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Calibration of IPM Using the Flying Septum

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AGS STUDIES REPORT

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Reported By: E. Bleser	
Subject: Calibration of IPM Using the Flying Septum	

EXPERIMENT

A low intensity beam was reduced in size by scraping on the dump, and its size was then measured by the Ionization Profile Monitor (IPM) and then by scanning it across the F6 extraction septum using the F3 fast extraction kicker. The results are in very good agreement.

IPM BEAM SIZE

At ten-turn beam was injected into the Booster and late in the cycle scraped on the D6 dump to reduce its size. The scraping experiment will be reported in a subsequent note. Figure 1 shows the horizontal and vertical beam sizes as measured by the IPM. The IPM results include the standard corrections for decreased sensitivity of the microchannel plates, but are not corrected for intensity and beam size effects. In any case, at this intensity, Thern's calculations indicate that these corrections should be zero. At the IPM, the beam has a horizontal width of 5.7 mm, where, as always, IPM results are quoted as one standard deviation.

THE FLYING SEPTUM

Using the F3 kicker, we can scan the beam across the F6 septum and get results quite analogous to those from a flying wire, i.e., a rather direct measurement of the profile in contrast to a scraping measurement that gives a rather complex result. Figures 2 and 3 show the data, which consist of loss monitor measurements versus kicker settings. (F5 goes negative presumably because it shares an overloaded power supply with F6, F7, and F8.) Figure 4 shows the results from the F6 loss monitor with the background subtracted. The essential points of this plot are:

A. At 30 kV, the beam is scraping the outside edge of the extraction channel;

B. At 26.5 kV, the beam is centered in the channel and is going down it without loss;

C. At 24 kV, the inside edge of the beam is scraping the outside edge of the septum;

D. At 14 kV, the beam is centered on the septum;

E. At 7 kV, the beam is kicked just enough to start scraping the inside edge of the septum.

One complication that we shall ignore for the present is that when the beam is straddling the septum, the protons that have not crossed the septum stay well within the Booster acceptance and on subsequent turns will either hit the septum or escape down the channel as shown in Figure 5.

THE WIDTH OF THE EXTRACTION CHANNEL

In order to calibrate the horizontal axis of Figure 4, we use Figures 6 and 7, which show the beam and the outer aperture of the Booster in Section F. In Figure 6, the beam is just kicked enough to scrape the inside edge of the septum, corresponding to the 7 kV case; in Figure 7, the beam is kicked enough to scrape the inside edge of the F5 dipole, corresponding to the 30 kV case. Based on this model, the beam displacement is 46 mm for a 23 kV kick, which sets the scale for Figure 4, redrawn now as Figure 8.

Note that the outside aperture of the extraction channel is not the septum or the vacuum chamber in the quad at F6, both of which are at 120 mm, but rather it is the exit of F5 dipole, which cuts the intended aperture nearly in half. This point is more radioactive than the dump exit, the injection region, and the other sections of the extraction channel. It seems to be the limiting aperture in the machine and one on which we have been losing a lot of beam.

