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Gold Beam BTA Transfer

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Title: Gold Beam BTA Transfer

Study Period: January 9, 1997, 1200-1300

Participants: P. Sampson, H. Huang, S.Y. Zhang

Reported by: S.Y. Zhang

Machine: BTA Transfer Line

Beam: Au 32+

Tools: Vertical Steering Magnets, Multiwires in BTA

Aim: To verify that the gold beam is scraping vertically at DH2 and DH3. To explore the application of MW for relative beam intensity variation.

Gold Beam BTA Transfer

1 Summary

1. The vertical acceptance at DH2 and DH3 in the BTA line is very tight, and the gold beam is scraping there. This is verified by vertically steering the beam, and observing the downstream intensity variation.

2. The relative beam intensity variation is observed by using the beam size and amplitude at the downstream multiwires. The tumbling of the heavily scraped beam is also observed through the transfer line.

3. A few days before the end of run, the BTA line optics is modified to improve the transfer efficiency.

2 Beam Size and Line Acceptance

The 1996-97 Au^{32+} beam emittance observed at BTA MW006 is shown in Fig.1, for both vertical and horizontal. Note that the emittance shown in Fig1 might be a little larger than it should be. The reason of this is that the initial conditions of the beam entering the BTA line are probably with some error in forming the BTA model. Given the model, one may take this situation as a 'mis-matching' of the beam with the transfer line.

In Fig.2, the BTA line aperture together with the beam size are shown. The beam half vertical size is for the normalized 95% emittance of 5 π *mmmr*, and the horizontal, 9.5 π *mmmr*, with the beam momentum spread $dp/p = \pm 0.2\%$. Also shown are the beam size observed at MW006, MW060, MW125, and MW166 in the BTA line in the Morning Number Log Book, which are plotted as dots, but look like bars. The data plotted are from Nov. 21, 1996 to Jan. 28, 1997, totally 63 set of numbers.

By examining the real data with the beam size given by the BTA line optics model, as shown in Fig.2, one may conclude that this model is usable. This optics model is obtained from P. Sampson.

It is also clear that the gold beam is scraping vertically at DH2 and DH3.

3 The Experiment

Using the newly installed vertical steering magnet DV030, about 4 *meters* upstream of DH2, the beam was steered at strength from about -1.5 *mr* to 1.5 *mr*, corresponding to DV030 driving current from -11.6 *A* to 4.6 *A*. Each step is apart from the next one by 2 *A*. The operation set point of the DV030 current is -3.6 A. This steering gives rise to the full range of the beam center movement at DH2 and DH3 of 10 mm, enough to see the difference in the scraping.

The steering is straightforward, however, the observation of the beam intensity variation with respect to the steering is not. The BTA line transformers, the loss monitors, and the transformers in the AGS ring, after some test, are all failed for this purpose. Early on, T. Roser suggested that the beam size and amplitude obtained by multiwires might be used to look at the beam intensity. The calibration of these multiwires is probably not very good, however, in this experiment, only the relative variation of the intensity is needed. The beam position, size, and amplitude at the multiwires are taken by using the application /USERS/SAMPSON/LOGMW_dir/LOGMW. For a Gaussian distribution, the area of the signal, which represents the beam intensity, is proportional to the rms size. Therefore, the beam intensity is obtained by using the rms beam size multiplied by the amplitude.

Since that the DH2 and DH3 are located between MW006 and MW060, the original beam intensity is identified by the intensity obtained at MW006. The intensities at other 3 multiwires are compared with this intensity. In Fig.3, the intensity variations of MW060, MW125, and MW166 are shown by their intensities divided by the MW006 intensities, along with the steering. The operation set point, i.e. DV030 current of -3.6 A, turns out not optimized in terms of the scraping at DH2 and DH3. However, the scraping effect in both directions still can be observed. Consider the relative intensity variation, the ratio of the most heavily scraped beam over the least scraped beam at MW060 is about $65/73 = 0.89$. At MW125, it is $50/55 = 0.9$, and at MW166, $40/44 = 0.9$. It looks that between MW060 to MW166, there is no more beam loss relevant to the steering.

