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Daily Log Summary II: BTA Steering

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AGS Complex Machine Studies (AGS Studies Report No. 321) Daily Log Summary II: BTA Steering
Study Period: March - September, 1994
Participants: Main Control Room Staff
Principals: K. Zeno and B. Tamminga
Reported by: E. Bleser
Machine: AGS Proton Complex
Aim: To analyze BTA steering from the Daily Log Reports.

SUMMARY

The vertical steering in the BTA for 1994 is analyzed from the daily log reports.

MODEL

For this note we assume the fields in the BTA line are fixed and constant for the 1994 proton run, except for small steering effects. We take the standard BTA settings to be those of August 1, 1994, to be discussed in a subsequent note.

The line has small apertures at the extraction and injection channels but a large aperture in between. The line is nearly 60 meters long and has 5 main horizontal bends, 2 horizontal steering magnets, 4 vertical steering magnets, 15 quadrupoles, and 4 multiwire detectors to measure horizontal and vertical positions and beam sizes. (The steering and detector capabilities are very limited compared with a conventional accelerator that typically has a position monitor and a steering magnet associated with each quadrupole.) Subsequent to initial layout of the line, a wall was built separating the Booster and the AGS, and the whole complex was buried under massive amounts of shielding. The beam line alignment may well be problematic. Given the small number of detectors and a problematic alignment, we would expect the beam orbit that optimizes the aperture to vary considerably from the ideal. Given the large aperture through most of the line, this may not matter except it introduces quadrupole steering if we try to tune the optics of the line.

RESULTS

Figure 1 shows Y at MW006, the first multiwire, where the position is determined entirely by the settings in the Booster. In Figure 2, we have discarded three extreme data points and fitted the data from March 14 to July 31 with a straight line. Over a span of five months, the vertical extraction point in the Booster moved by 3 mm, but with a daily variability of only 0.2 mm. (We speculate no further on the source of this motion, but note with great pleasure the short-term stability.)

In considering the vertical position of the beam in the BTA, we assume there are two effects:

