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Beam Loss Pattern at DH4 in the BTA Line

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Beam Loss Pattern at DH4 in the BTA Line

Study Period: June 26, 1996	
Participants: P. Sampson and S.Y. Zhang	
Reported by: S.Y. Zhang	
Machine: BTA	
Beam: Proton	
Tools: BTA Multiwires, Loss Monitors and Current Transformers	
Aim: To understand the beam loss at DH4.	

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1 SUMMARY

The proton beam is found to scrape vertically at the vacuum chamber at DH4, on the top, in the BTA line.

2 EXPERIMENT

It has been noticed that the vertical aperture at the horizontal steering magnet DH4 in the middle of the BTA line is tight. The beam loss pattern, observed by loss monitors, and the radiation level surveys give rise to consistent results showing that the beam loss in the neighborhood of DH4 is among the highest in the line. In this experiment, the vertical steering has been used to study the beam loss pattern at DH4, as suggested by J.W. Glenn. The vertical steering, the horizontal motion and the loss pattern of the beam at DH4 were studied. Since the only vertical steering magnet upstream of DH4, DV007, is about 27 meters in distance, the results are less than conclusive. However, we are still able to show that during the 1996 HEP run the proton beam was set up to scrape vertically at the vacuum chamber at DH4, on the top.

In Table 1, the DV007 driving current and the location of DV007 in the BTA line are shown. Throughout the experiment, the beam position data at the multiwires were taken using the application /USERS/SAMPSON/LOGMW_dir/LOGMW, originally written by M. Blaskiewicz. The BTA model used in the analysis is from E. Bleser and J. Niederer.

	At	I	II	III	IV	V	VI	Unit
DV007	5.00 m	-8.8	-7.3	-6.9	-5.3	-2.2	-0.37	A

Table 1

3 RESULTS

3.1 Vertical Steering

In Table 2, the vertical steering data at MW006, MW060, and MW125 is shown. Also shown are the locations and local beta functions at these multiwires. MW166 was not functioning at the time of this study.

	At	β_V	I	II	III	IV	V	VI	Unit
MW006	4.34 m	15.308 m	2.40	2.39	2.40	2.39	2.39	2.40	mm
MW060	20.7 m	13.556 m	-2.00	-0.44	0.03	1.44	4.47	6.59	mm
MW125	42.3 m	3.126 m	4.69	3.98	3.77	3.14	1.81	0.9	mm

Table 2

Note that MW006 is upstream of DV007, therefore, the beam position there should not be affected by the DV007 steering. In Fig.1, the beam vertical trajectory owing to DV007 steering of 1 *mrad* is shown. In Fig.2A, the vertical positions of the beam at the MW's, shown in Table 2, are plotted. In Fig.2B, these positions are normalized using the vertical trajectory of the DV007 steering, shown in Fig.1. It is observed that the vertical steering of DV007 is linear, according to the data at MW060 and MW125.

3.2 Horizontal Motion

In Table 3, the beam horizontal positions at MW's are shown.

	At	β_H	I	II	III	IV	V	VI	Unit
MW006	4.34 m	3.368 m	-1.44	-1.66	-1.61	-1.16	-0.84	-0.95	mm
MW060	20.7 m	76.826 m	-8.89	-10.48	-10.2	-7.31	-4.49	-6.41	mm
MW125	42.3 m	30.882 m	0.77	-0.32	-0.22	1.38	3.07	1.49	mm

Table 3

To explain the horizontal motion, the beam positions at the MW006 are taken to represent the incoming beam. Also the incoming beam is assumed to be solely determined by the F6 steering. In Fig.3, the horizontal trajectory of the beam owing to F6 horizontal steering of 1 *mrad* is shown. In Fig.4A, the horizontal positions of the beam at the MW's, shown in Table 3, are plotted. In Fig.4B, these positions are normalized using the beam horizontal trajectory of the F6 steering, shown in Fig.3. Disregarding the offset, one may observe that the beam horizontal motion in this experiment can be explained by the F6 drift, and this motion is completely decoupled from the DV007 vertical steering. The maximum horizontal position deviation at MW060 is 5.99 *mm*, which is equivalent to the F6 steering of 0.3 *mrad.*

3.3 DH4 Beam Loss Pattern

In Table 4, the Booster late and the AGS CBM intensities are shown to indicate the total BTA beam loss for one AGS cycle, or 4 Booster cycles. The BTA line loss monitor data is also shown, together with the approximate loss monitor cable coverage in the line.