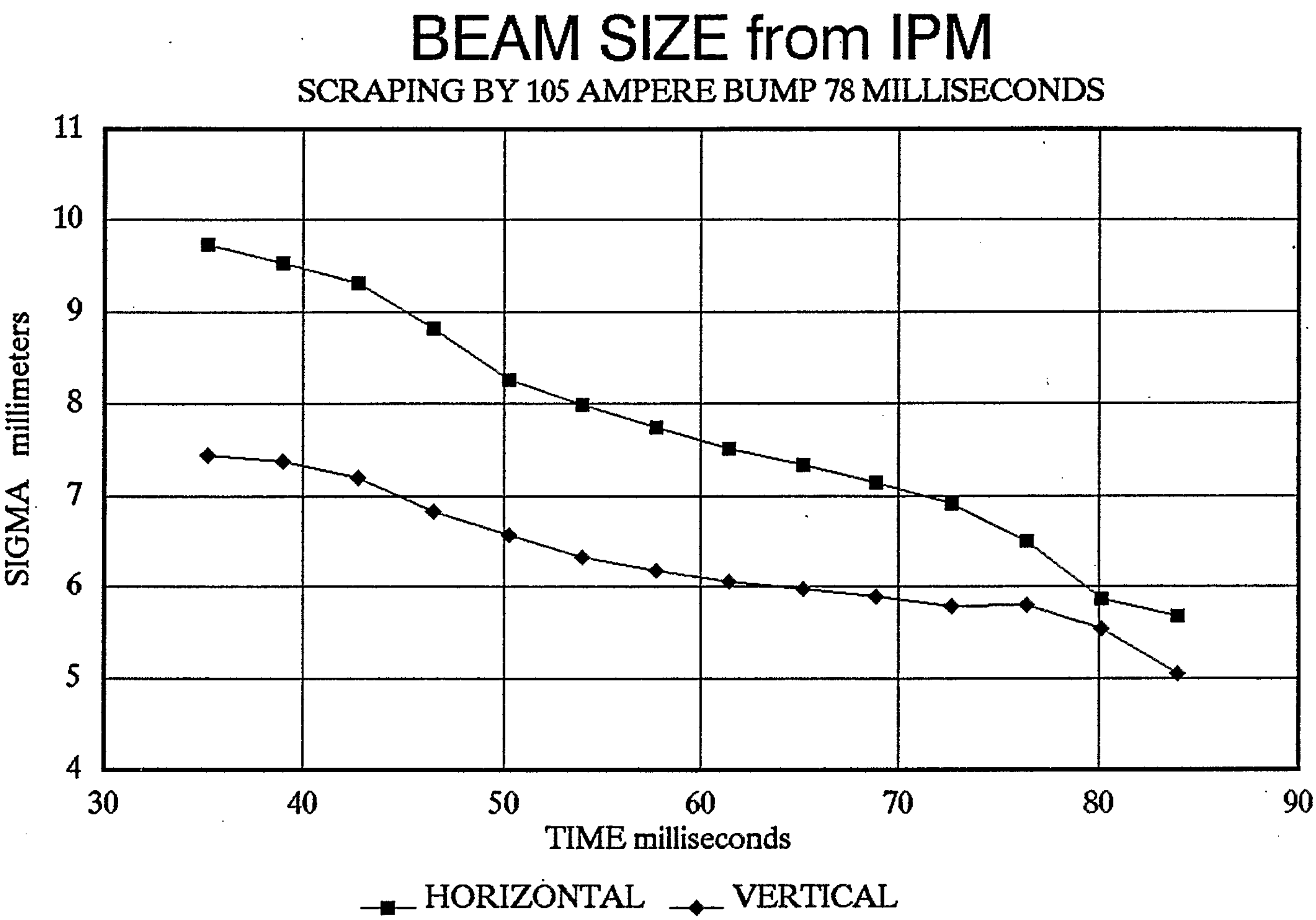
BEAM WIDTH AT EXTRACTION

We are scanning a beam with a width (one sigma) of about 6 mm across a septum of width 5.1 mm. To unfold the measurements, we can model cases of this sort and come up with results that we can expect to see a very good Gaussian with a width slightly larger than the beam width, as given in Figure 9. (A little thinking about this will lead one to conclude that these results are somewhat counter intuitive, so deeper thinking may be called for.) The fitted Gaussian has a width of 6.3 mm and is shown in Figure 8. Using Figure 9 and the appropriate transformations, leads to Figure 10, which shows the width at the IPM predicted by the flying septum measurement as a function of the momentum spread in the Booster. A good estimate for dP/P is 0.001, which gives a predicted value of 5.2 mm compared with an IPM measured value of 5.7 mm. The agreement is very good.

