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Daily Log Summary IV: BTA Horizontal Steering and Emittance

E. Bleser

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Collider Accelerator Department

Brookhaven National Laboratory

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DISCLAIMER

AGS Complex Machine Studies (AGS Studies Report No. 323) Daily Log Summary IV: BTA Horizontal Steering and Emittance
Study Period: March - July, 1994
Participants: Main Control Room Staff
Principals: K. Zeno and B. Tamminga
Reported by: E. Bleser
Machine: AGS Proton Complex
Aim: To Analyze the Horizontal Beam in the BTA.

MODEL

For this note we assume the BTA line is fixed and constant for the 1994 proton run. The details of the model will be documented later. The parameters are given in Table 1.

TABLE 1. BTA LINE HORIZONTALOPTICS

	BETAX	ALPHAX	MUX
	m		2 Pi
MW006	3.368	0.378	0.114
MW060	86.528	8.937	1.168
MW125	23.581	2.345	1.223
MW166	3.082	−0.752	1.48

DATA

The data come from the Daily Log Reports and are the horizontal beam positions and the full width at half-maximum beam sizes measured at the four multiwires in the BTA. As discussed below, we exclude data taken prior to March 22, 1994.

STEERING RESULTS

From the positions of the beam at MW006 and at MW060, we can calculate the angle of the beam at MW006 and plot in Figure 1 the phase space at MW006 mapped out by the beam center over a period of four months. Figures 2 through 4 are similar plots for the other three multiwires. Also shown on the plots are emittance envelopes that would be generated by the central orbits of an array of beams that left the Booster with a central orbit emittance of 4 π mm mr. This value was selected by making an eyeball fit to the data,and the envelopes were centered on the data also by eyeball. The results at MW006 and MW060 are good, at MW125 there is more scatter than we might like, and at MW 166 something else is plainly going on.

One possible explanation for the scatter is that the DH4 magnet was being adjusted. Figures 5 and 6 repeat Figures 3 and 4 but use all the available data from the start of the run and include a line showing what would happen if magnet DH4 were varied by $\pm$ 1 milliradian.

Another example of steering effects is shown in Figure 7, which shows the horizontal position at MW125 plotted versus the position at MW060. Some of the data points are labelled with numbers that correspond to dates in March, 1994. Note that between the 16th and 17th the beam was shifted, for five days it stayed in this new condition, and then between the 21st and the 22nd it returned to its normal condition. From the Booster Proton Log Book we find that the 16th was a shutdown day, the machine apparently came back up in a strange condition, which was ignored while people worked on Booster injection, until on the 22nd the operator noted:

> "Found that BTA losses/transfer eff was very bad. Reloaded archive from 1-1/2 weeks ago to improve these."

The archive that was reloaded changed various bending magnets in the BTA line, but we have not tried to sort out the detailed effects of this change. For most of this paper, we have excluded data taken prior to March 22.

Another question is why the data in the figure seem to lie along lines sloping 30 degrees positive, as typified by the set of points from March 17 to March 21. Figure 8 shows these points plotted alone along with a model prediction of what would happen to the beam of March 19 if it were given a 1 milliradian kick by the F6 septum. The results are remarkably good and strongly suggest that the F6 septum has a 1.5 milliradian jitter that gives the orbits a 3 centimeter spread at MW060. The time dependence of this jitter should be a fruitful and easy area of study.

For completeness, Figure 9 shows the data and the predictions at MW006, which amounts to only a few millimeters of scatter. Figure 10 shows the data and the model at MW166, where the agreement is not very good. We shall see below that the model has problems at MW166, and in addition for this set of data the beam could well have been scraping the wall.

EMITTANCE RESULTS

Squaring the measured FWHMs and dividing by the beta values from the model gives an emittance value containing 99% of the beam. Figures 11, 12, and 13 show the emittances at the downstream multiwires plotted versus the emittance at MW006. No allowance for momentum dispersion has been made. Also shown on the plots are a 45 degree line and a fitted line. The emittances measured by multiwires 060 and 125 are in good agreement, but they are 20% low from that at MW006.

To emphasize how well MW060 and MW125 agree, Figure 14 shows the emittance at MW125 plotted versus the emittance at MW060. The fitted slope is 1.01 ± 0.06 when we expect 1. Further analysis is needed before settling on the best absolute value of the emittance.

In Figure 13 at MW166, the emittance is a factor of 2.3 larger than expected. The model must be examined here. Another problem is that late in the run, when the intensity and hence the emittance were large, the emittances measured at MW166 were around 60 π mm mr when we might have expected them to be less than 50. This shows up as a bulge in the data. This could have resulted from some magnet retuning.

CONCLUSIONS

The horizontal data is not as clean as the vertical data (AGS Studies Reports 320 and 321) but still is very suggestive. The variability in the horizontal steering seems to be dominated by:

1. Jitter in the F6 septum
2. Inadvertent steering magnet settings
3. Adjustments of DH4

The model, while not completely perfect at the first three multiwires, has serious problems at the last multiwire. However, this data gives us good criteria for exploring the inputs to the model.