4 Tumbling of the Scraped Beam

The phase advance between the exit of DH2 to the entrance of DH3 vacuum chambers is only about 2 degrees, therefore, the scraping is one-dimensional. The scraping in this experiment is considered not small. Thus, the scraped beam will be tumbling along the transfer line. The phase advance between DH3 to MW060 is again only about 3 degrees, therefore, MW060 gives rise to perfect observation of the scraping, as shown in Fig.4. The phase advances of MW125 and MW166 to DH3 are 63 and 198 degrees, respectively. Therefore, the beam size variation observed at MW125 does not show much for the scraping, whereas the MW166 shows the similar variation as that of MW060. This represents the tumbling of the scraped beam along the transfer line.

5 Optics Modification

By Jan. 29, 1997, a few days before the machine shutdown, K. Zeno modified the BTA optics by adjusting the quadrupoles as shown in Table 1, where only the modified quadrupoles are shown,

	QH2	QV3	QH8	QV9	QV11	QH12	QV13	QH14	QV15	
Original	387	118	219	202	160	158	182	150	51	A
New	440	211	214	192	150	168	123	124	58	A
Change	14	79	-1	-5	-6	6	-32	-17	14	%

Table 1

It can be observed from Fig.2 that the transfer line aperture is pretty large except only vertically at DH2 and DH3. In Table 1, the biggest change is QV3, the driving current is increased by 79%. The resulting beam size for the same emittance is shown in Fig.5, where the vertical scraping at DH2 and DH3 is improved. Zeno claimed that this change improved the BTA transfer efficiency from 35% to 38%. Since the Booster late intensity is inflated by the Booster circulating transformer calibration by about 17%, the BTA transfer efficiency is in fact increased from 40% to 44%. Taking 60% stripping efficiency and 75% efficiency due to the short pulse of the fast kickers BF3 and AA5, the gold beam transfer efficiency is in a good shape.

The job remains to be done is to set the downstream quadrupoles to improve the optics matching between the BTA to the AGS. Meanwhile, the possible vertical scraping downstream at AGS L20 septum, as shown in Fig.5, should be avoided.