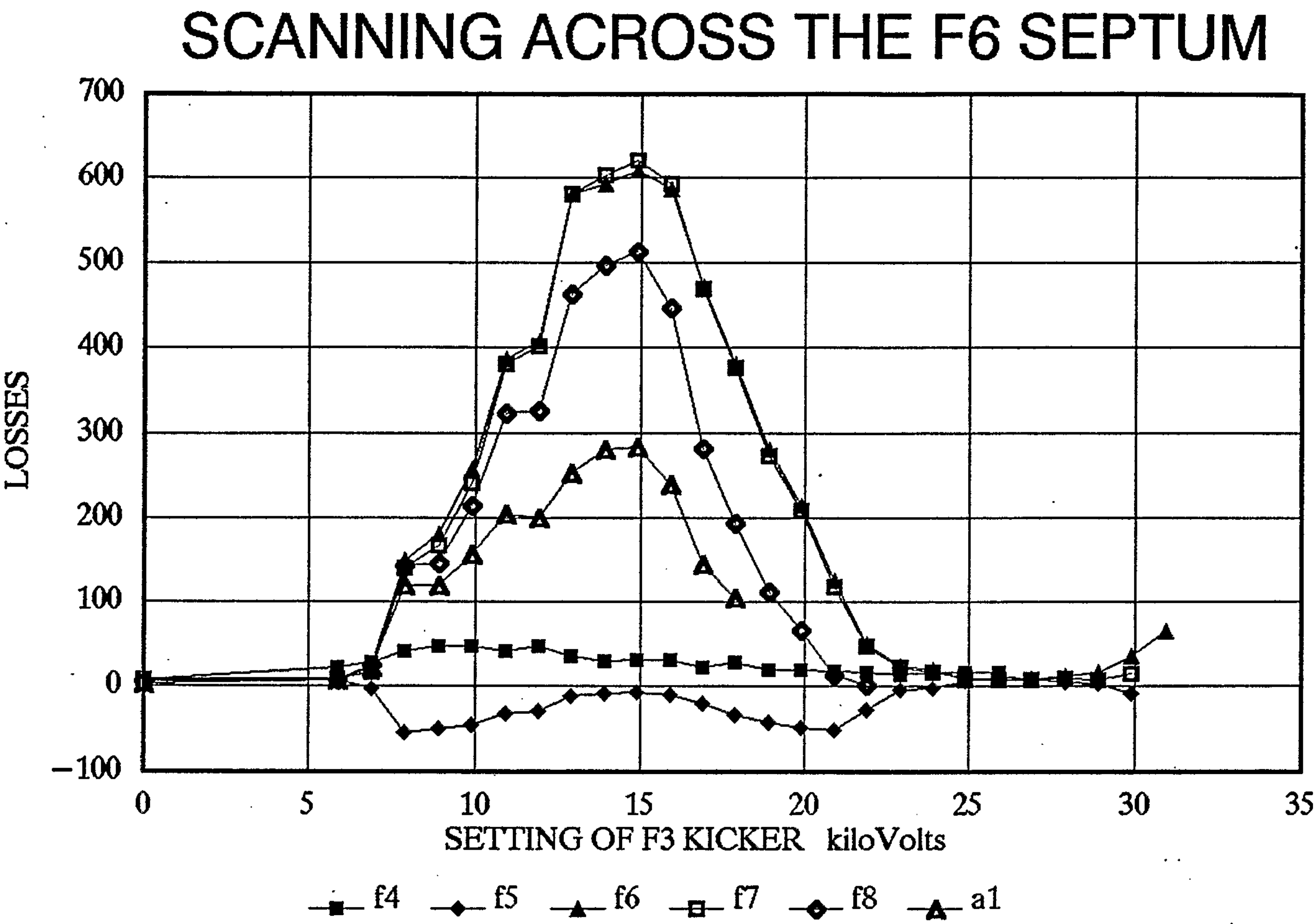
CONCLUSIONS

1. At this low intensity, the IPM measurements can be taken to