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Steering in the BTA with the F6 Septum Magnet

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AGS Complex Machine Studies

(AGS Studies Report No. 325)

Steering in the BTA with the F6 Septum Magnet

Study Period: March 12, 1995

Participants: B. Tamminga

Reported by: E. Bleser

Machine: AGS Proton Complex

SUMMARY

The horizontal acceptance in the BTA line may be only 75% of the design acceptance.

DATA

On Sunday, March 12, 1995, an effort was made to record certain data each time the F6 extraction septum was reset to compensate for drifts in the BTA efficiency. Before and after changing F6, the Operators recorded the set points, some intensities, and the horizontal and vertical positions at MW060. The readbacks from F6 were unreadable. The results are summarized in Table 1.

TABLE 1: F6 STEERING DATA from 3/12/95

			F6 SETPOINT	BSTRLATE	AGSCBM	MW060 MEAN	
						HOR	VERT
TIME			counts	10^10	10^10	mm	mm
600	BEFORE	1	10549	7075	4400	5.99	0.11
	AFTER	2	10505	7075	4700	−8.36	0.32
1000	BEFORE	3	10549	7140	4240	10.89	−0.04
	AFTER	4	10498	7140	4720	−3.78	0.14
1630	BEFORE	5	10520	6830	4390	−21.94	0.5
	AFTER	6	10571	7000	4650	−8.59	0.35

At 0600 hours, F6 was adjusted to restore the AGS intensity. Between 0600 and 1000, there was some beam tuning that shifted the set point of F6, among other things. Subsequent to this tuning the efficiency drifted until at 1000 hours F6 was adjusted to restore the AGS intensity. Between 1000 and 1630 there was some beam tuning that shifted the set point of F6, among other things. By 1630 hours, the efficiency had drifted until it was necessary to adjust F6 to restore the efficiency. These observations are summarized in Figure 1. The lines 1-2, 3-4, and 5-6 represent the recorded adjustments of F6. The lines 2-3 and 4-5 represent some combination of unrecorded adjustments and drifts over a period of several hours. Table 2 shows that F6 moves the beam about as modeled. (Appendix I records for completeness the general effects of F6, for the assumed model.)

TABLE 2: MEASURED F6 STEERING

POINTS	SLOPE mm/count
1–2	0.326
3–4	0.288
5–6	0.262

MODEL	0.263

OBSERVATIONS

In Figure 2 we define the BTA efficiency as AGSCBM divided by BSTRLATE and plot it versus the horizontal position at MW060. The data are nicely fit by a parabola centered at -10.1 mm. The figure suggests that as the beam drifts off center (points 1, 3, and 5) the efficiency decreases, but it can be restored by steering the beam back on center (points 2, 4, and 6). Figure 3 replots this data as the fractional transmission loss, defined as

$$1 - EFF(X)/EFF(10.1) \ ,$$

versus dX, defined as,

$$dX = X + 10.1 \ .$$

The formula for the curve is:

$$Y = 2.46 \times 10^{-4} \times (dX)^2 \ .$$

SENSITIVITY

Figure 4 expands this plot on a log scale to explicitly show the sensitivity. A 2 mm steering error gives a 0.1% loss. A 6 mm steering error gives a 1% loss. From Table A1, one count in F6 gives a quarter of a millimeter displacement. Thus eight counts will give a 0.1% loss and 25 counts will give a 1% loss. The present overall loss down the BTA is over 30%, so an additional 1% is not very significant, but it seems fair to request that the F6 septum be stable to at least the level of producing 1% losses. This corresponds to 25 counts out of 10,000 or 0.25%.

If this is the best we can achieve, we shall have the beam moving at MW060 by plus or minus 6 mm, easily observed and operationally unsettling. The amplitude of the current in the septum is reportedly stable to 0.1% (J. Sandberg). Appendix II discusses timing jitter between F3 and F6. To hold the bend angle stable to 0.1% requires timing stability to 21 microseconds. The matter is under investigation.

SPECULATION

If we scan a very narrow beam across a wide aperture, we should get an intensity distribution with a wide flattop. If we scan a very wide beam across a very narrow aperture, we should get an intensity distribution reproducing that of the beam. What we see in Figure 2 is a very nice parabola, which is reasonable if the aperture has a width of around three beam widths, where we assume the beam is Gaussian and a beam width is one standard deviation.