In Fig.5, the BTA114 loss monitor data and the BTA beam loss per AGS cycle are shown. The BTA114 loss monitor cable covers the section where DH4 is located. The DV007 driving current is normally set around -3 amperes to -5.5 amperes in the high intensity proton run. When the DV007 driving current is increased from -5.3 amperes to -0.37 amperes, both the BTA beam loss and the loss monitor BTA114 readings increase sharply, as shown in Fig.5. At these steerings, the beam horizontal positions monitored at the MW060 are within the range of -4.49 *mm* and -7.31 *mm*, these values are usually tolerable in the normal high intensity

HEP run. Considering that the vacuum chamber height at the DH4 is the tightest in the region, it is suggested that the beam is scraping vertically at DH4, on the top.

	At	I	II	III	IV	V	VI	Unit
B Late - AGS CBM		78-50	78-55.5	79-57	82-60	80-57	80-50	*TP*
BTA023	3-10 *m*	2047	2047	1804	2047	1934	2047	*cnts*
BTA045	10-17 *m*	666	5674	558	632	676	1778	*cnts*
BTA067	17-24 *m*	274	3121	225	230	323	965	*cnts*
BTA114	29-36 *m*	5580	8560	7990	8030	13530	15320	*cnts*
BTA137	36-43 *m*	1920	2910	2876	2979	5772	6889	*cnts*
BTA160	43-50 *m*	1318	2028	2009	2209	4571	5777	*cnts*
BTA183	50-57 *m*	666	950	916	1087	2097	2714	*cnts*
BTA206	57-63 *m*	510	655	570	700	1055	1345	*cnts*

Table 4

From Fig.1, for DV007 steering of 1 *mrad*, the beam positions at MW060 and MW125 are 13.64 *mm* and -6.97 *mm*, respectively. From Table 2, the full vertical drifts at MW060 and MW125 are 8.59 *mm* and -3.79 *mm*, respectively, in an order starting from settings I to VI. This gives rise to full steering strength of 0.63 *mrad* and 0.54 *mrad* at DV007, respectively. If the steering strength of 0.63 *mrad* is used, then according to the trajectory at DH4 due to DV007 steering of 1 *mrad* (which is 3.34 *mm*), it is found that the full vertical range of steering at DH4 is only 2.1 *mm*. This is not large enough to give rise to a very conclusive result. The effect with this small vertical steering, however, is large. Moving the beam vertically by 1.2 *mm*, i.e., from DV007 current -5.3 *A* to -0.37 *A*, increases the BTA114 loss monitor reading by 7290 counts, and also increases the BTA beam loss by 8 *TP* for an AGS cycle. Whether this amount of beam is lost just at DH4 or also at other places is not known.

Taking the vertical normalized beam emittance as 60 $\pi mmmr$, we calculate that the beam size for 95% particles at DH4 (where the beta function is 18.744 *m*), is $2.45 \times 8.75 = 21.44$ *mm*. Comparing this size with the local maximum vacuum chamber half height of 33 *mm*, the beam does not fill the chamber.

On the other hand, moving the beam to the opposite direction at DH4, the local beam loss observed by the loss monitor in the BTA line is reduced, the total Booster to AGS transfer loss, however, is increased. This mechanism is not yet understood.