Figure 1: PHASE SPACE AT MW006

Betax=3.368, Alphax=0.378, dX=0.0, dX'=0.5

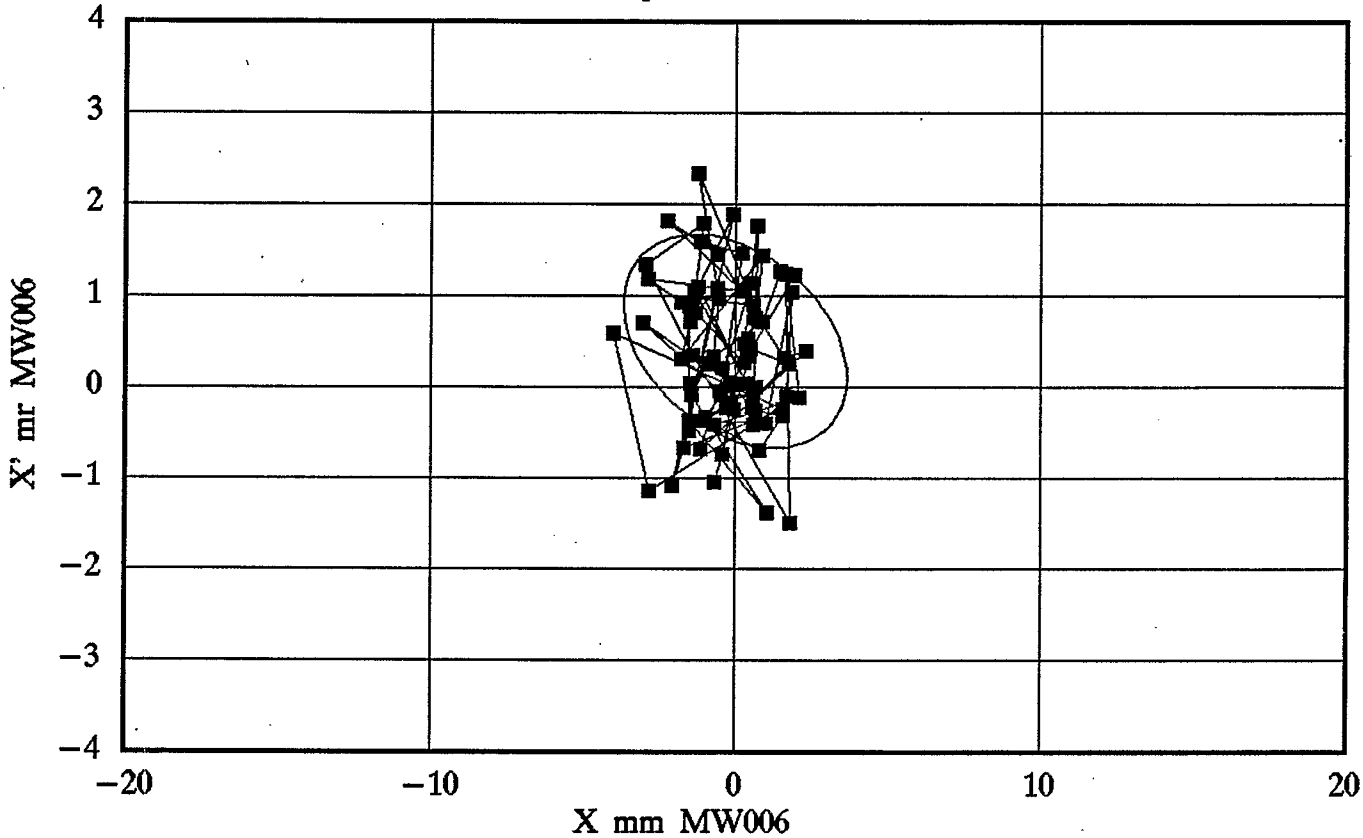

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Figure 2: PHASE SPACE AT MW060

Betax=86.528, Alphax=8.937

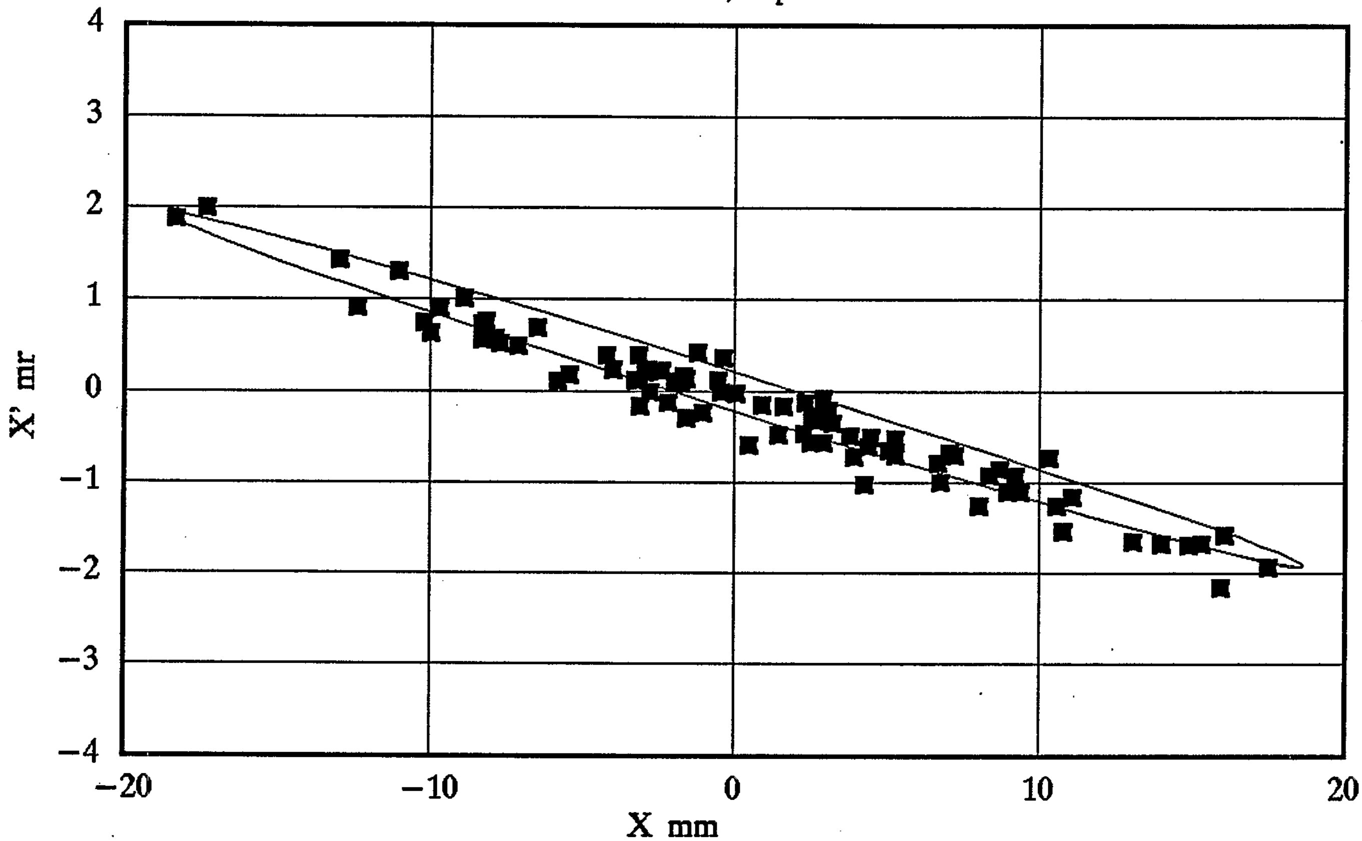

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Figure 3: PHASE SPACE AT MW125