In particular, the beam at MW060 has a measured width of 20 mm. Figure 3 shows that moving the beam 20 mm produces a loss of 10%. A little modeling suggests that this corresponds to an effective aperture of 72 mm full width. At MW060, betax = 86 meters and we have an effective acceptance of 15 π mm mr. Table 3 summarizes our assumptions about acceptances. we seem to be missing 25% of our horizontal acceptance. This could easily arise from bad steering. On the other hand, this section is rather speculative.

TABLE 3: BTA ACCEPTANCES

	ACCEPTANCE PI mm mr
BOOSTER EXTRACTION CHANNEL	25
BTA MINIMUM at QH8	41
AGS INJECTION CHANNEL	20
ESTIMATED IN THIS PAPER	15

FURTHER EXPERIMENTS

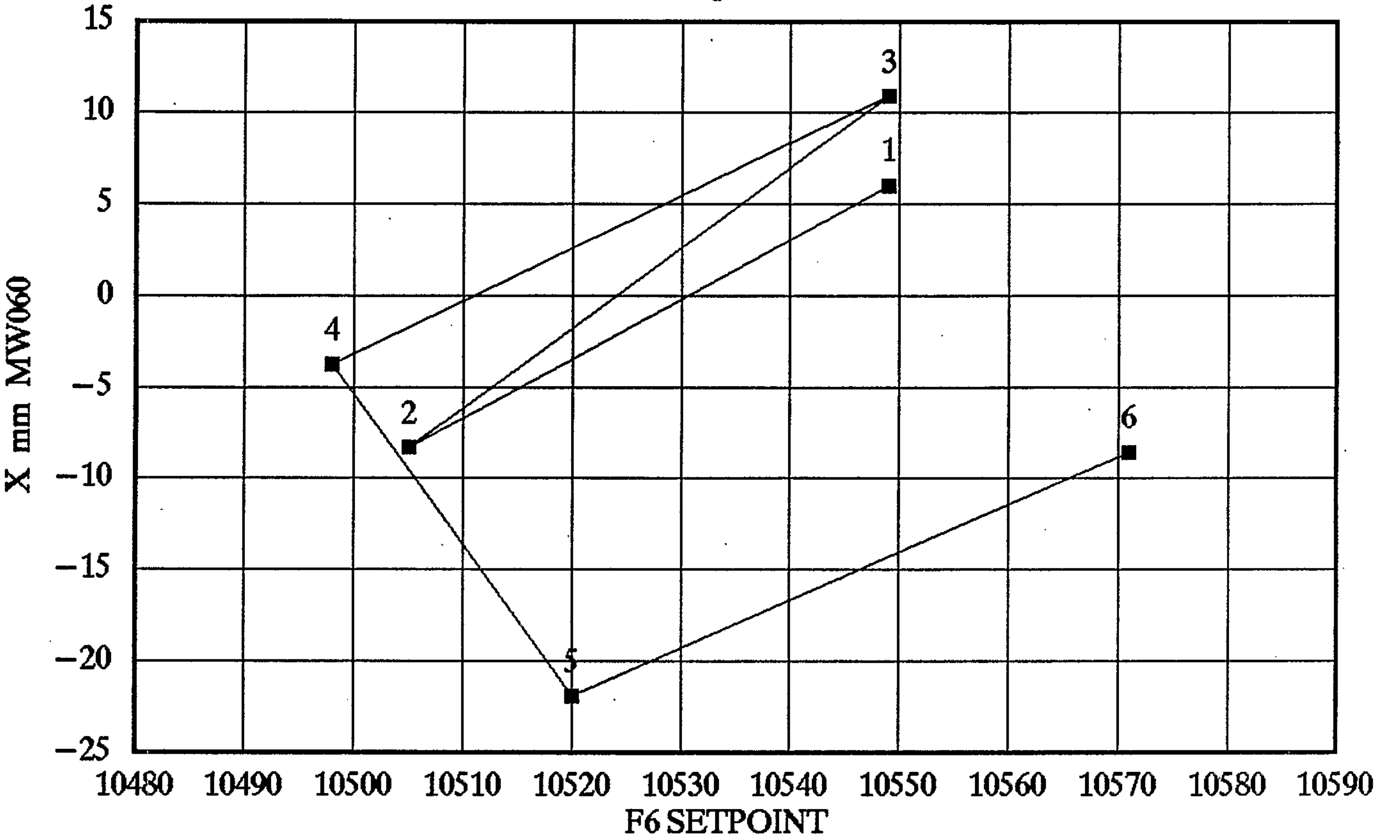
1. Scan F6 up and down in 10 count steps as far as proves reasonable (probably more than 50 counts but less than 100). Record the intensities and print out the four multiwires at each setting. This should enable us to get a good evaluation of the effective aperture and from the intensities at each multiwire perhaps some idea of its location. Loss monitor data should also be taken.