Vertical Trajectory of DV007 Steering of 1 mrad

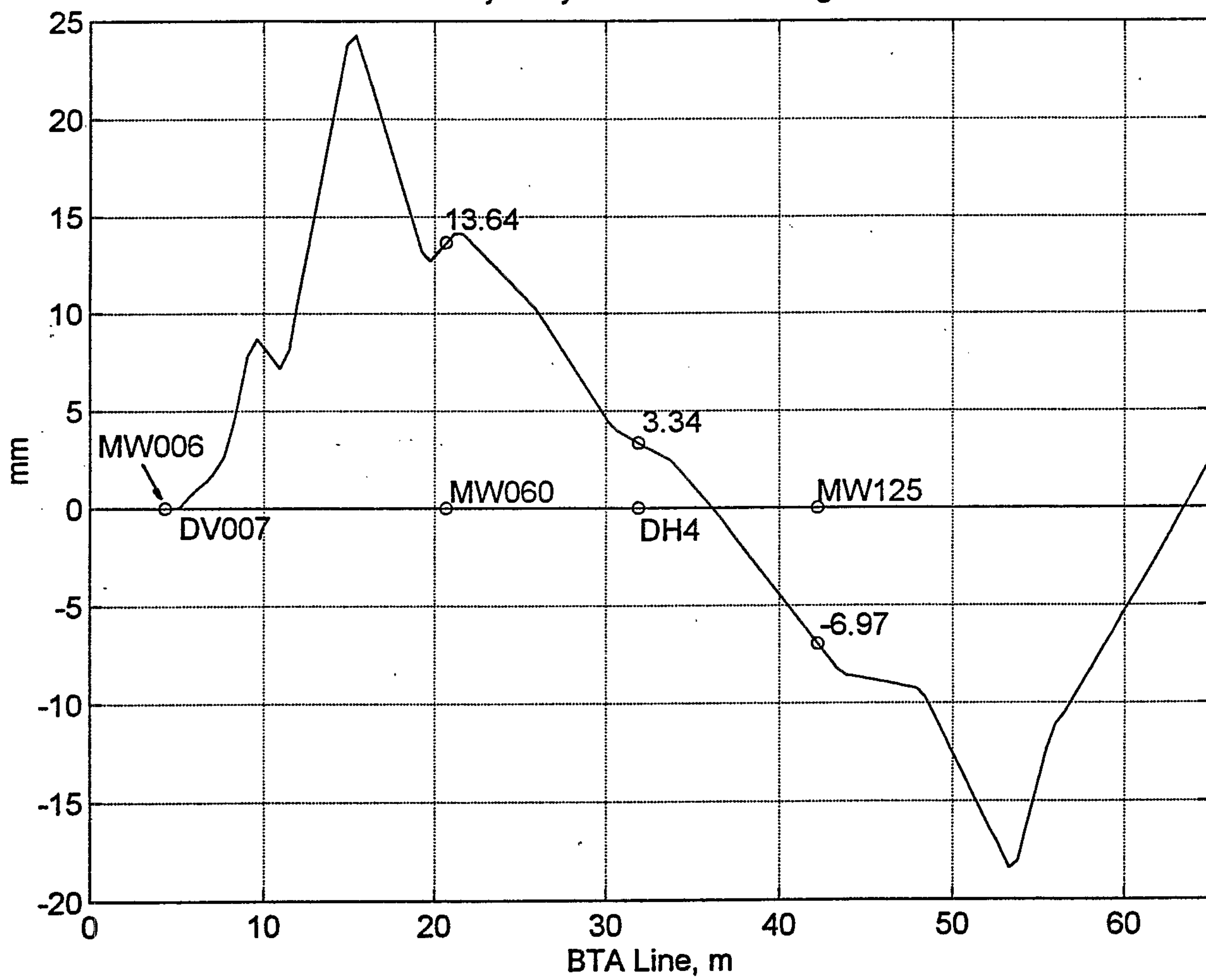