be of great absolute accuracy.

2. Similar measurements can be done at higher intensities to calibrate the IPM over the full Booster operating range.

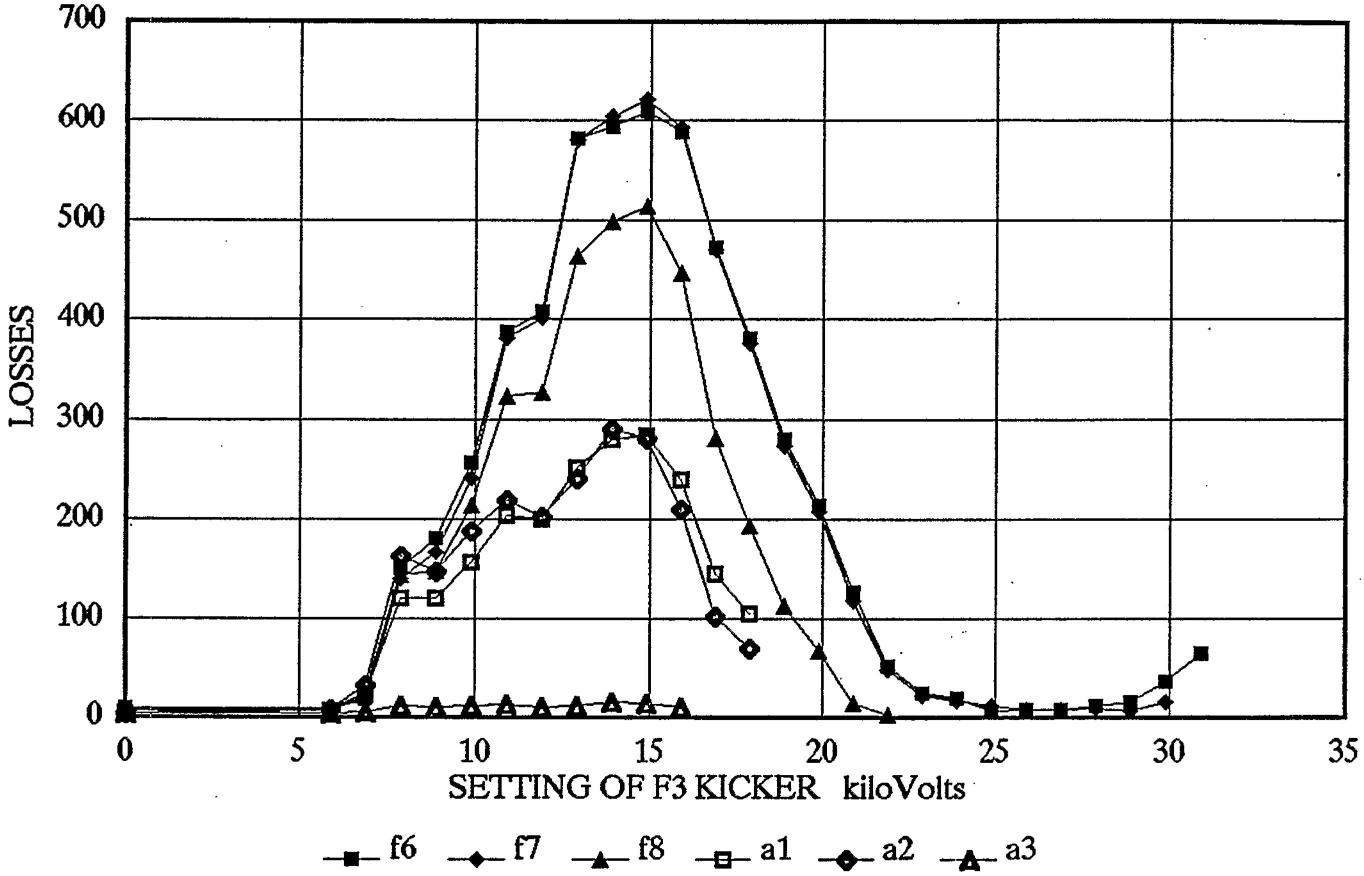


C:\EXT\ANAL21.WK3; FIGURE 1
30–Sep–92