2. What is the source of "drift"?

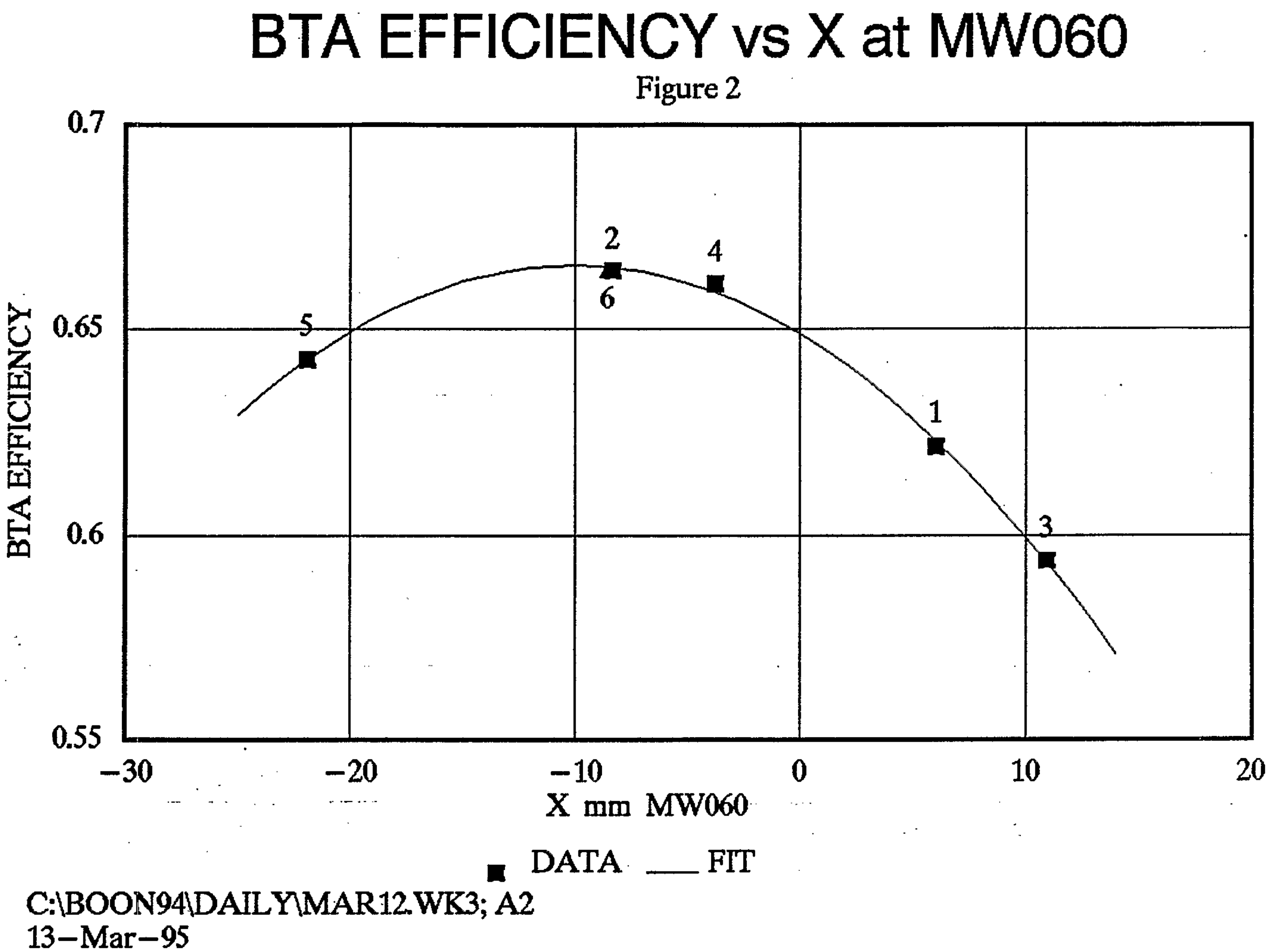
   As a first experiment, when we have a good setup and everybody is happy, hold everything upstream of the AGS fixed and record a subset of the Daily Log: Booster extraction field, Booster extraction bumps, average Booster orbit at extraction, BTA SEMs, BTA efficiencies, Booster intensities. If after the passage of time the efficiency drops, rerecord the above before adjusting F6. After restoring the efficiency with F6, rerecord the above. The orbit changes should point at the culprit.