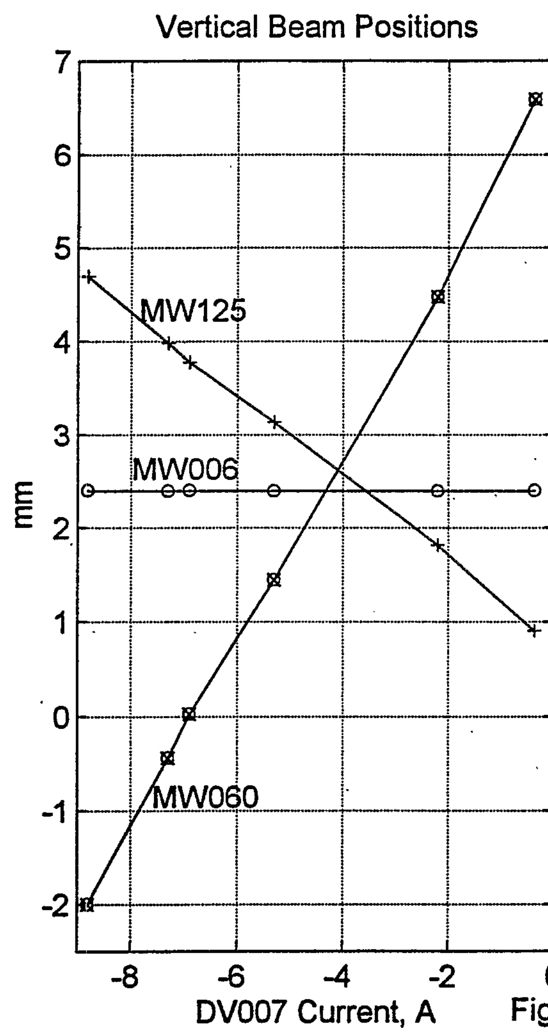
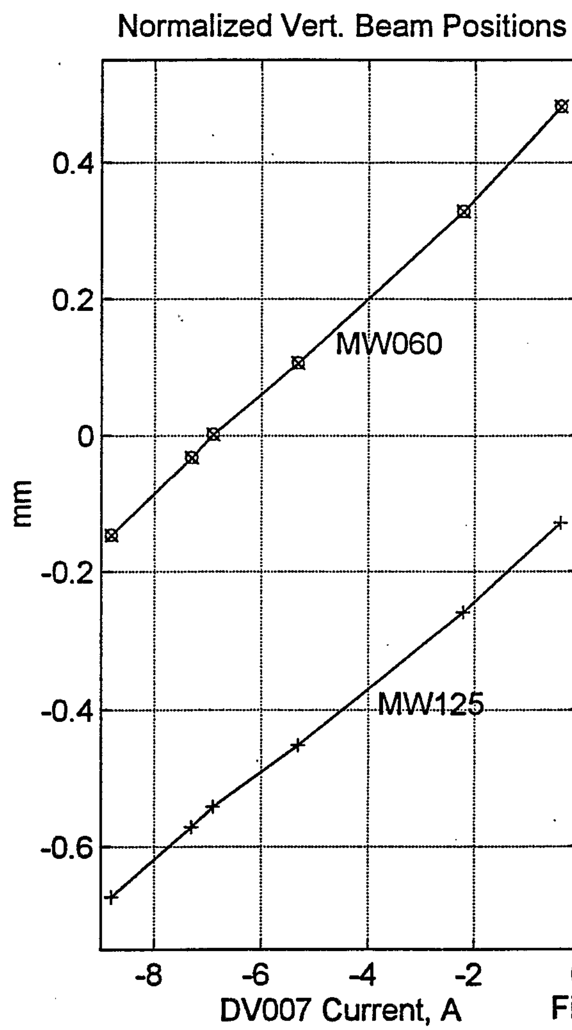