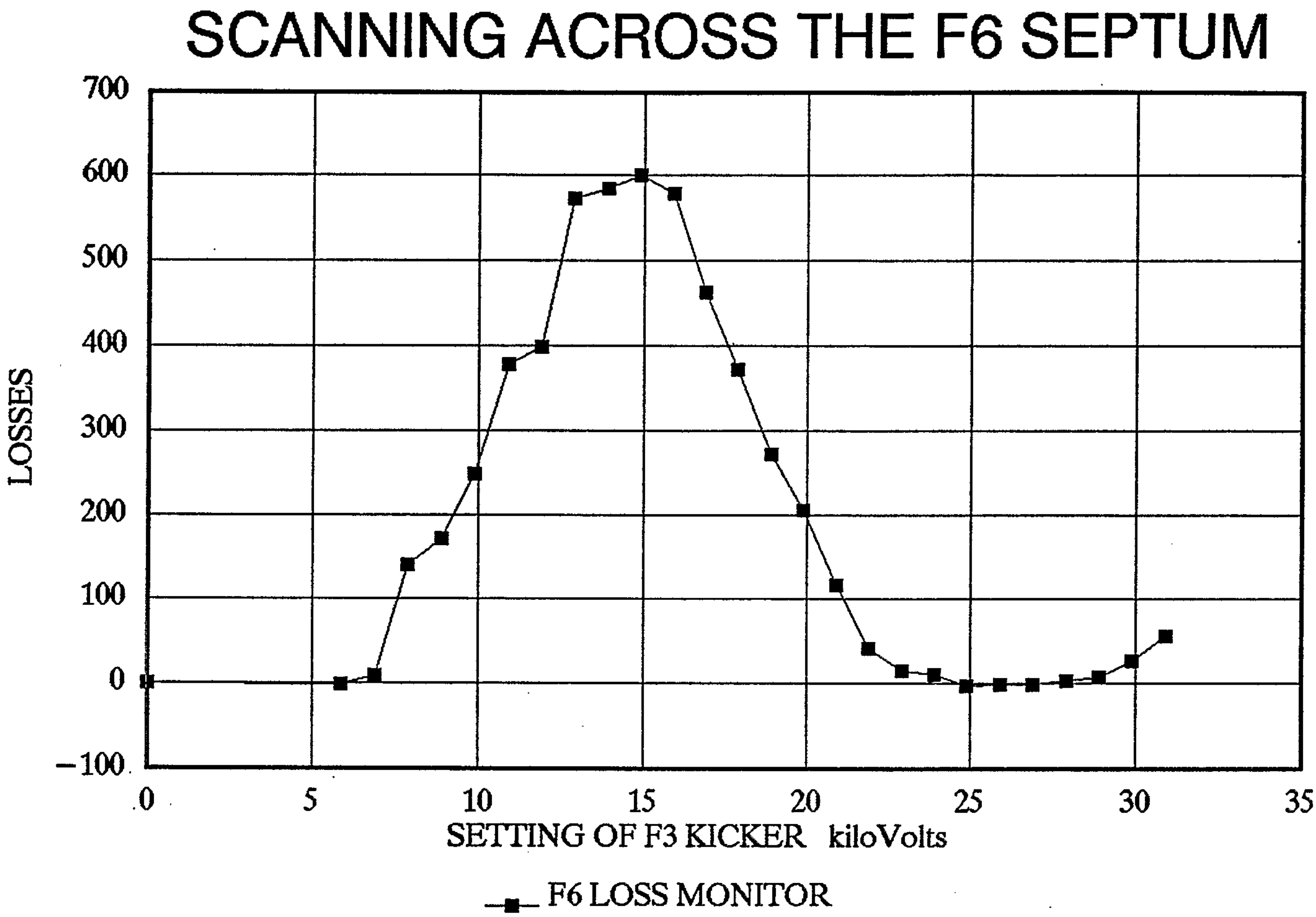


c:\study86\scan1.wk3; FIGURE 2
30−Sep

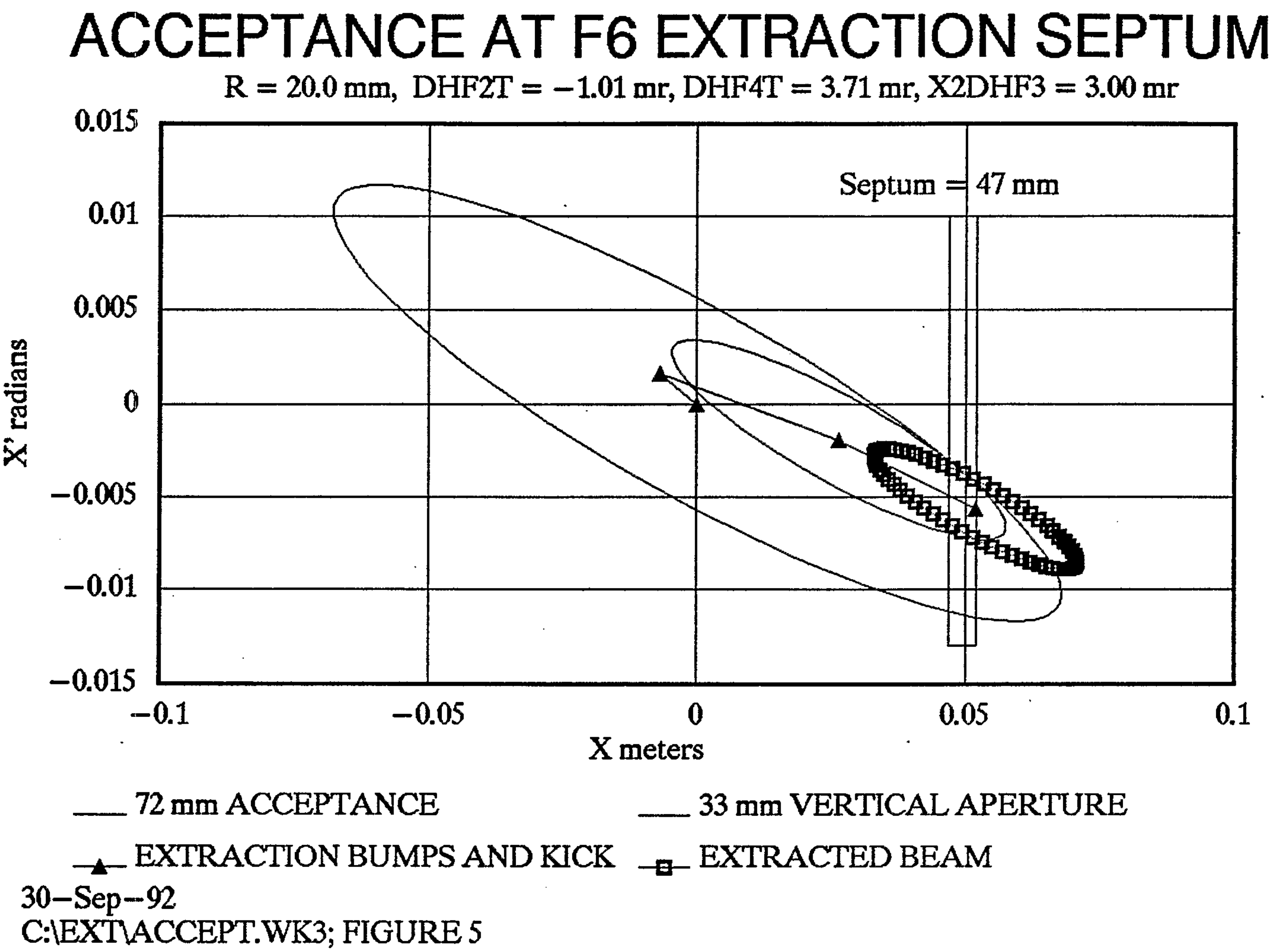