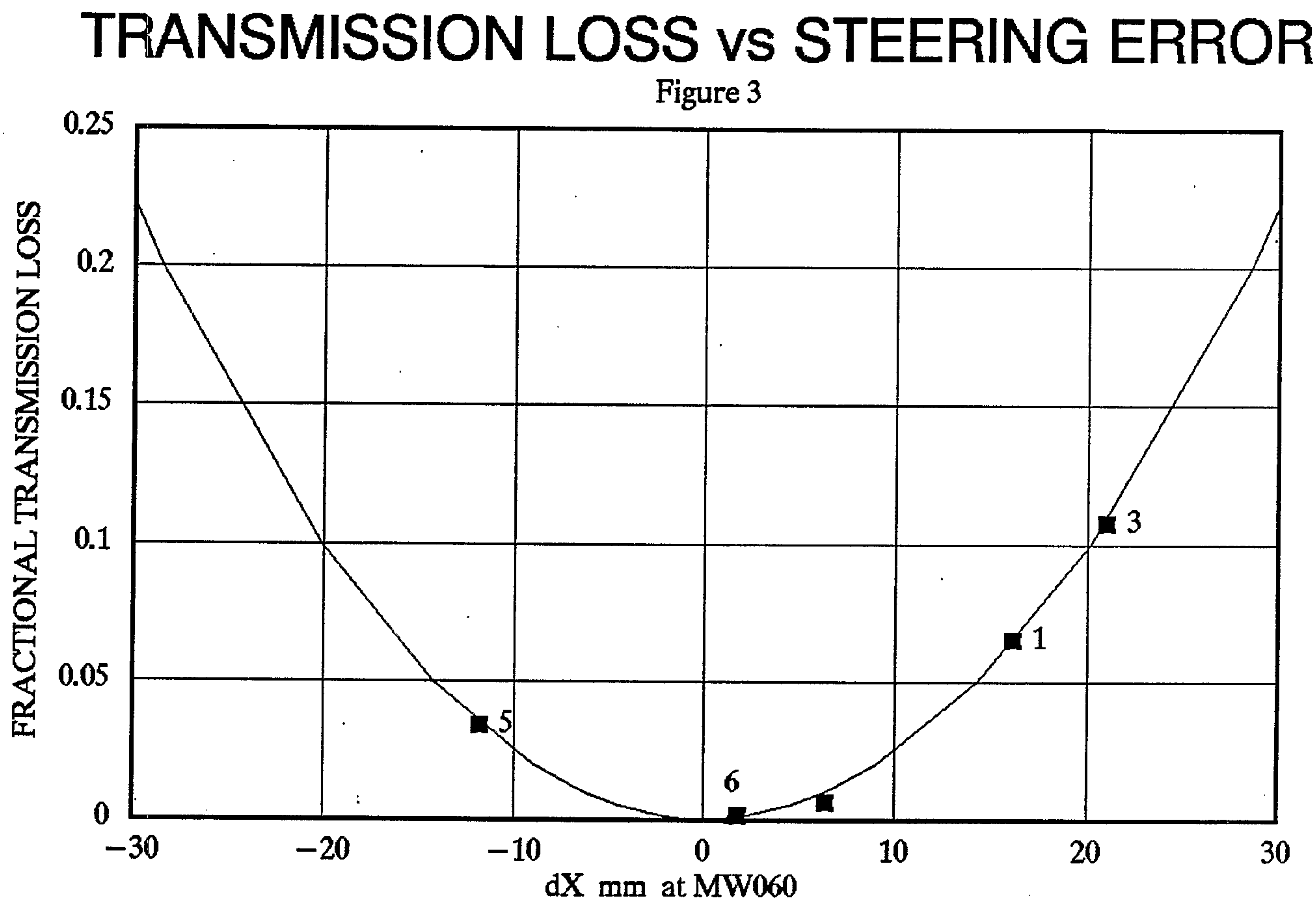
F6 ADJUSTMENTS: 3/12/95

Figure 1



C:\BOON94\DAILY\MAR12.WK3; A1
13−Mar−95


BTA EFFICIENCY vs X at MW060
Figure 2
0.7
0.65
0.6
0.55
BTA EFFICIENCY
−30
−20
−10
0
10
20
X mm MW060
1
2
3
4
5
6
DATA
FIT
C:\BOON94\DAILY\MAR12.WK3; A2
13−Mar−95