1. The vertical motion of the beam in the Booster as noted above.

2. The response of the Operators to the source motion and to the increasing beam intensity.

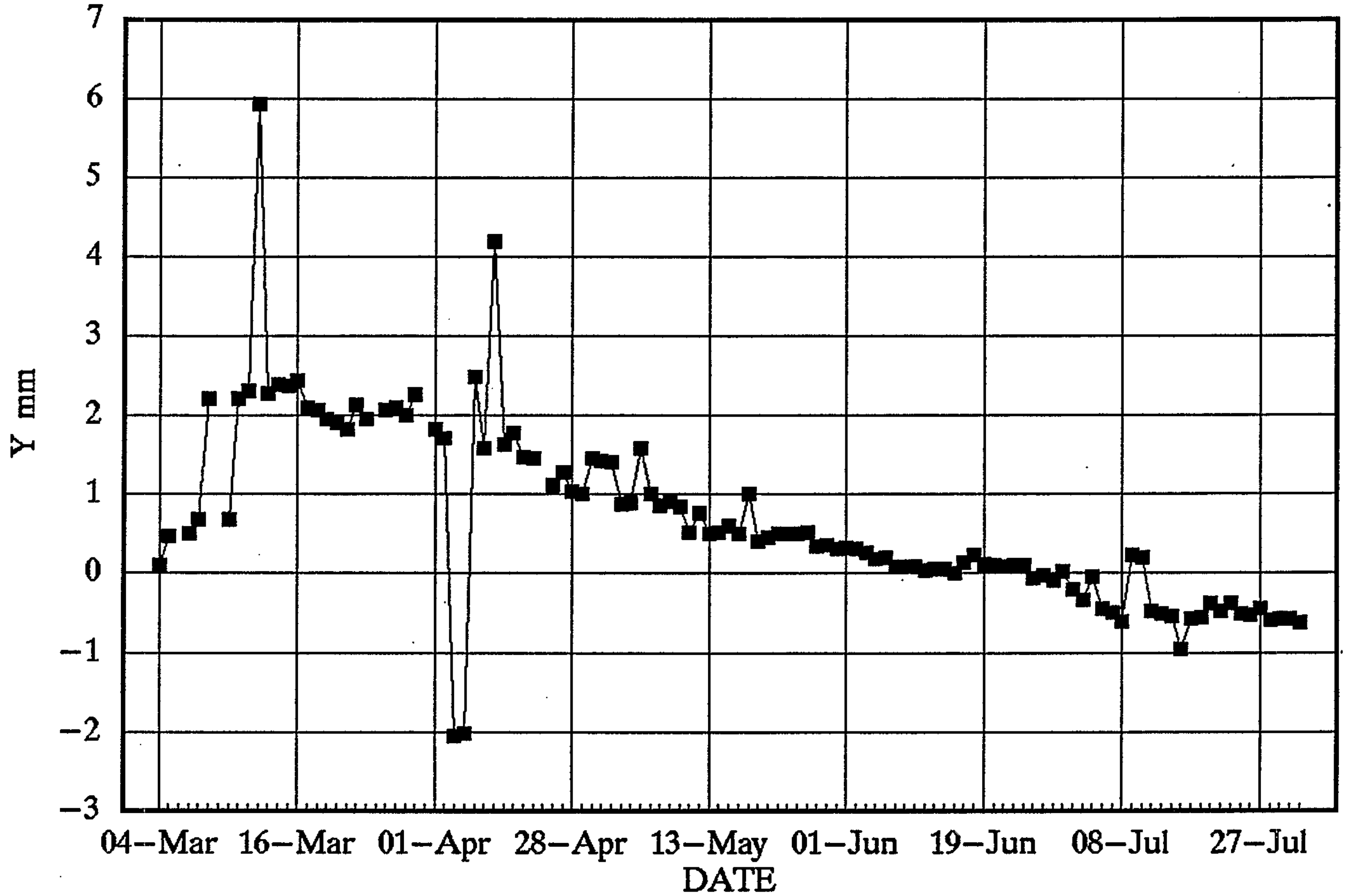
We hypothesize that at the start of the run we have a low intensity, small diameter beam, which can be transported cleanly through the large aperture beam line, even though it may well be far off alignment. As the run progresses, the intensity goes up, the beam size increases, the losses increase, and the operators empirically steer the beam to reduce losses, moving the actual orbit closer to the optimum orbit. The effects of operator tuning presumably show up in the data of the downstream multiwires that display a pattern of punctuated equilibrium (AGS Studies Report No. 320).

Using the model and the measured positions, we can calculate the orbit angle at each multiwire and generate the vertical phase space plots shown in Figures 3 through 6, using all the available data points. We can also calculate from the model the phase space ellipses, making an eyeball estimate of the emittance to be 1.7 π mm mr. We introduce here the concept of the central orbit emittance envelope, which is the area in phase space mapped out by the central orbit of a beam over a period of time. Ideally, if everything were constant, the central orbit emittance would be zero. The beam motion is fairly small compared to the beam size that is of the order of 25 π mm mr. The ellipses were centered on the data also by eyeball estimate. Note that in some multiwires, the beam was systematically far off center. We attribute this to the problematic alignment discussed above. With 15 quadrupoles and 4 position detectors, untangling this would be very painful.

CONCLUSIONS

Most of the data points shown in the figures fall within the calculated ellipses. Thus, we can make a first order conclusion that the BTA line is a constant fixed entity that is well calculated and most orbit variations can be explained by saying that the Booster produces a beam whose center moves with a central orbit vertical emittance envelope of 1.7 π mm mr.