Betax=23.581, Alphax=2.345, dX=0.0, dX'=−0.2

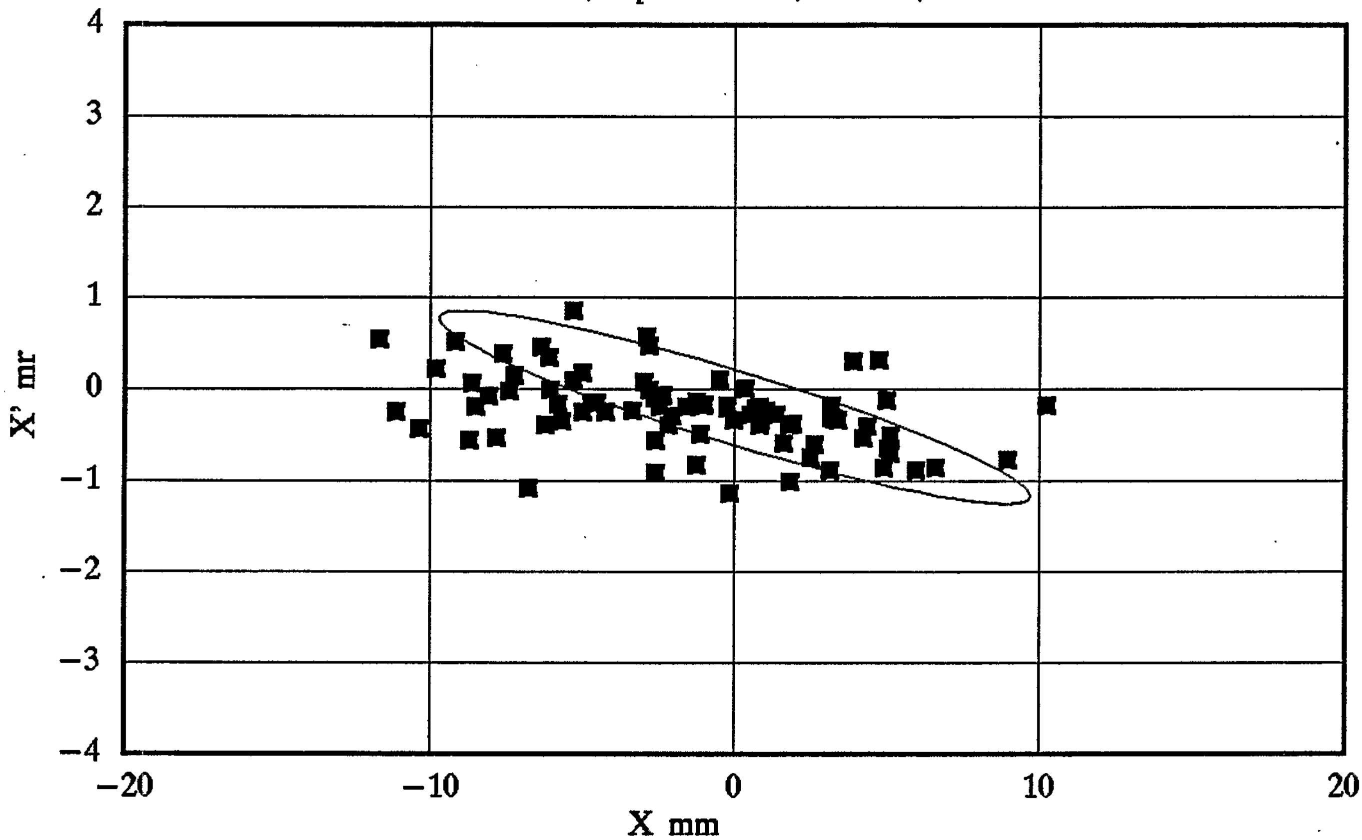

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Figure 4: PHASE SPACE AT MW166

Betax=3.028, Alphax=−0.752, dX=−2.5, dX'=−0.5

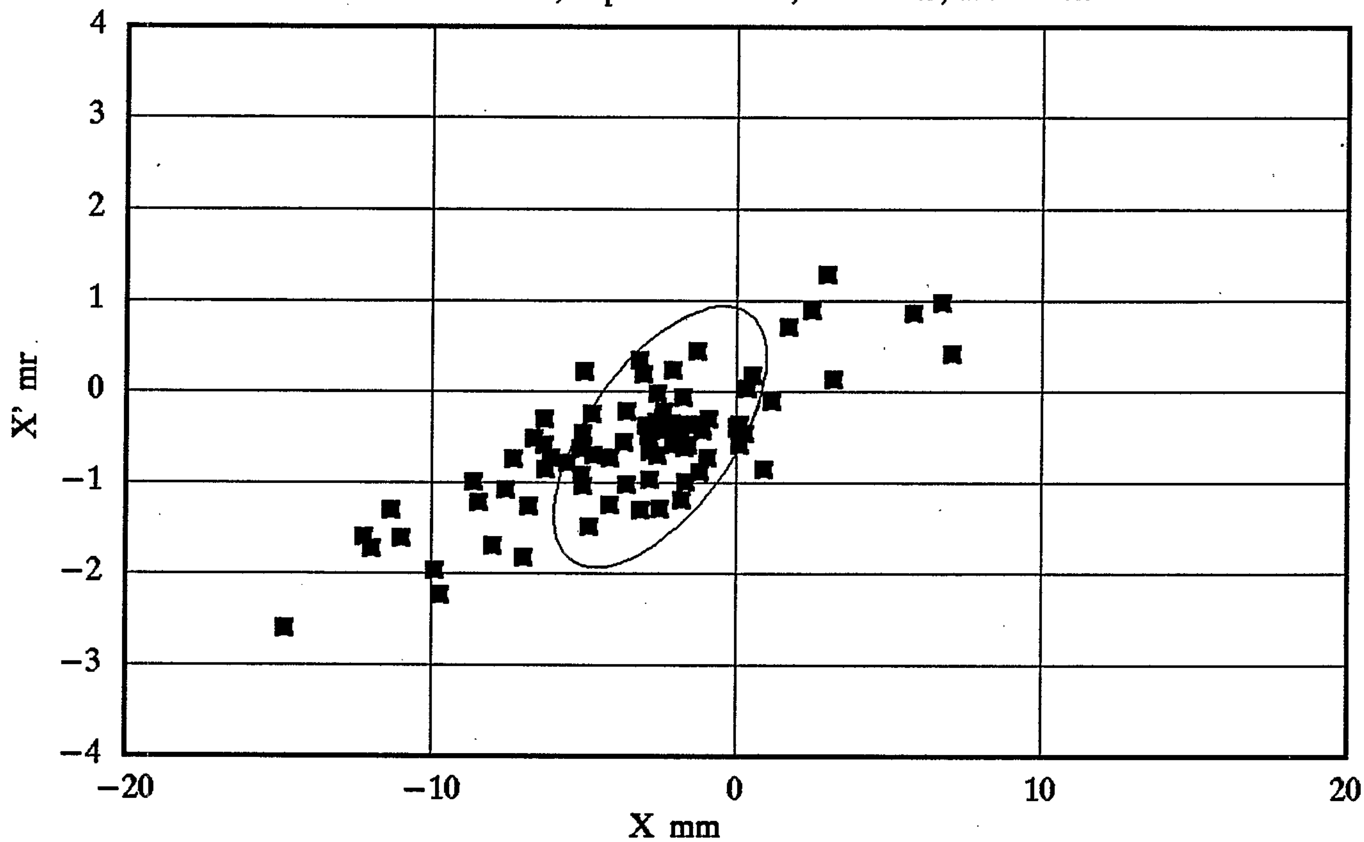

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Figure 5: PHASE SPACE AT MW125