Fig.1



Vertical Beam Positions
7
6
5
4
3
2
1
0
-1
-2
mm
MW125
MW006
MW060
-8
-6
-4
-2
0
DV007 Current, A

Fig.2A



Normalized Vert. Beam Positions
0.4
0.2
0
-0.2
-0.4
-0.6
mm
MW060
MW125
-8
-6
-4
-2
0
DV007 Current, A

Fig.2B

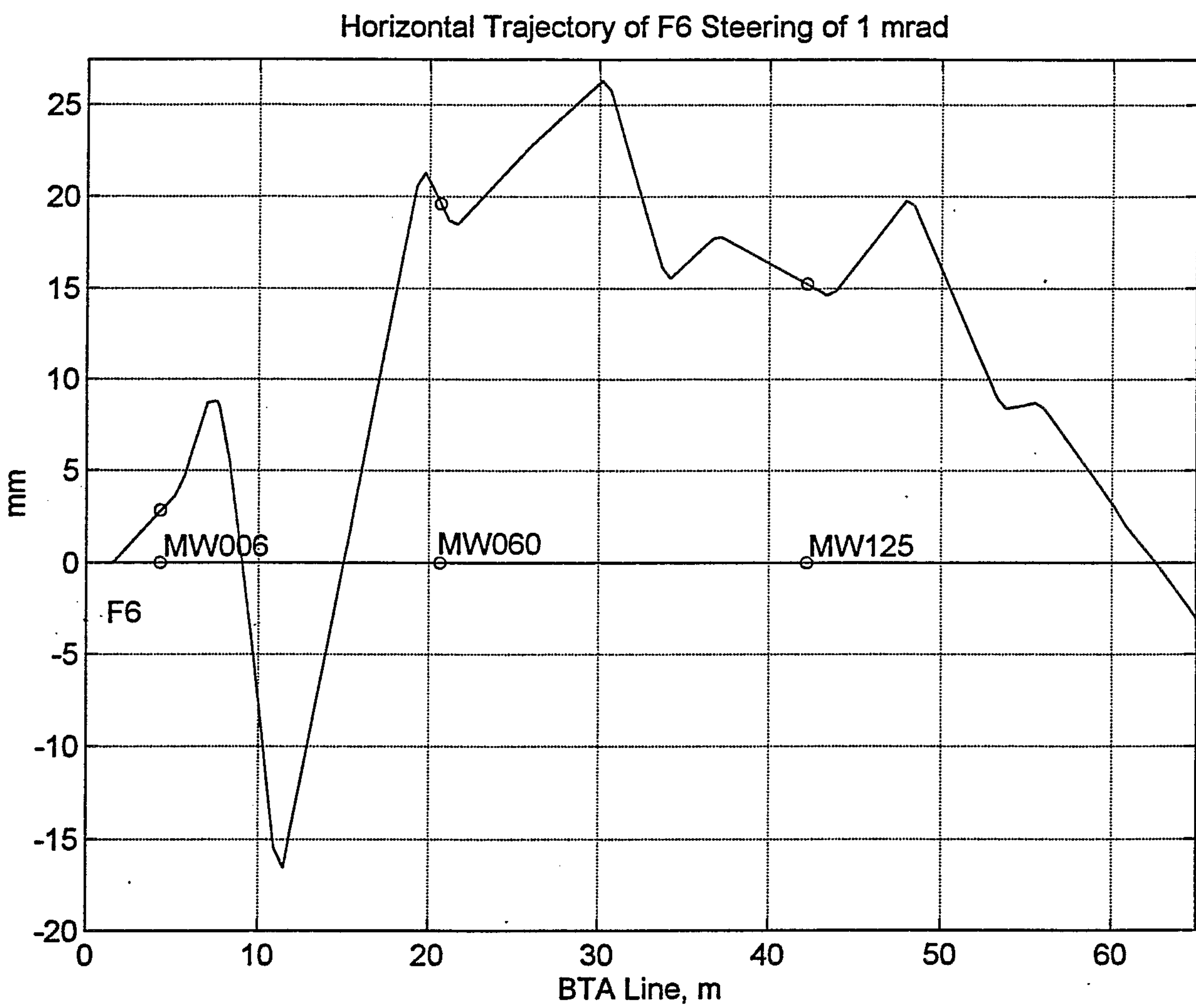

Horizontal Trajectory of F6 Steering of 1 mrad
25
20
15
10
5
0
-5
-10
-15
-20
mm
MW006
MW060
MW125
F6
0
10
20
30
40
50
60
BTA Line, m