FIGURE 1: Y at MW006, All Data



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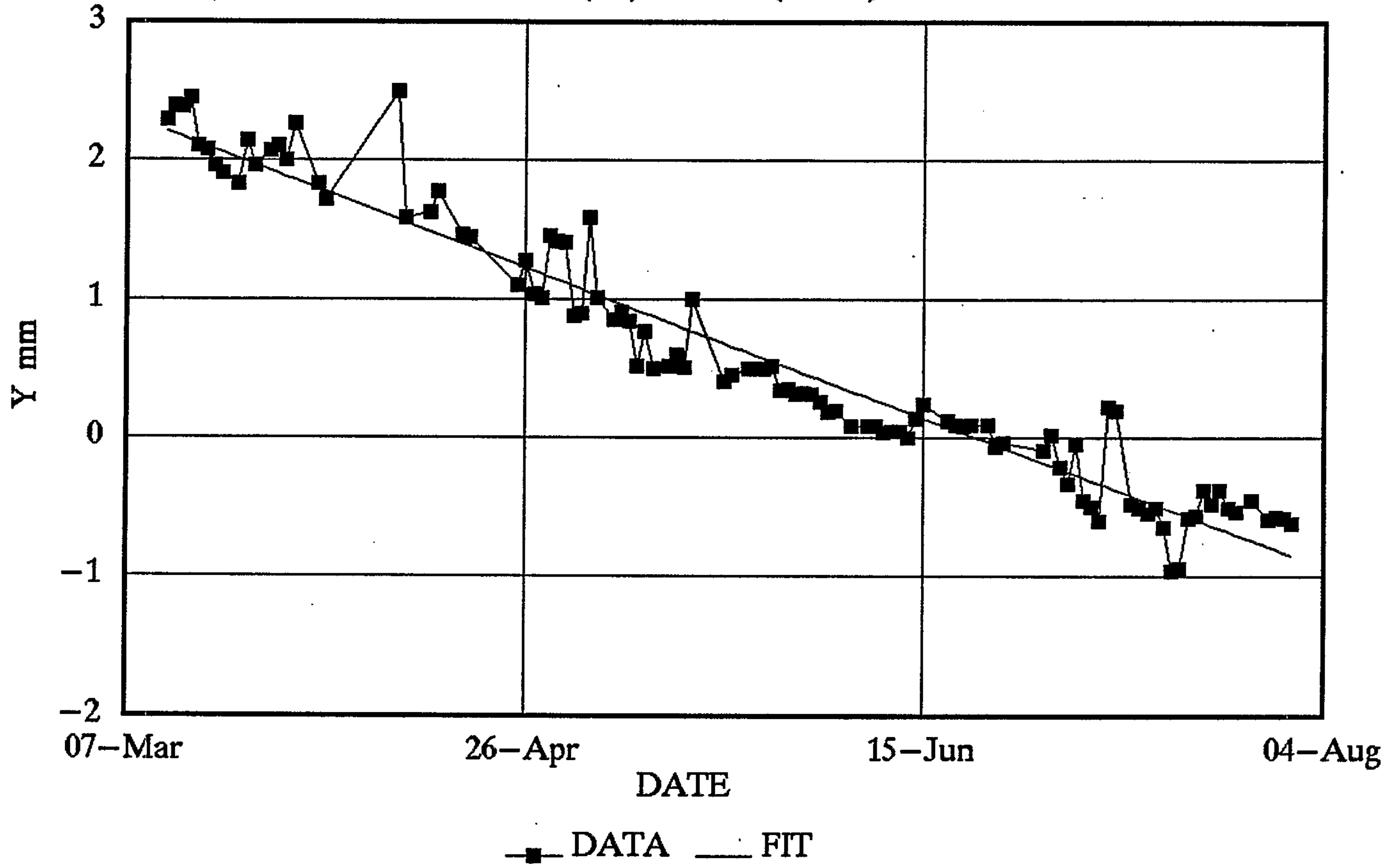
17−Feb−95