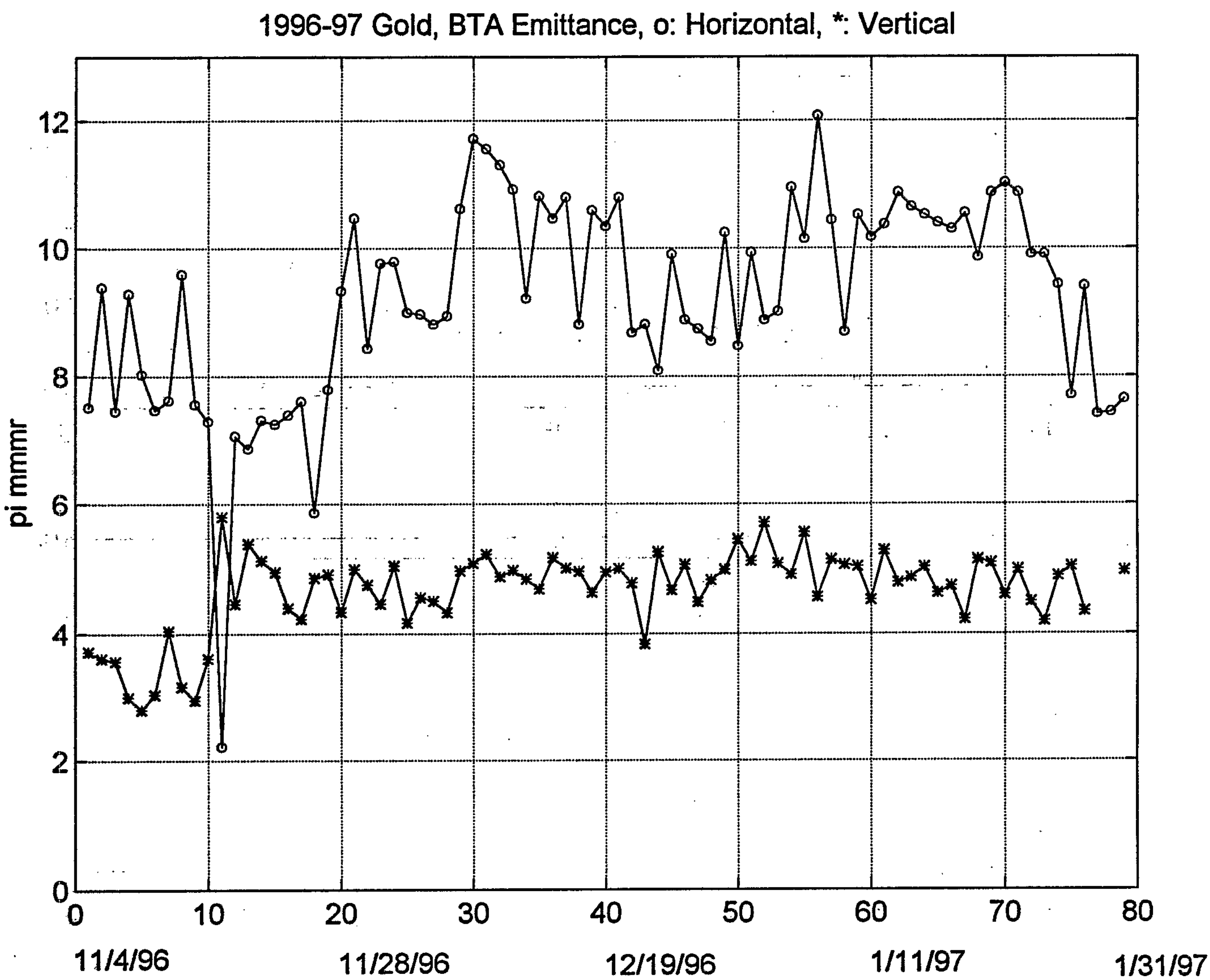

1996-97 Gold, BTA Emittance, o: Horizontal, *: Vertical
pi mmmr
0
2
4
6
8
10
12
0
10
20
30
40
50
60
70
80
11/4/96
11/28/96
12/19/96
1/11/97
1/31/97

