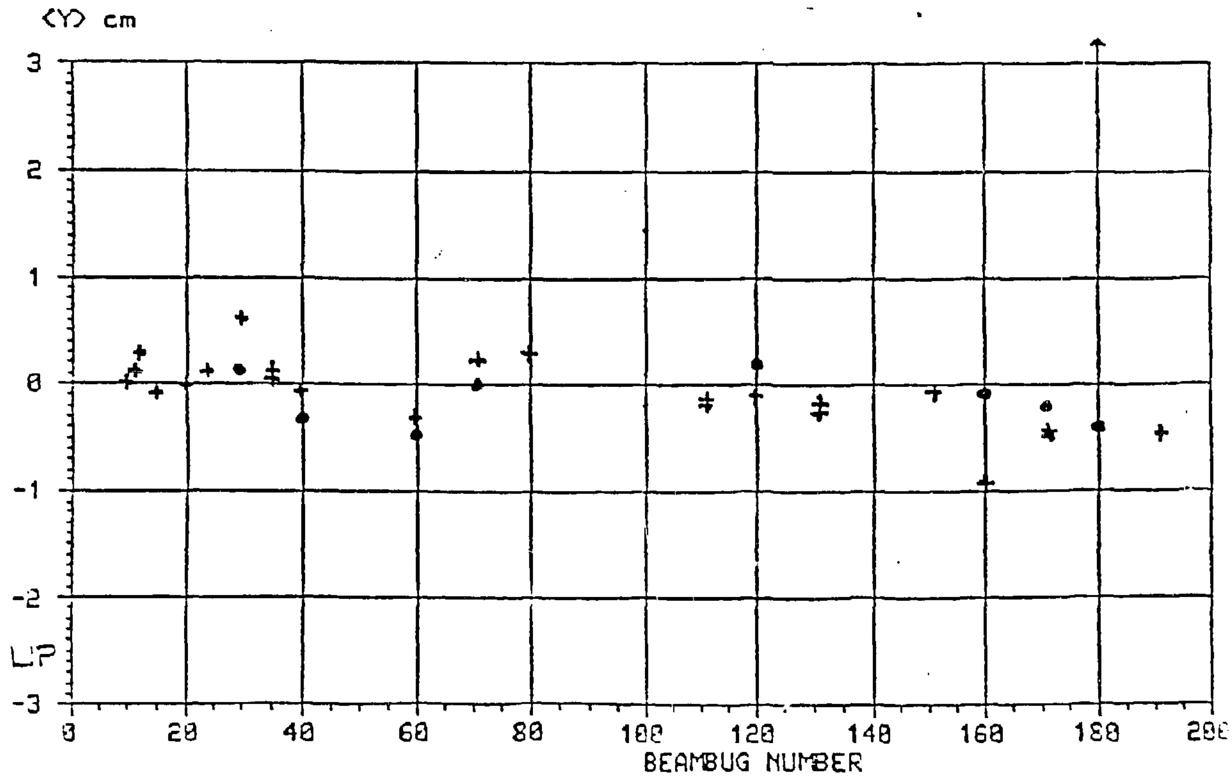


Figure 2

Analysis date = 24-FEB-84 Analysis program = BUGANN.MES

B18401 - 30-JAN-84 - WIRE ZONE, .6 CM DIA HOLE, 750 A/T
B18402 - 30-JAN-84 - WIRE ZONE, .6 CM DIA HOLE, 750 A/T