FIGURE 2: Y at MW006, Selected Data
Y = 2.6(0.2) – 0.0217(0.0006) * DATE



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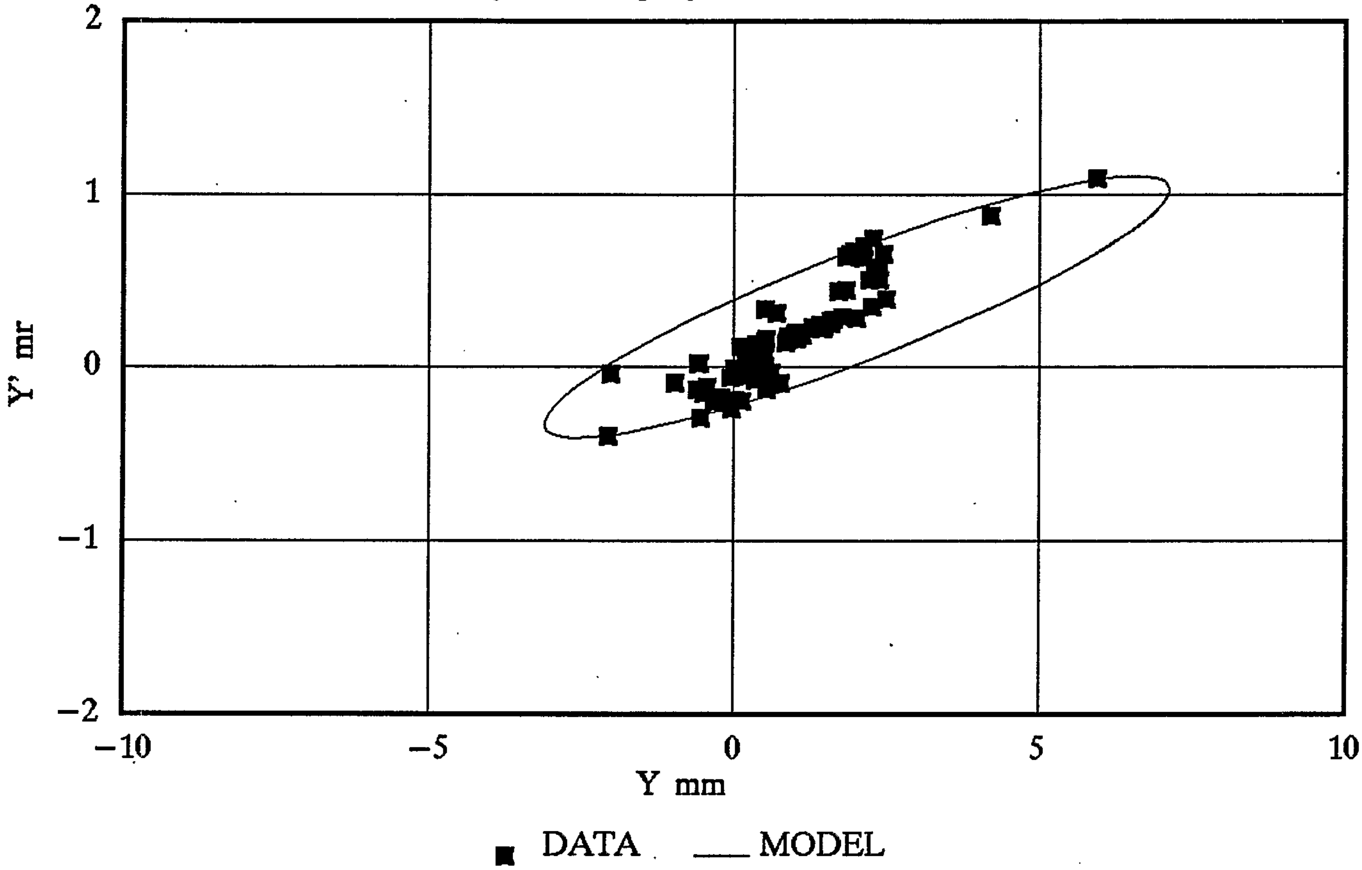
17−Feb−95