Fig.1

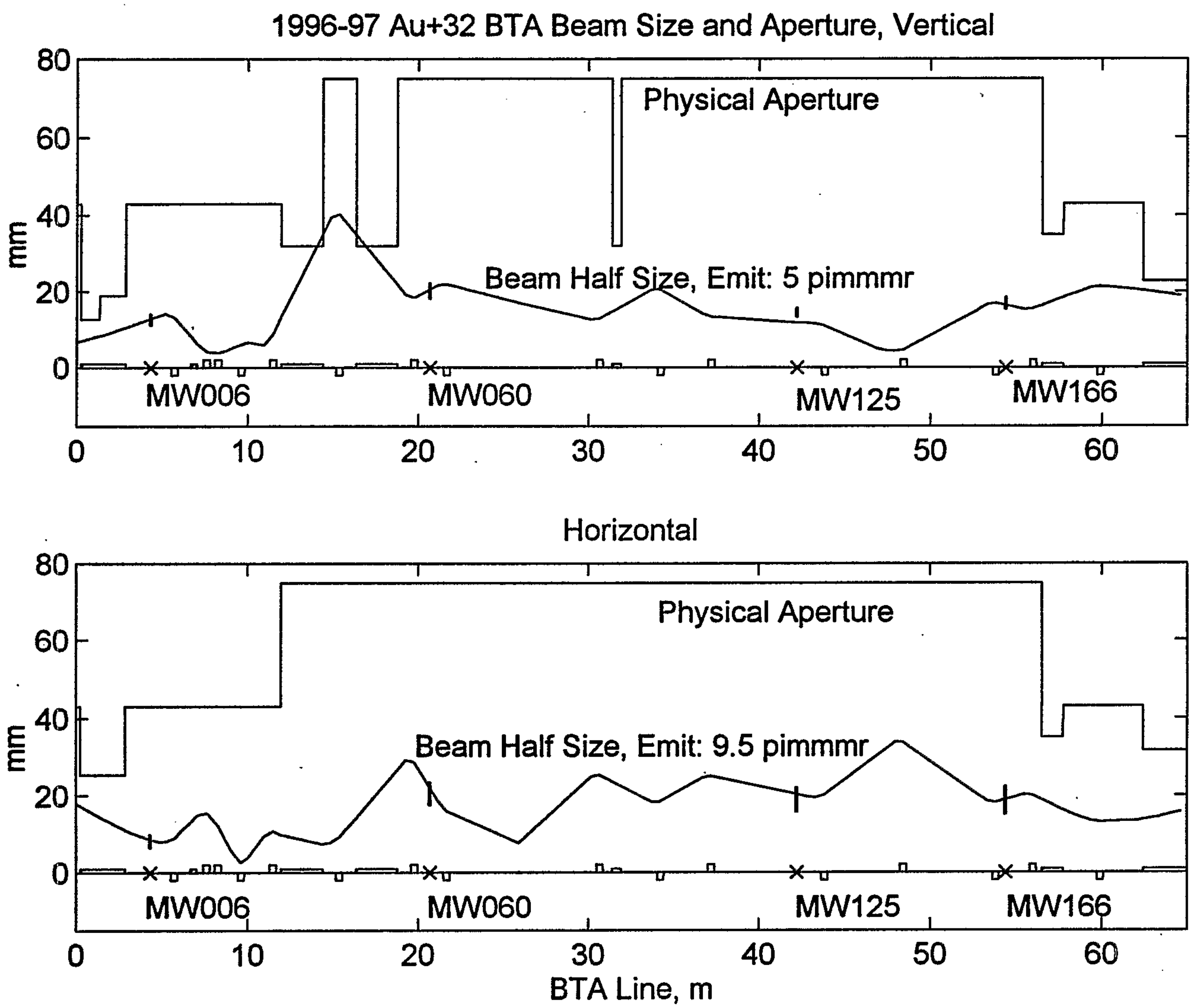