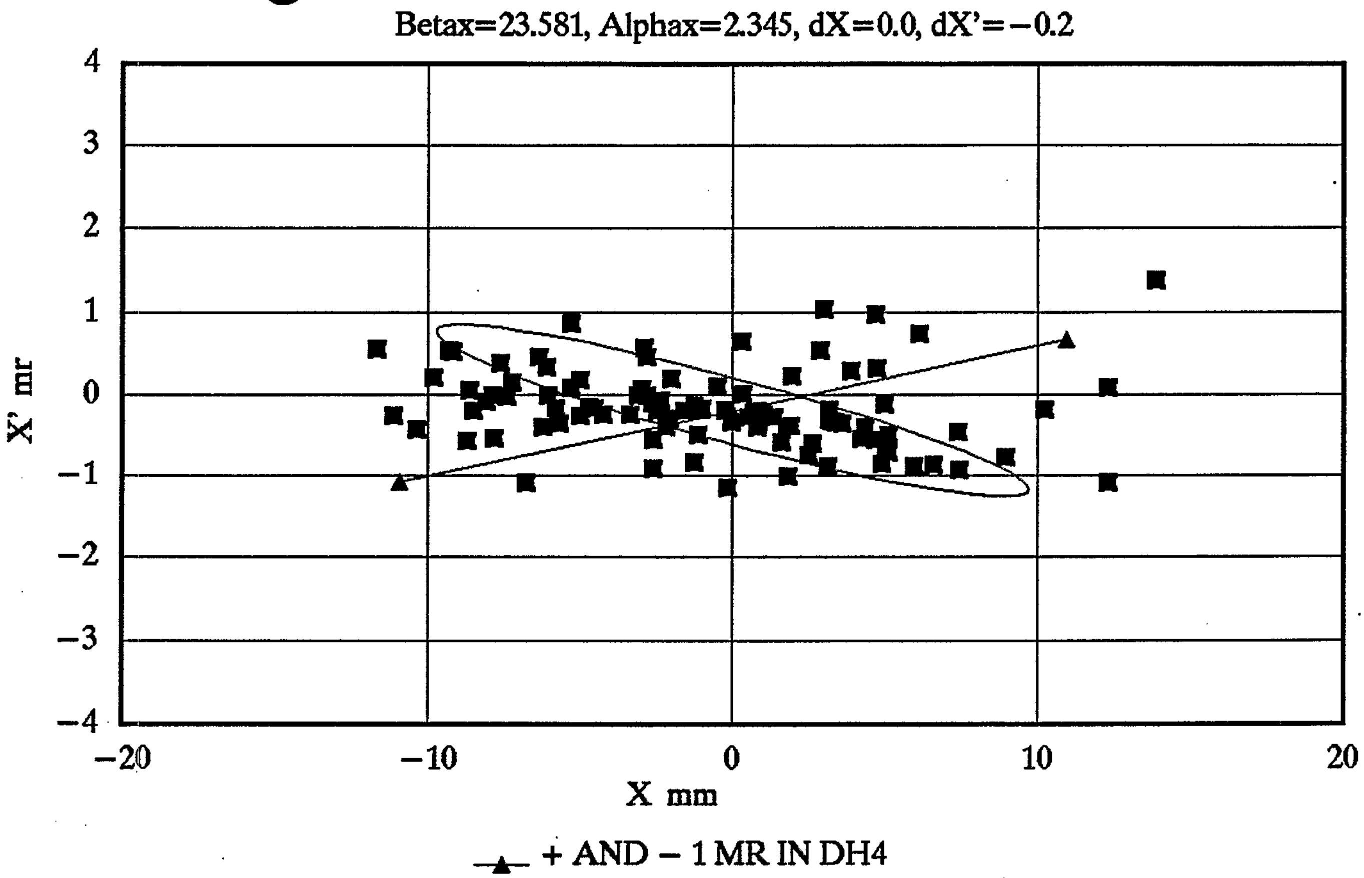

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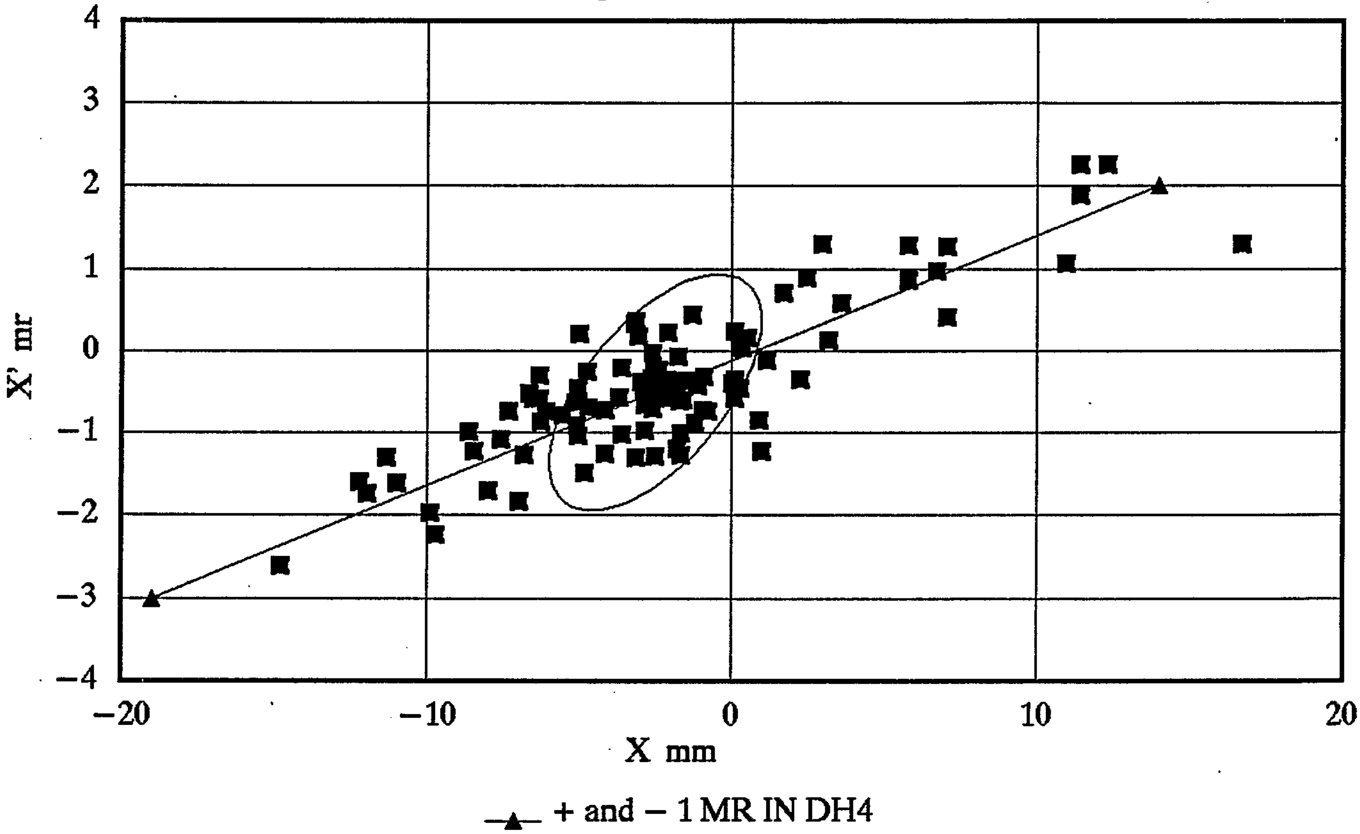
Figure 6: PHASE SPACE AT MW166