FIGURE 3: PHASE SPACE at MW006
Betay=15.3, Alphay=−2.03, dY=2, dY'=.35



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17−Feb−95

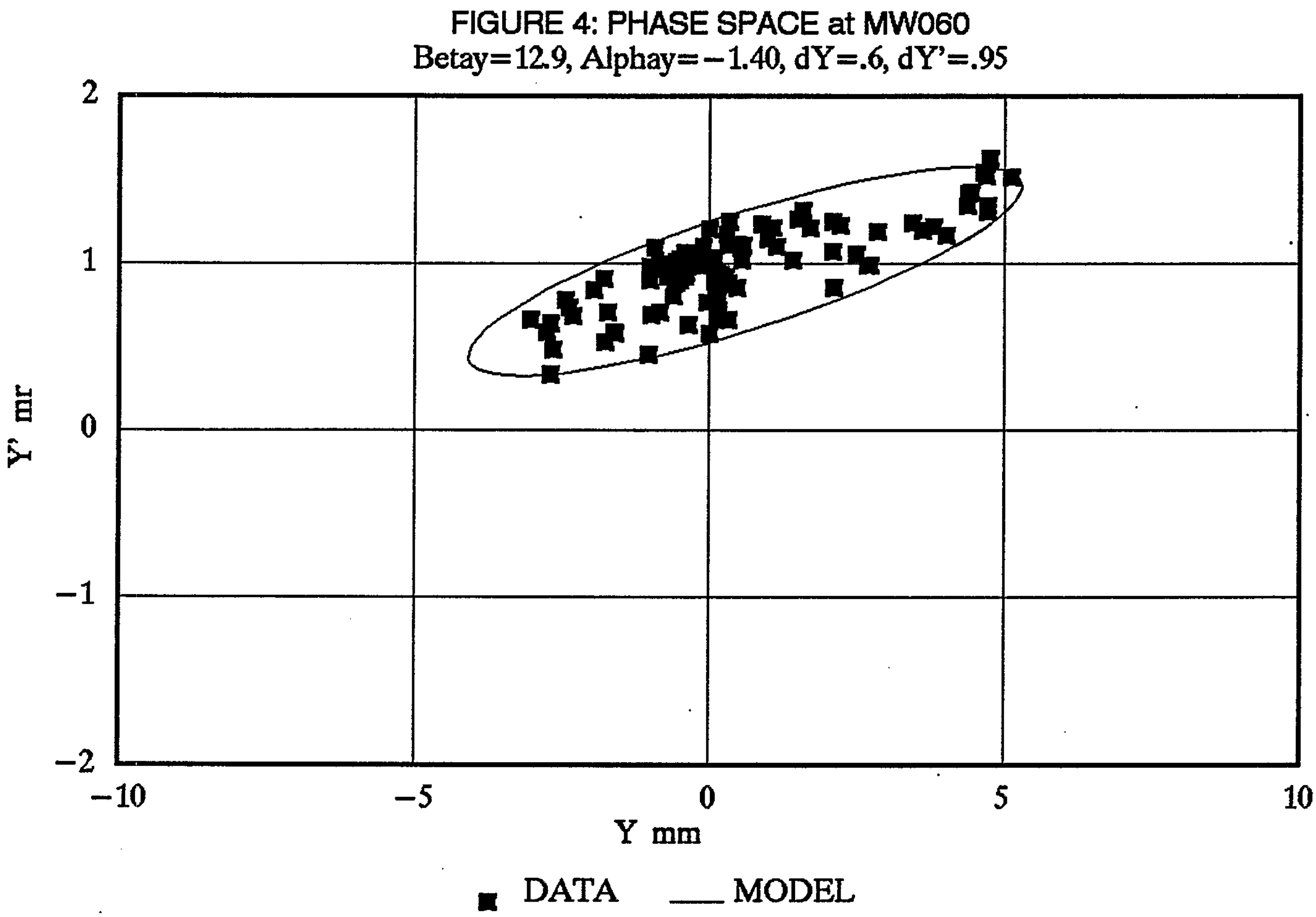

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FIGURE 5: PHASE SPACE at MW125
Betay=5.38, Alphay=0.07, dY=7, dY'=−0.2