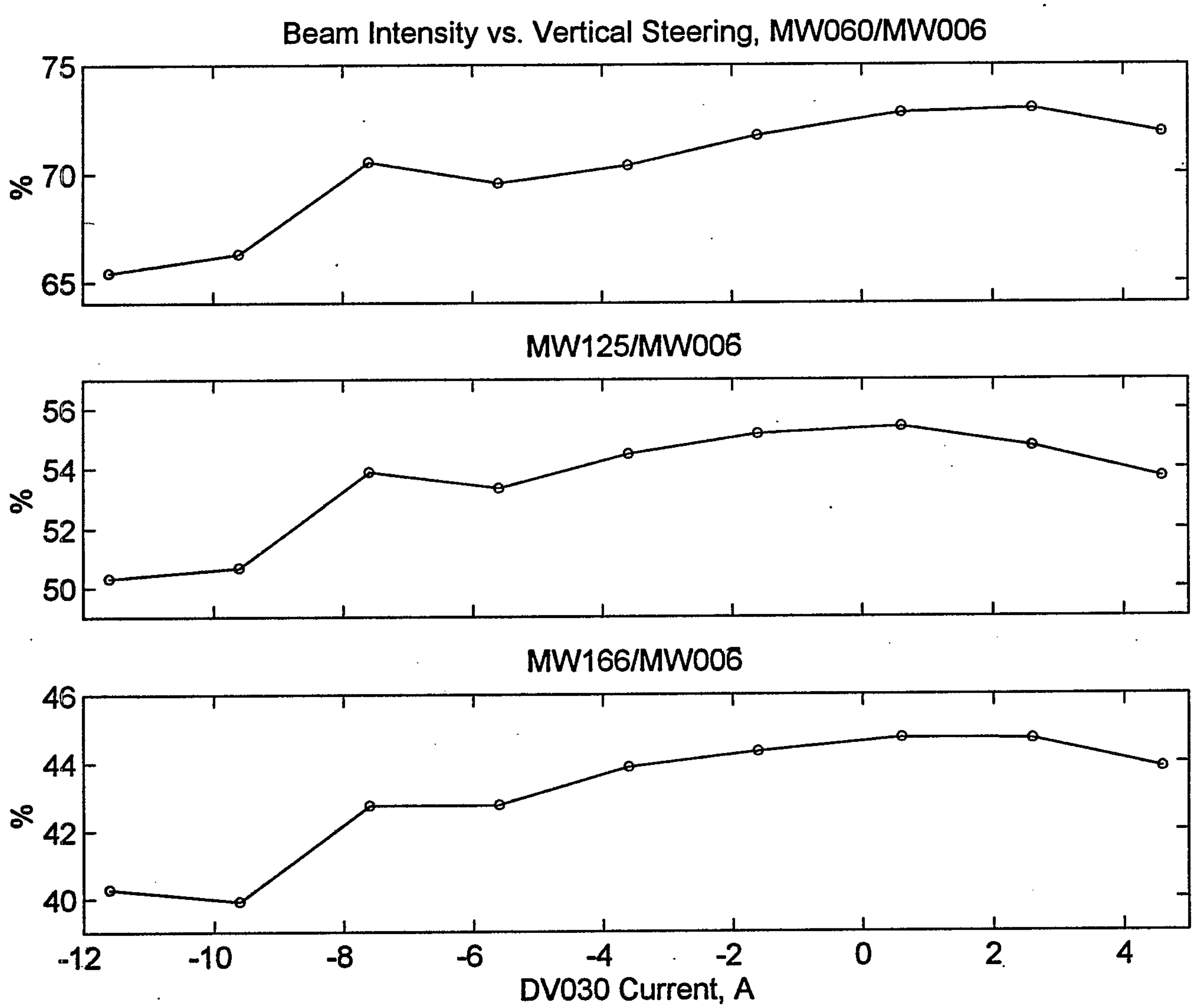