Betax=3.028, Alphax=−0.752, dX=−2.5, dX'=−0.5



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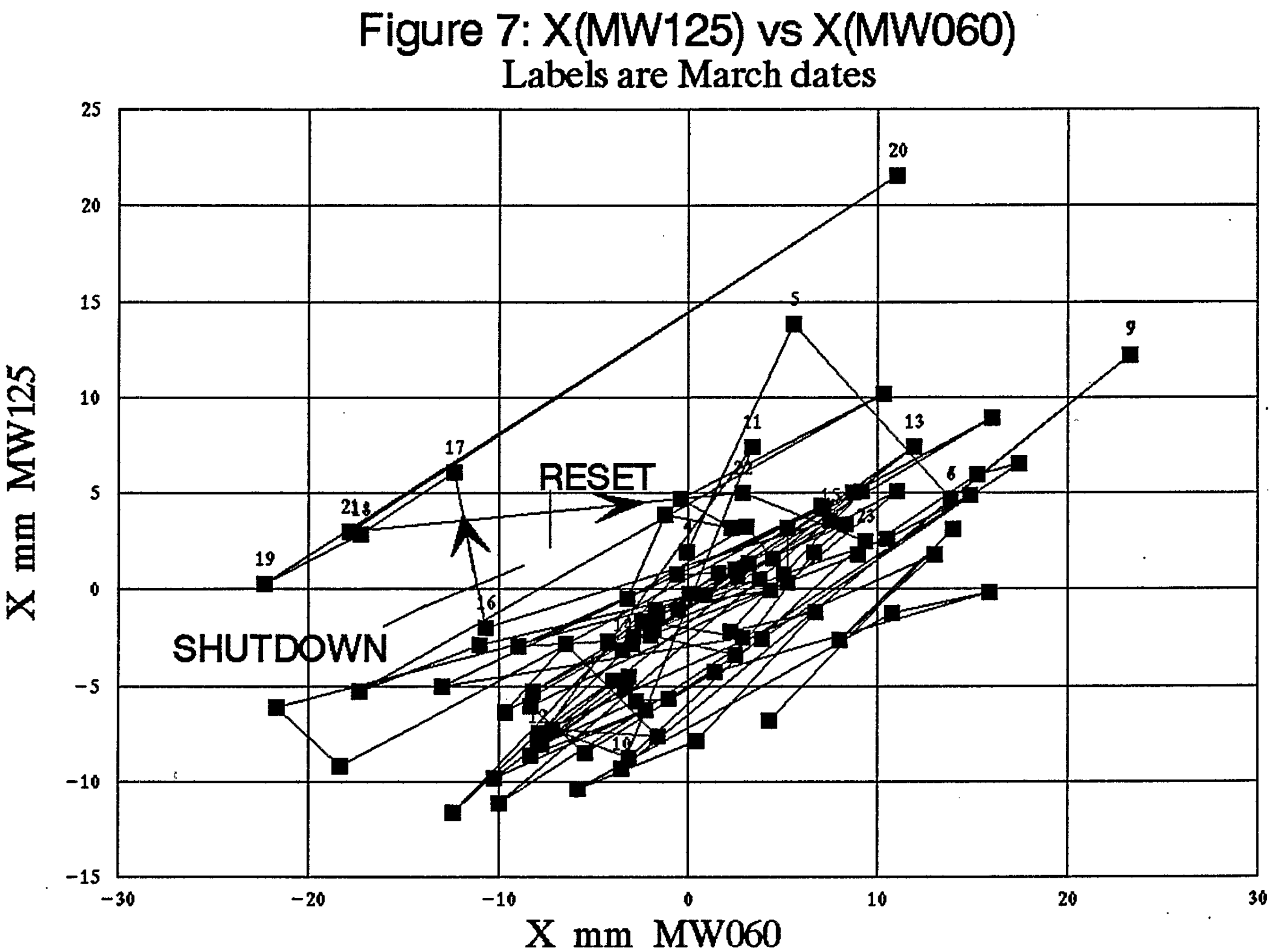