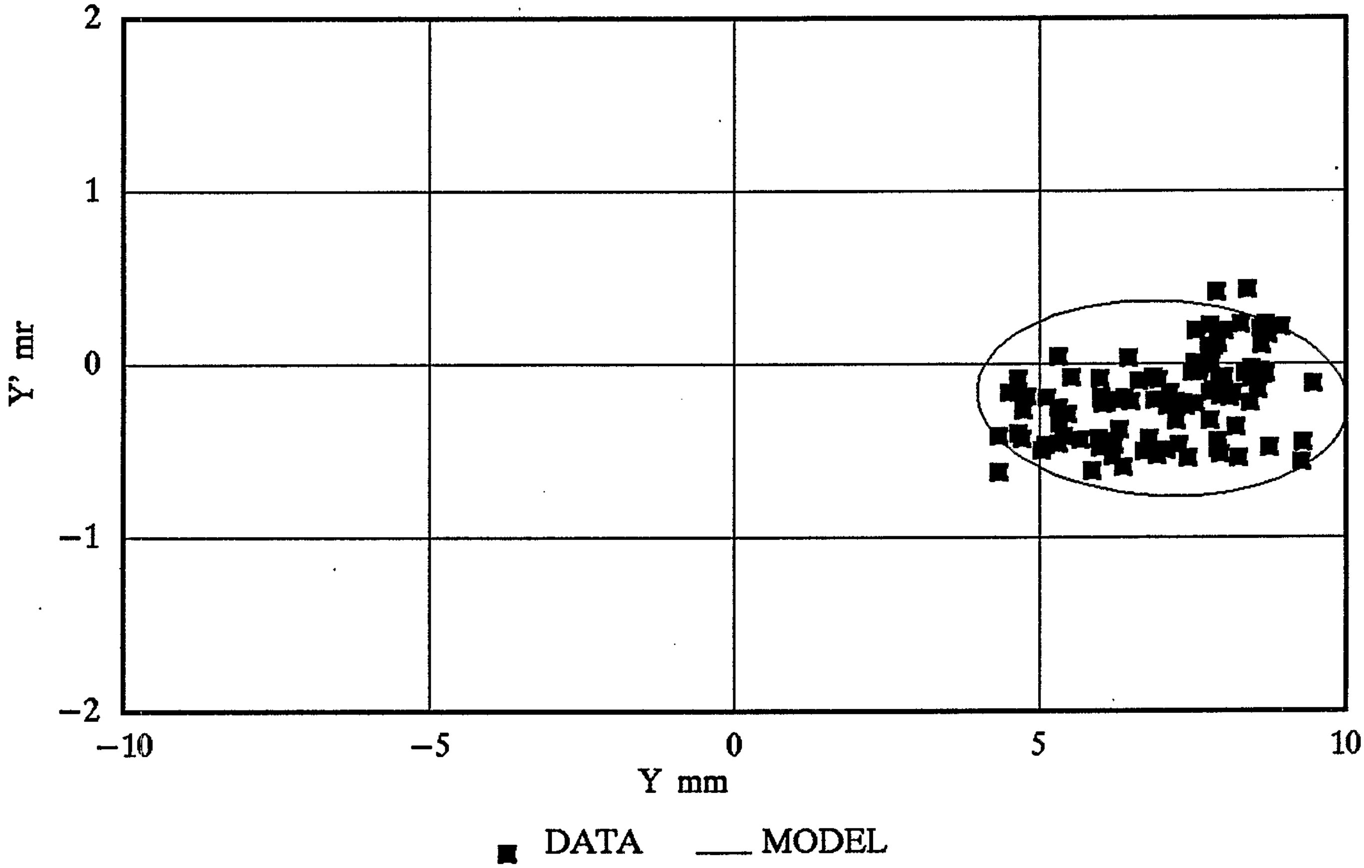

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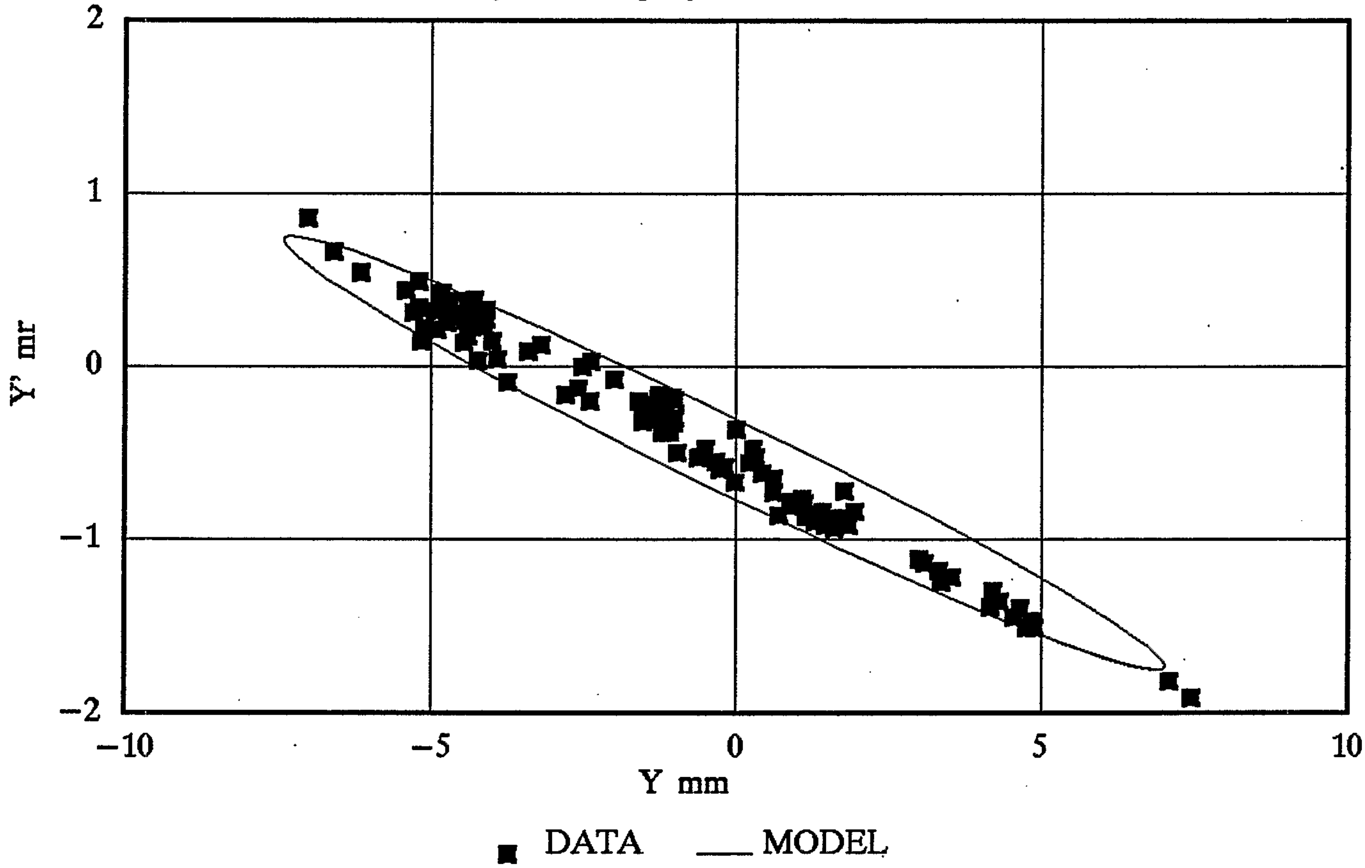
FIGURE 6: PHASE SPACE at MW166
Betay=30.5, Alphay=5.2, dY=−.2, dY'=−.5



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