1996-97 Au+32 BTA Beam Size and Aperture, Vertical
Physical Aperture
Beam Half Size, Emit: 5 pimmmr
mm
MW006
MW060
MW125
MW166
Horizontal
Physical Aperture
Beam Half Size, Emit: 9.5 pimmmr
mm
BTA Line, m

Fig.2



Beam Intensity vs. Vertical Steering, MW060/MW006
75
70
65
%
MW125/MW006
56
54
52
50
%
MW166/MW006
46
44
42
40
%
-12
-10
-8
-6
-4
-2
0
2
4
DV030 Current, A

Fig.3

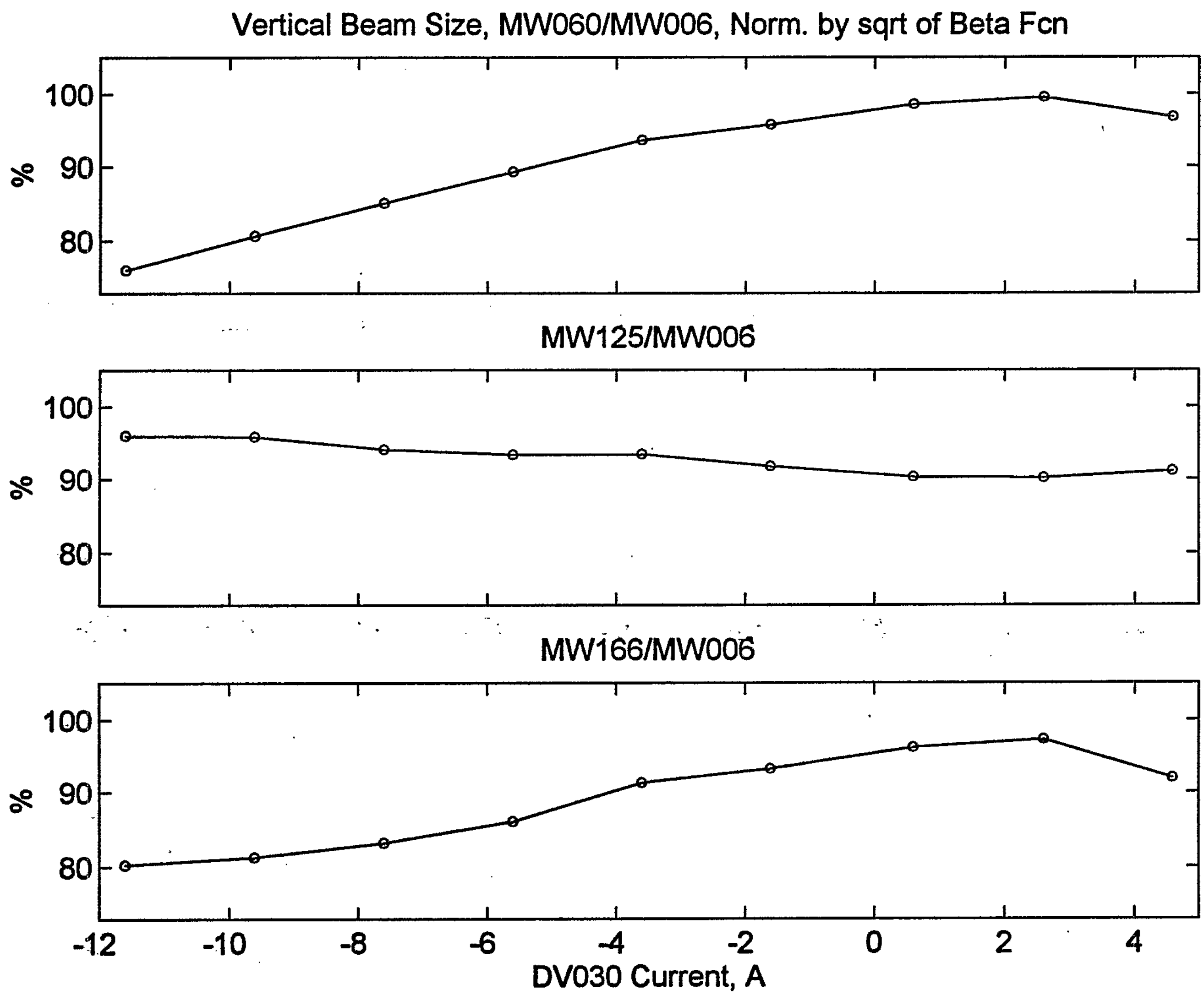