Fig.3

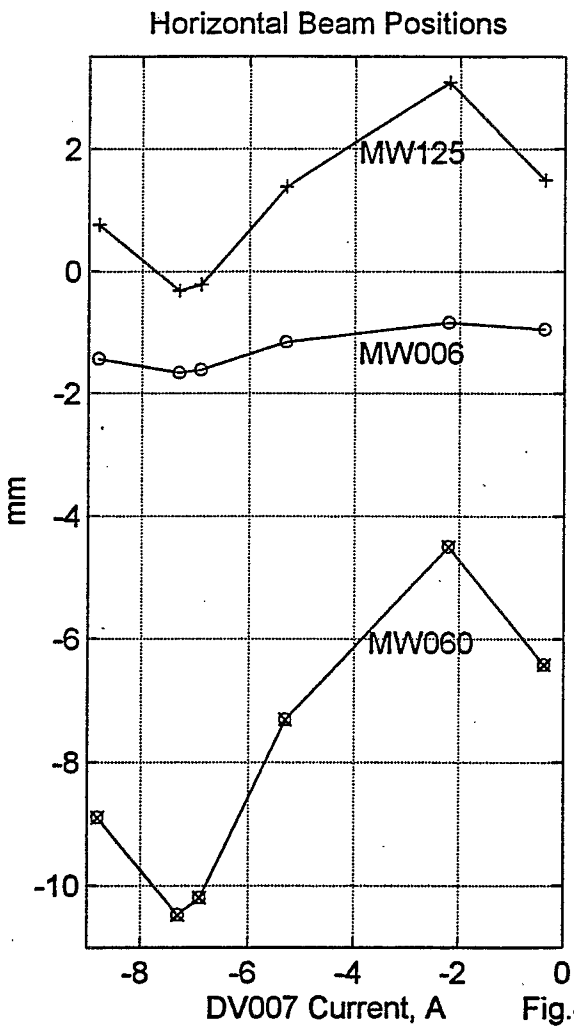

Horizontal Beam Positions
MW125
MW006
MW060
mm
2
0
-2
-4
-6
-8
-10
-8
-6
-4
-2
0
DV007 Current, A