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Figure 8: DATA vs MODEL

ONE MILLIRADIAN KICK AT F6 SEPTUM

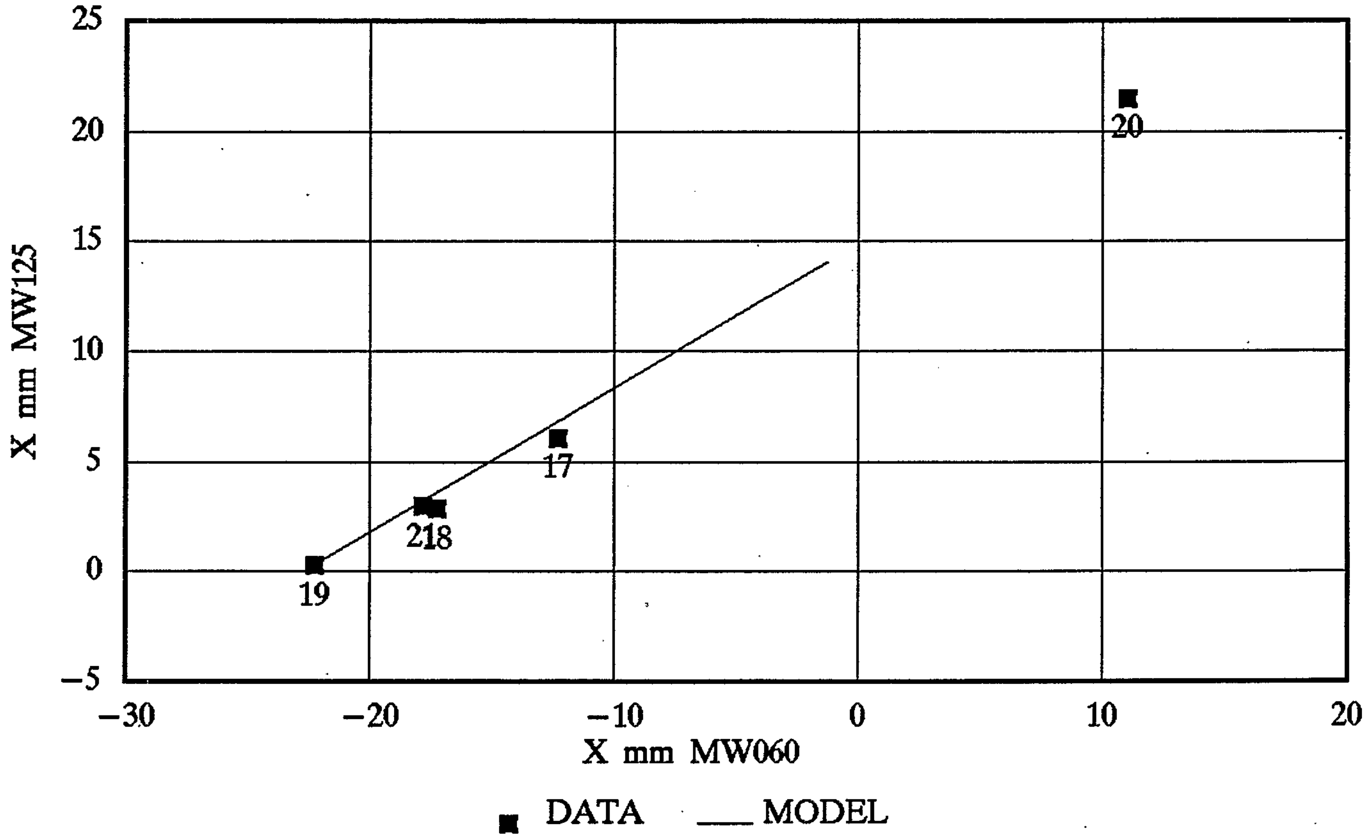

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Figure 9: DATA vs MODEL

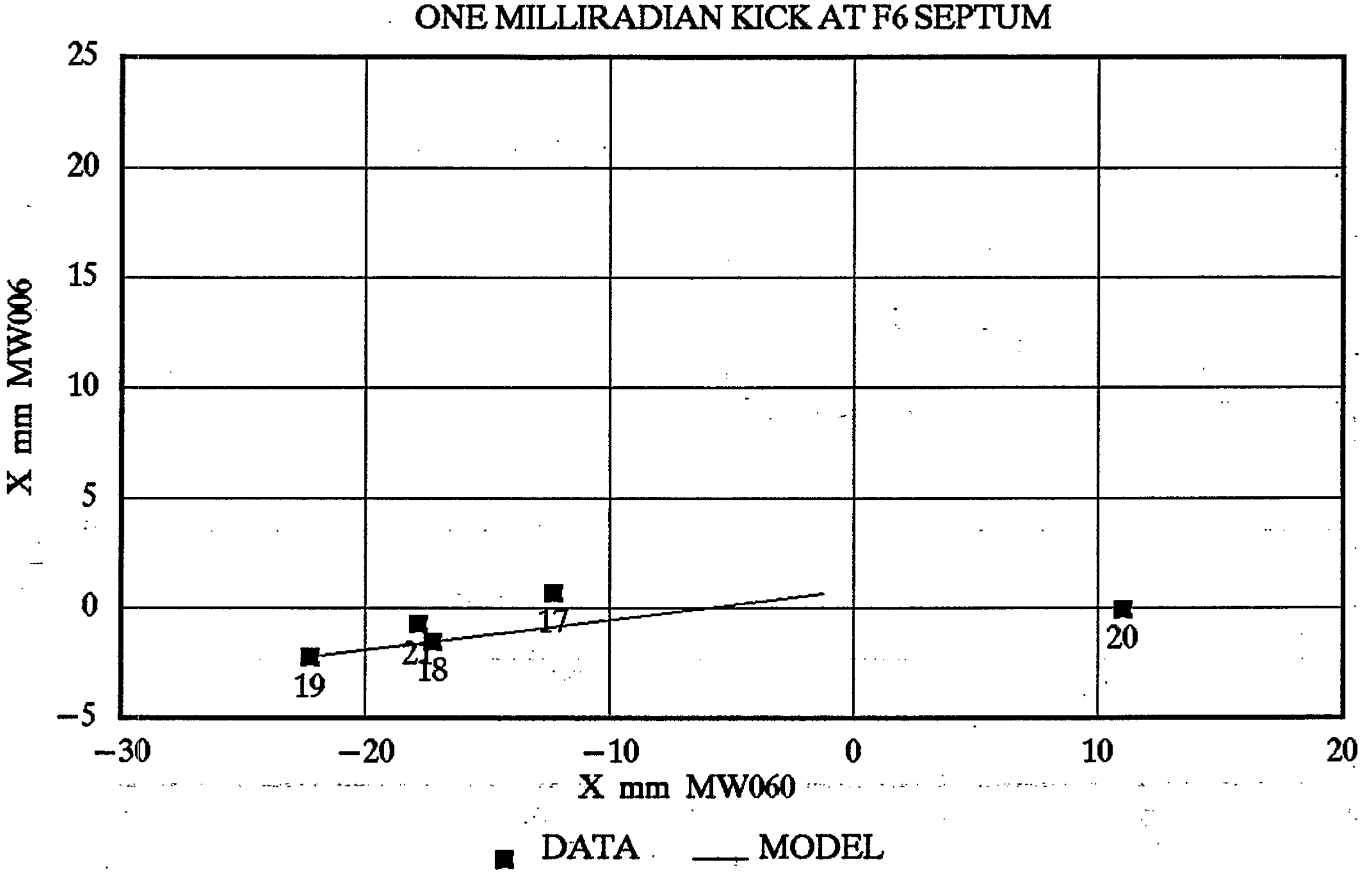

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Figure 10: DATA vs MODEL