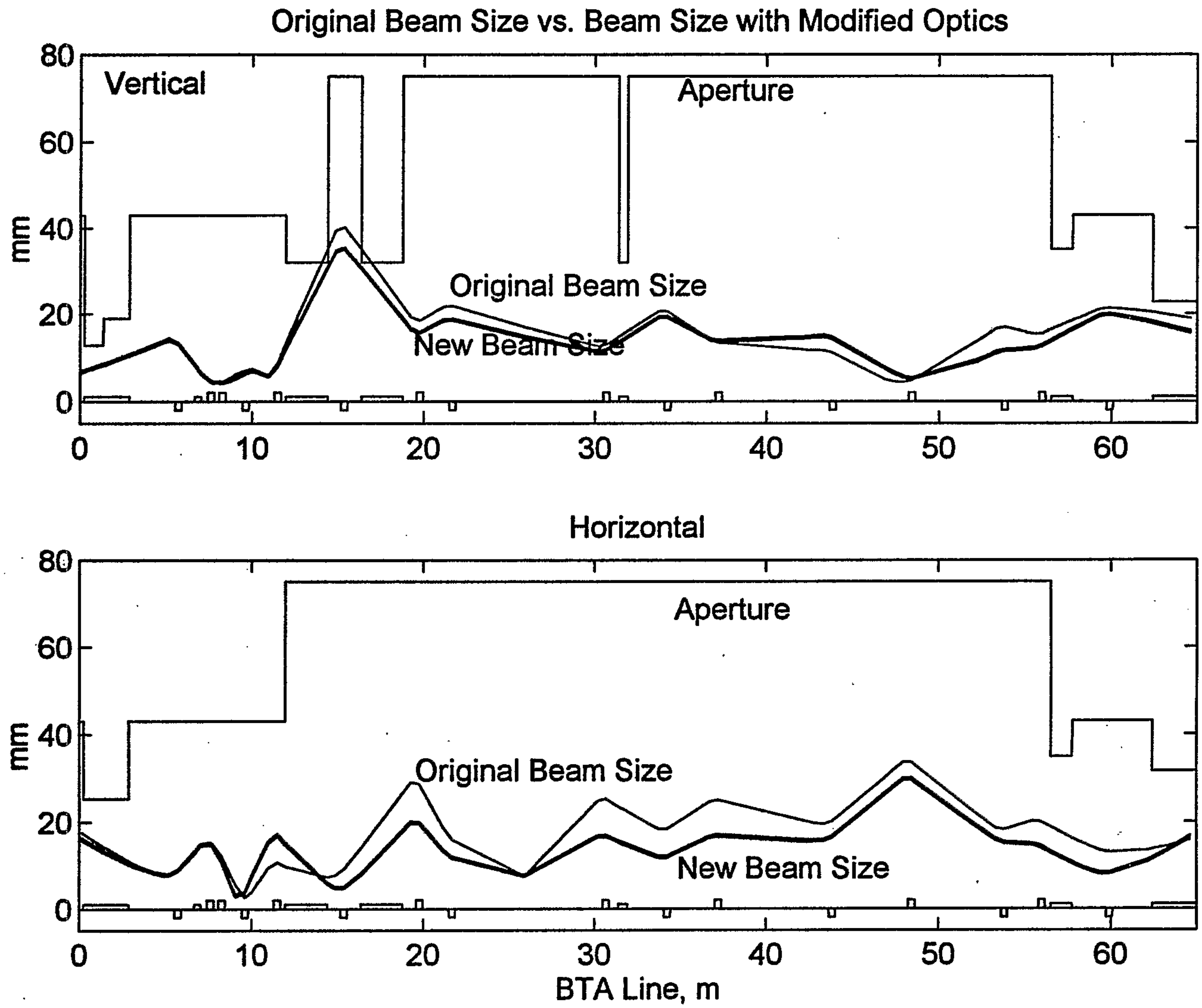

Vertical Beam Size, MW060/MW006, Norm. by sqrt of Beta Fcn
%
100
90
80
MW125/MW006
%
100
90
80
MW166/MW006
%
100
90
80
-12
-10
-8
-6
-4
-2
0
2
4
DV030 Current, A

Fig.4



Original Beam Size vs. Beam Size with Modified Optics
Vertical
Aperture
Original Beam Size
New Beam Size
mm
Horizontal
Aperture
Original Beam Size
New Beam Size
mm
BTA Line, m

Fig.5