Fig.4A

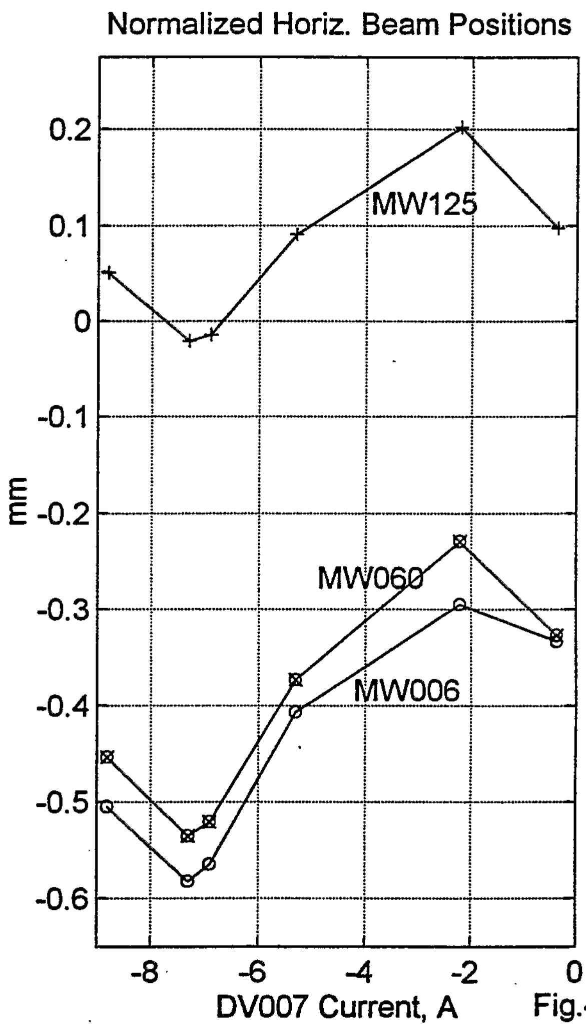
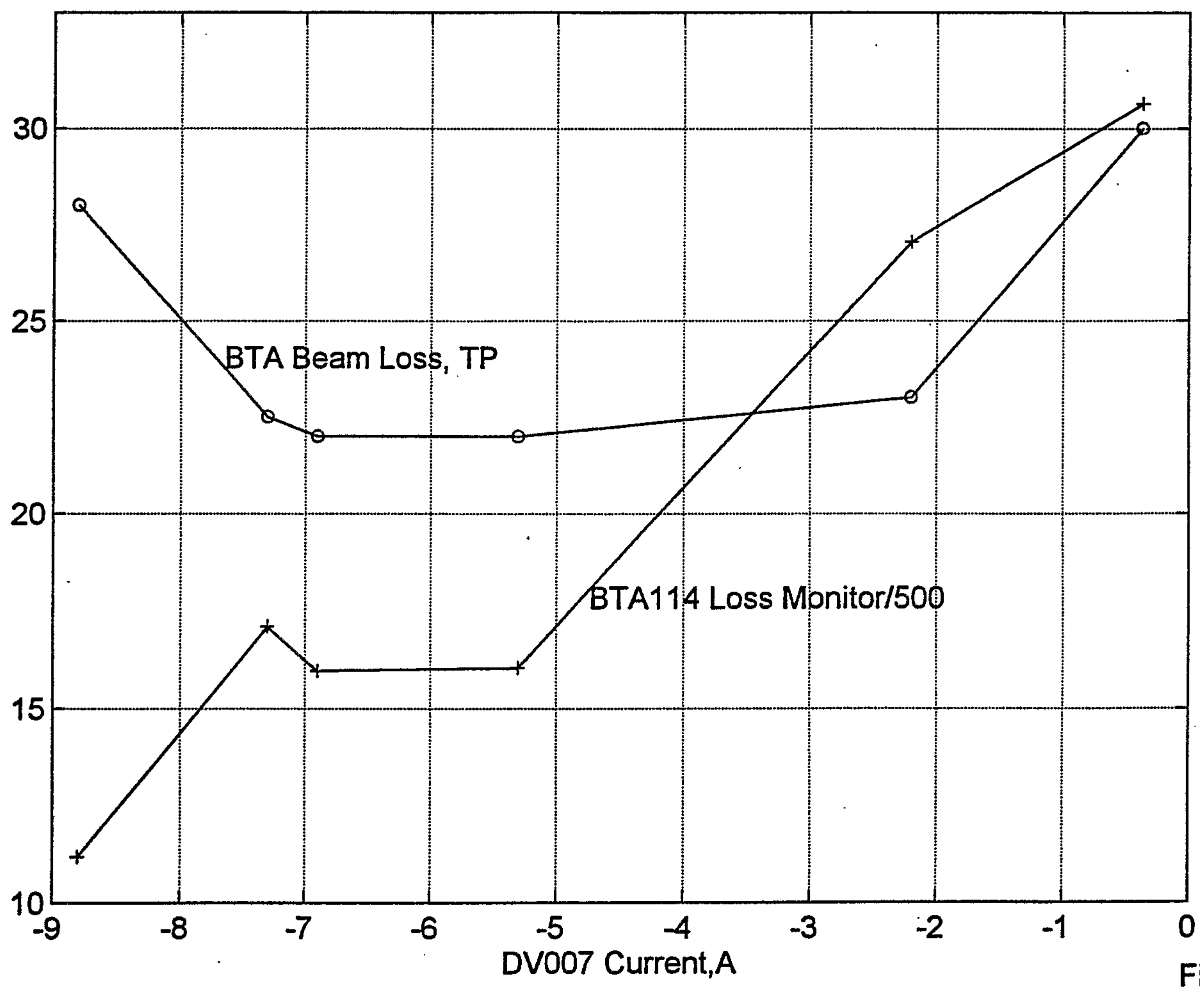

Normalized Horiz. Beam Positions
MW125
MW060
MW006
mm
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-8
-6
-4
-2
0
DV007 Current, A

Fig.4B



30
25
20
15
10
-9
-8
-7
-6
-5
-4
-3
-2
-1
0
BTA Beam Loss, TP
BTA114 Loss Monitor/500
DV007 Current,A

Fig.5