ONE MILLIRADIAN KICK AT F6 SEPTUM

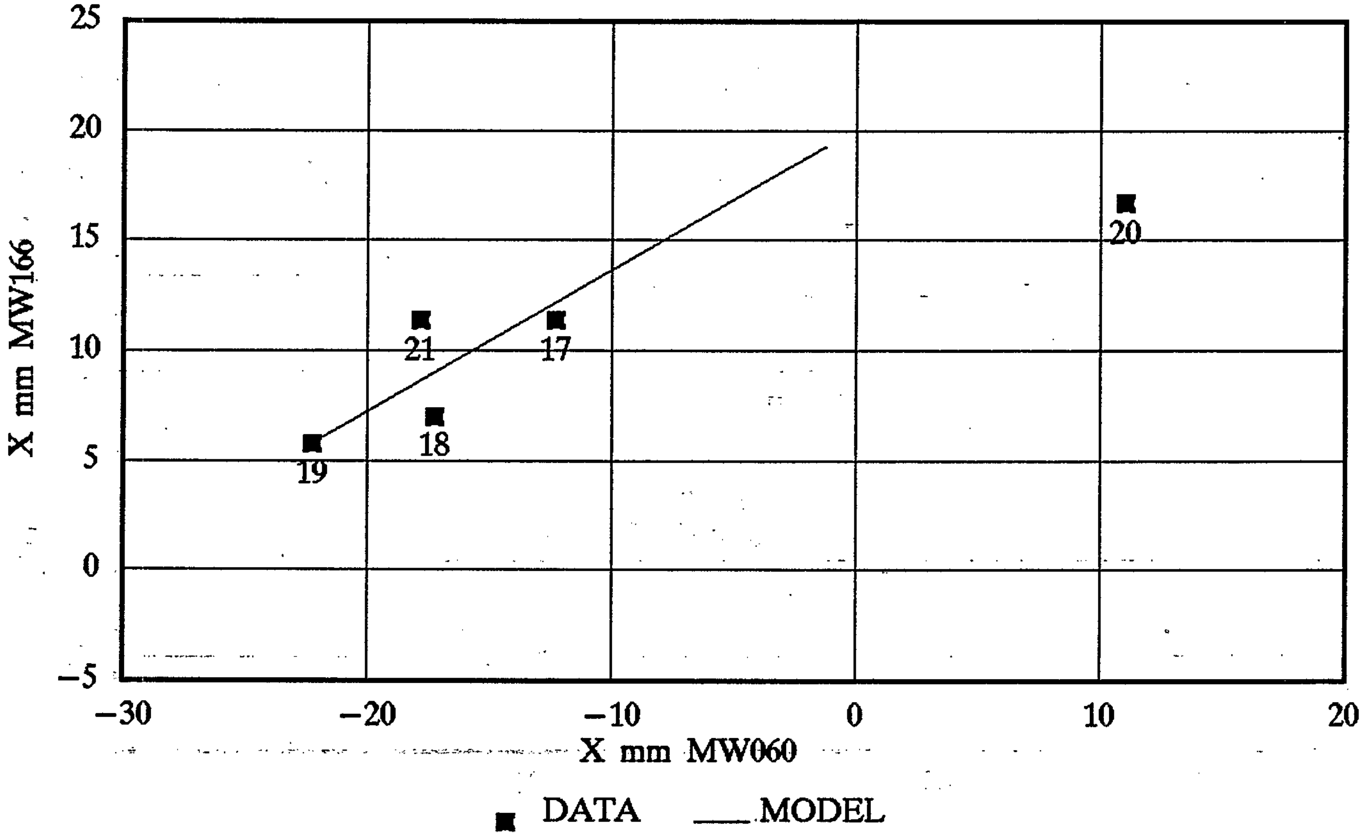

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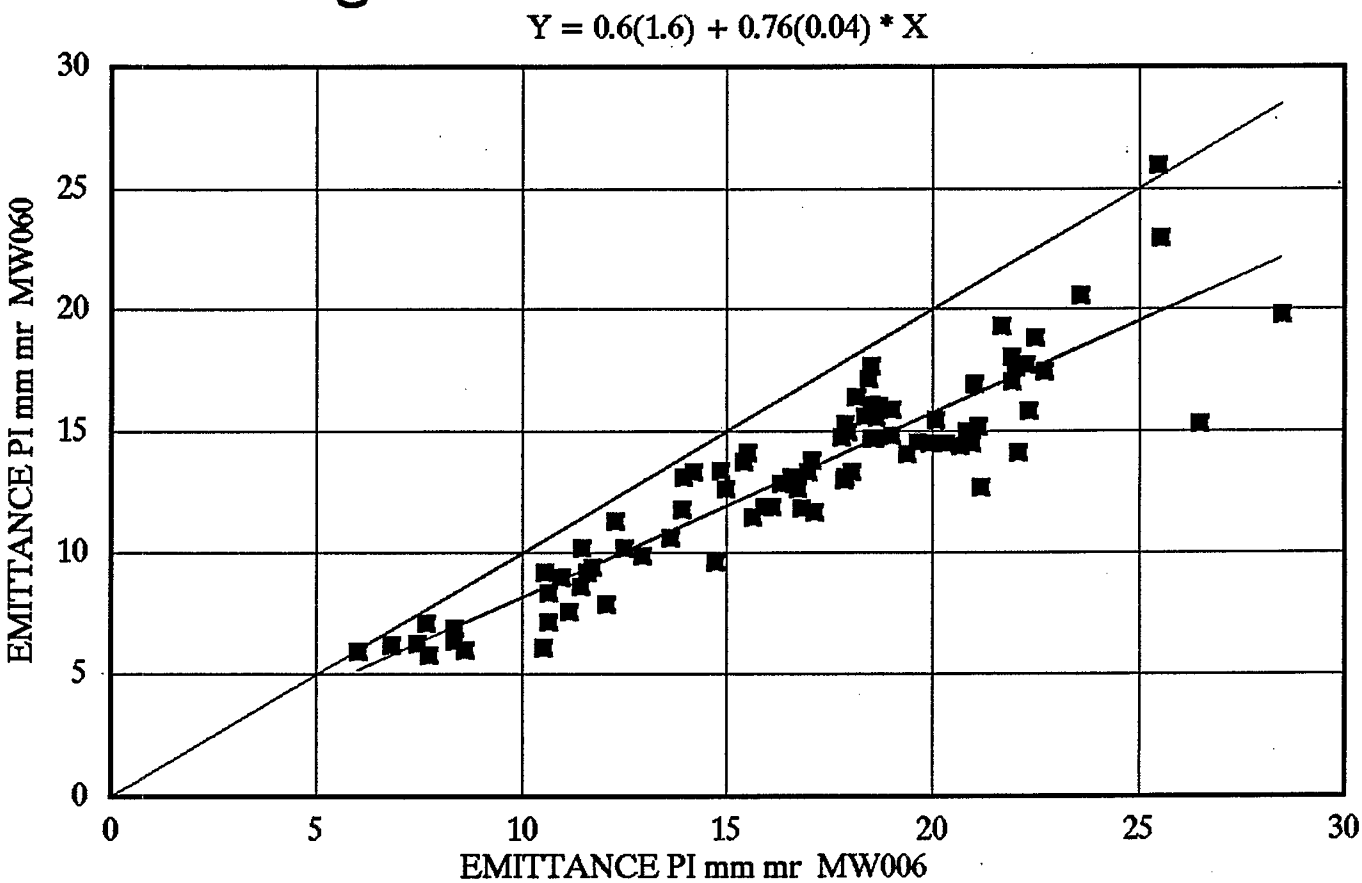
Figure 11: MW060 VS MW006



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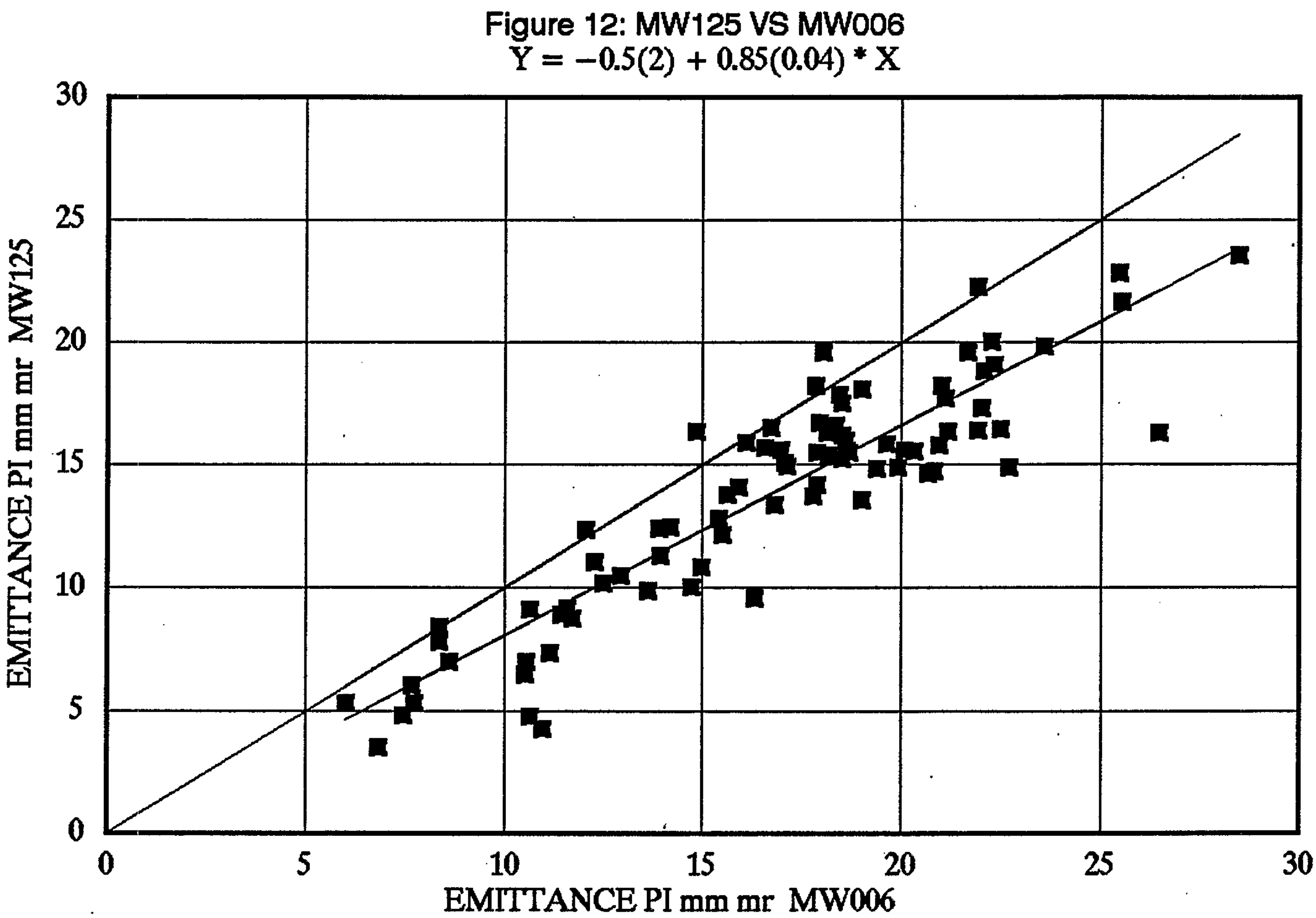