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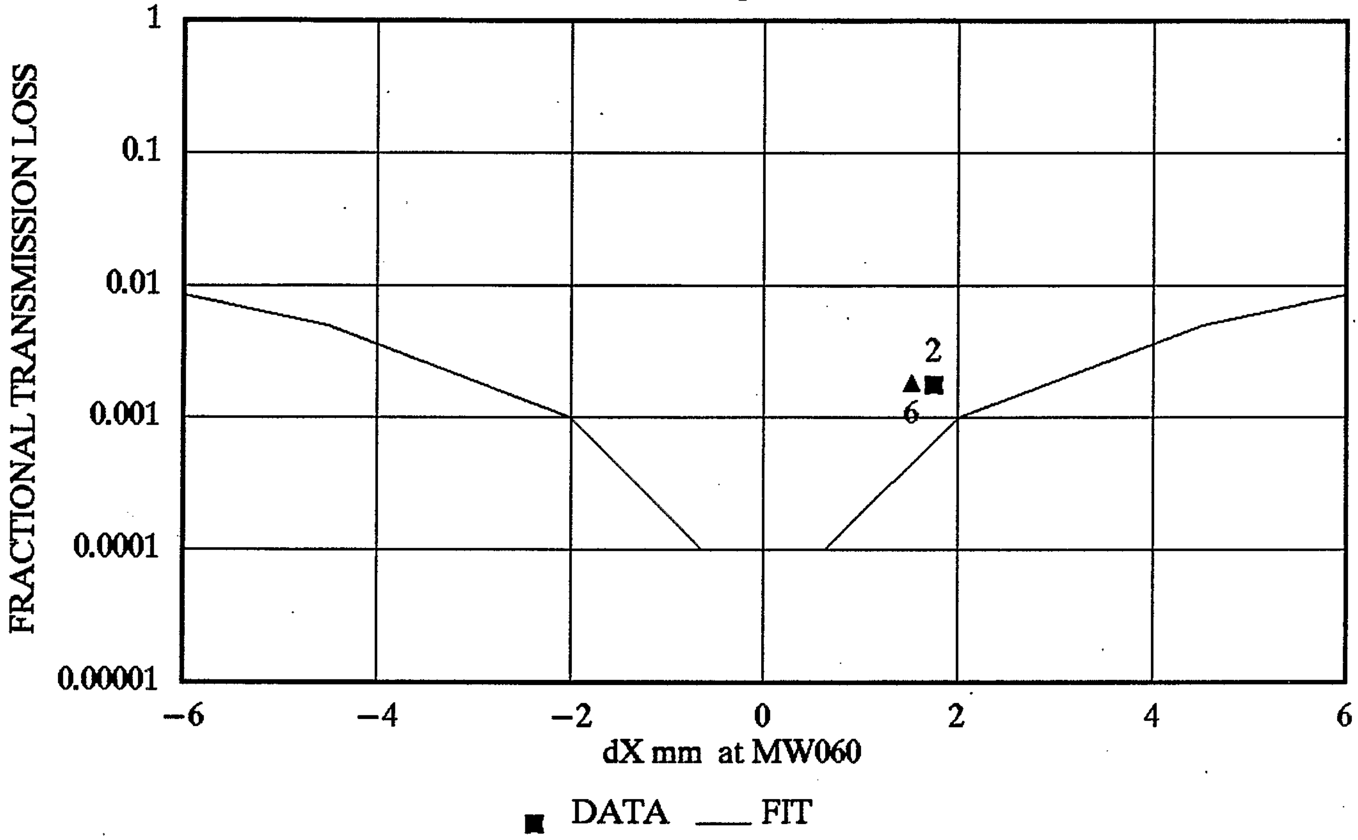
13-Mar-95

TRANSMISSION LOSS vs STEERING ERROR

Figure 4



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13−Mar−95

APPENDIX I

The bend in the F6 septum is 130.84 milliradians. The nominal setpoint is about 1050 counts. For the standard model, which we shall document soon, Table A1 gives the displacements and angle changes expected from a change at F6 of 1 milliradian, and, more usefully, a change of 10 counts. Note that at the entrance to the L20 septum, which is the tightest aperture in the system, the position is quite sensitive to F6. We have earlier (AGS Studies Report No. 323) expressed some concern about the quality of the model at this end of the beam line, so this observation may not be correct; but if there is some truth to it, we have found a very critical point.