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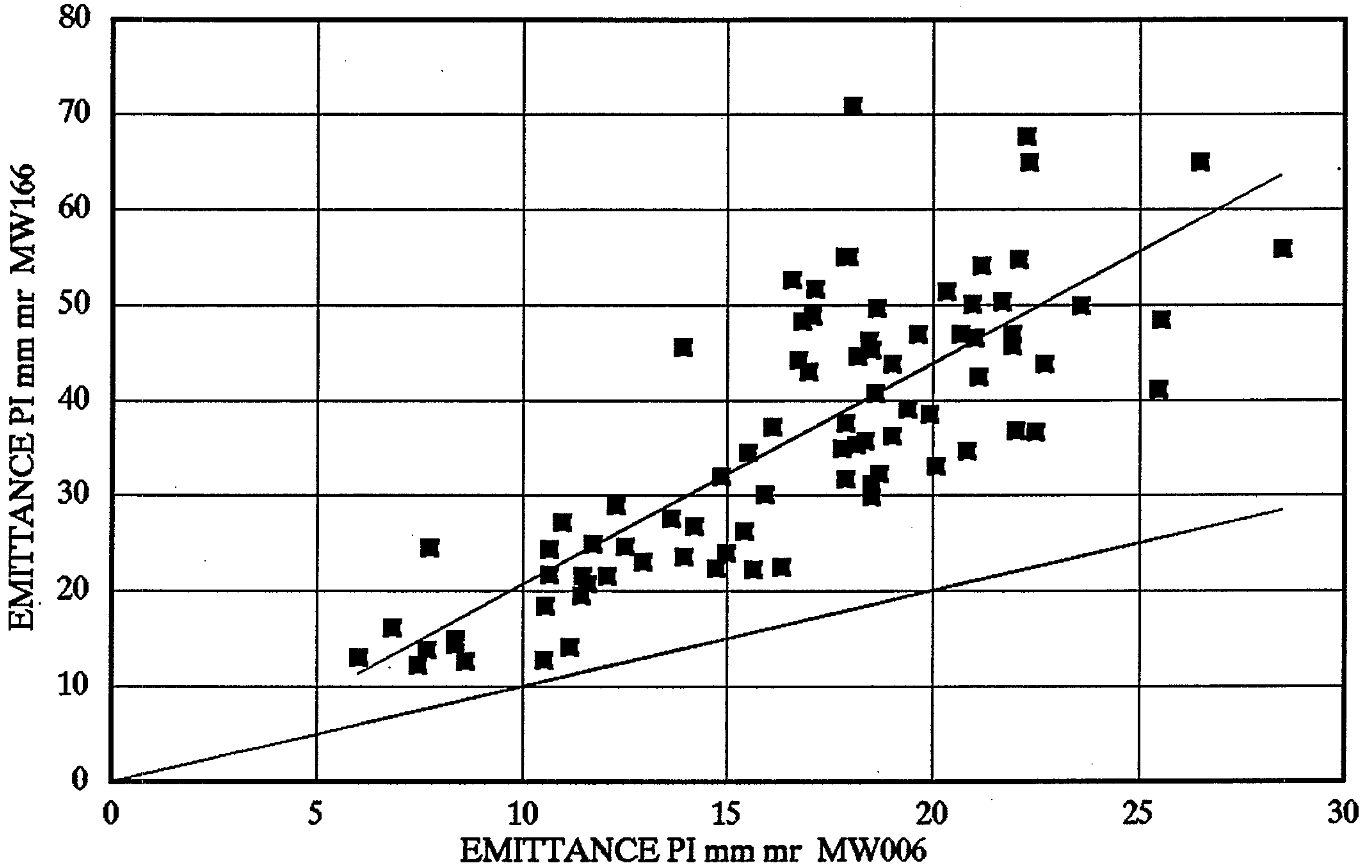
Figure 13: MW166 VS MW006

Y = −2(8) + 2.33(0.19) * X



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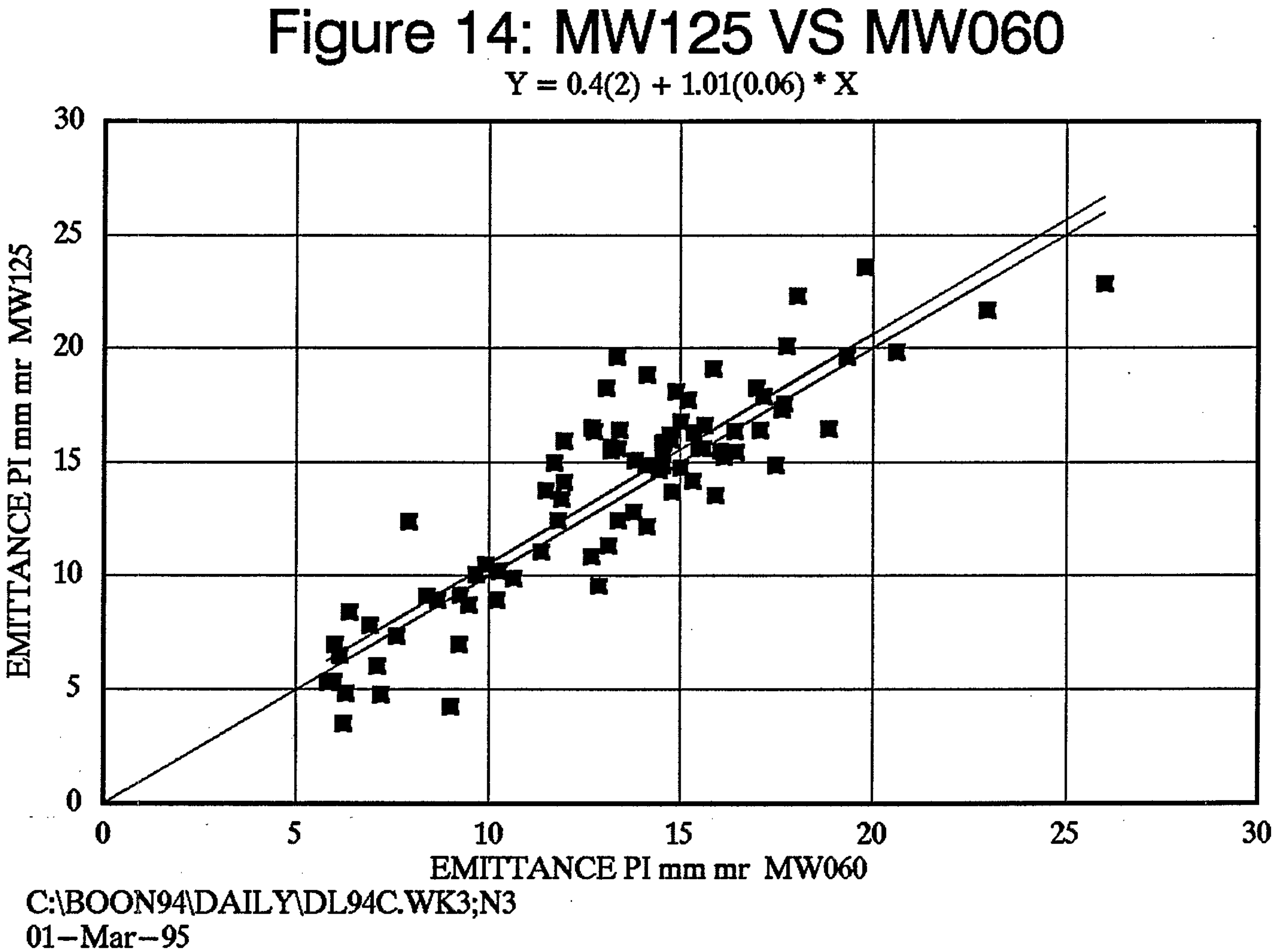
Figure 14: MW125 VS MW060
Y = 0.4(2) + 1.01(0.06) * X
30
25
20
15
10
5
0
EMITTANCE PI mm mr MW125
0
5
10
15
20
25
30
EMITTANCE PI mm mr MW060
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