TABLE A1: CALCULATED F6 STEERING

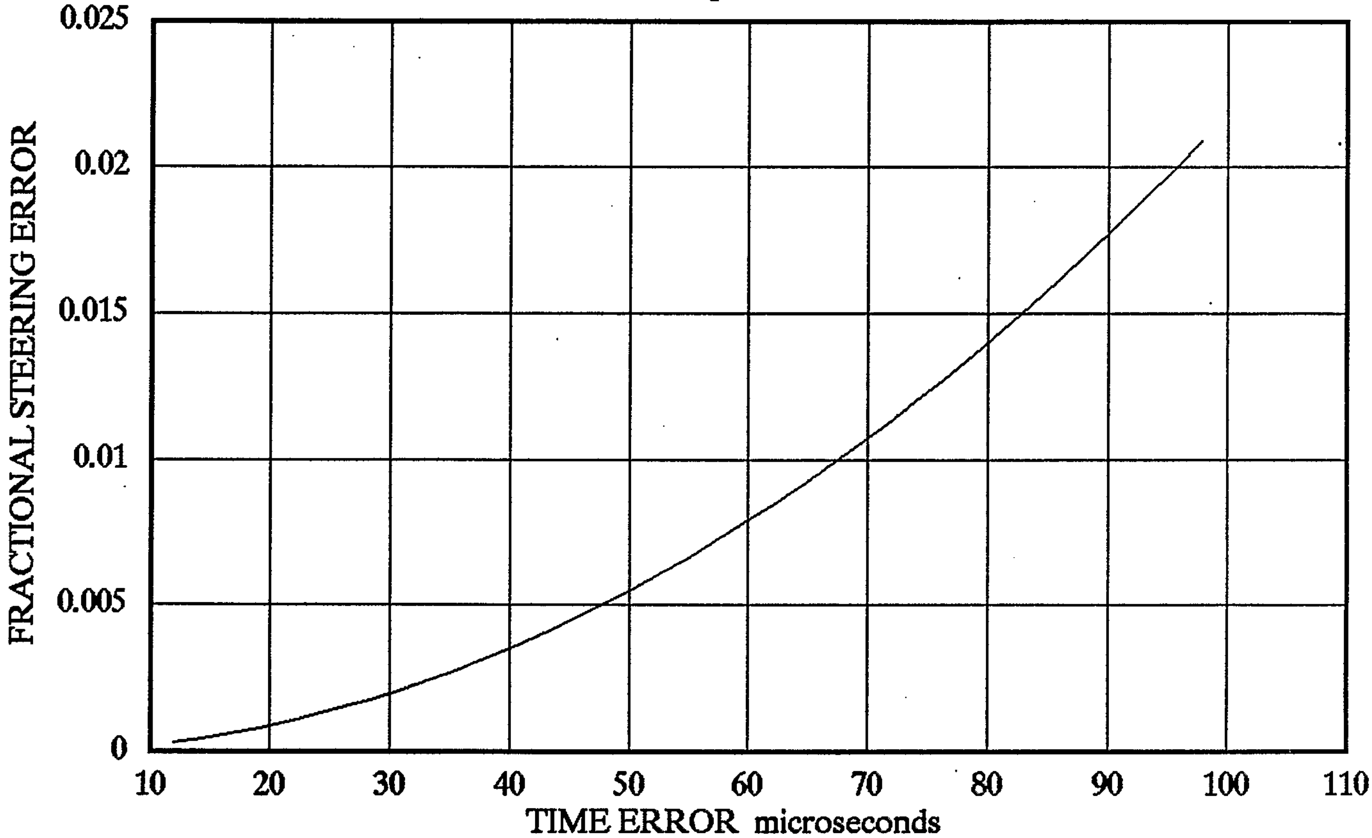
	FOR dF6 = 1 mr		FOR dF6 = 10 COUNTS	
	X	X'	X	X'
	mm	mr	mm	mr
MW006	2.85	1.00	0.355	0.124
MW060	21.10	−1.99	2.630	−0.248
MW125	13.26	−1.11	1.652	−0.139
MW166	1.35	−1.25	0.168	−0.156
ENT L20	−8.42	−1.23	−1.049	−0.153

APPENDIX II

The F6 septum has current pulse in it which has the shape of a half cycle sine wave with a base width of 1.5 milliseconds. The F3 kicker has a pulse length of some microseconds and it must be fired just at the peak of the F6 septum field. If there is a timing error, extraction will not occur at the maximum field in F6 and the beam will be bent less than desired. Figure A2 shows the fractional steering error that will result from a given timing error.

STEERING ERROR vs TIME JITTER

Figure A2



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15–Mar–95