SCANNING ACROSS THE F6 SEPTUM

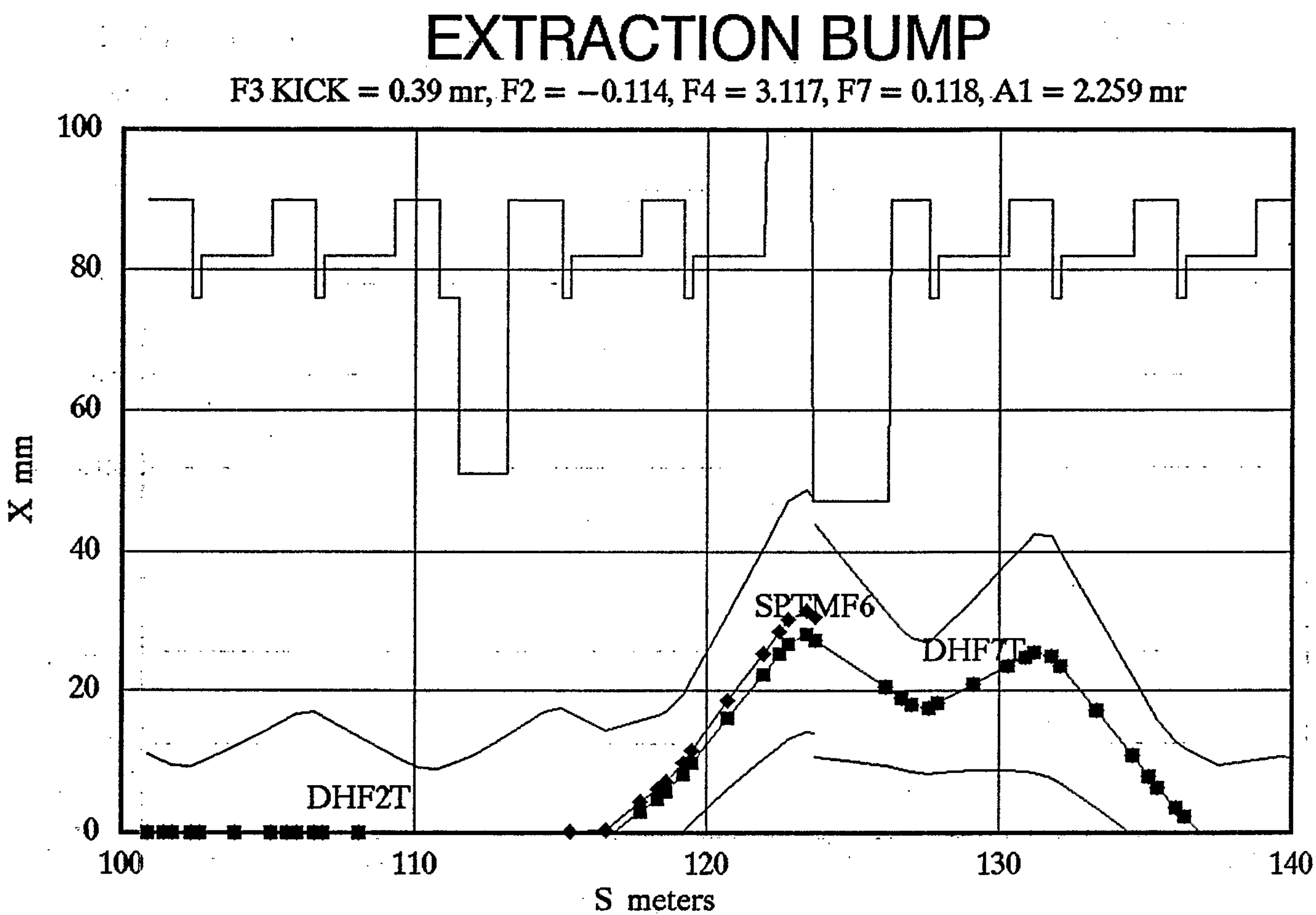


c:\study86\scan1A.wk3; FIGURE 3
30–Sep

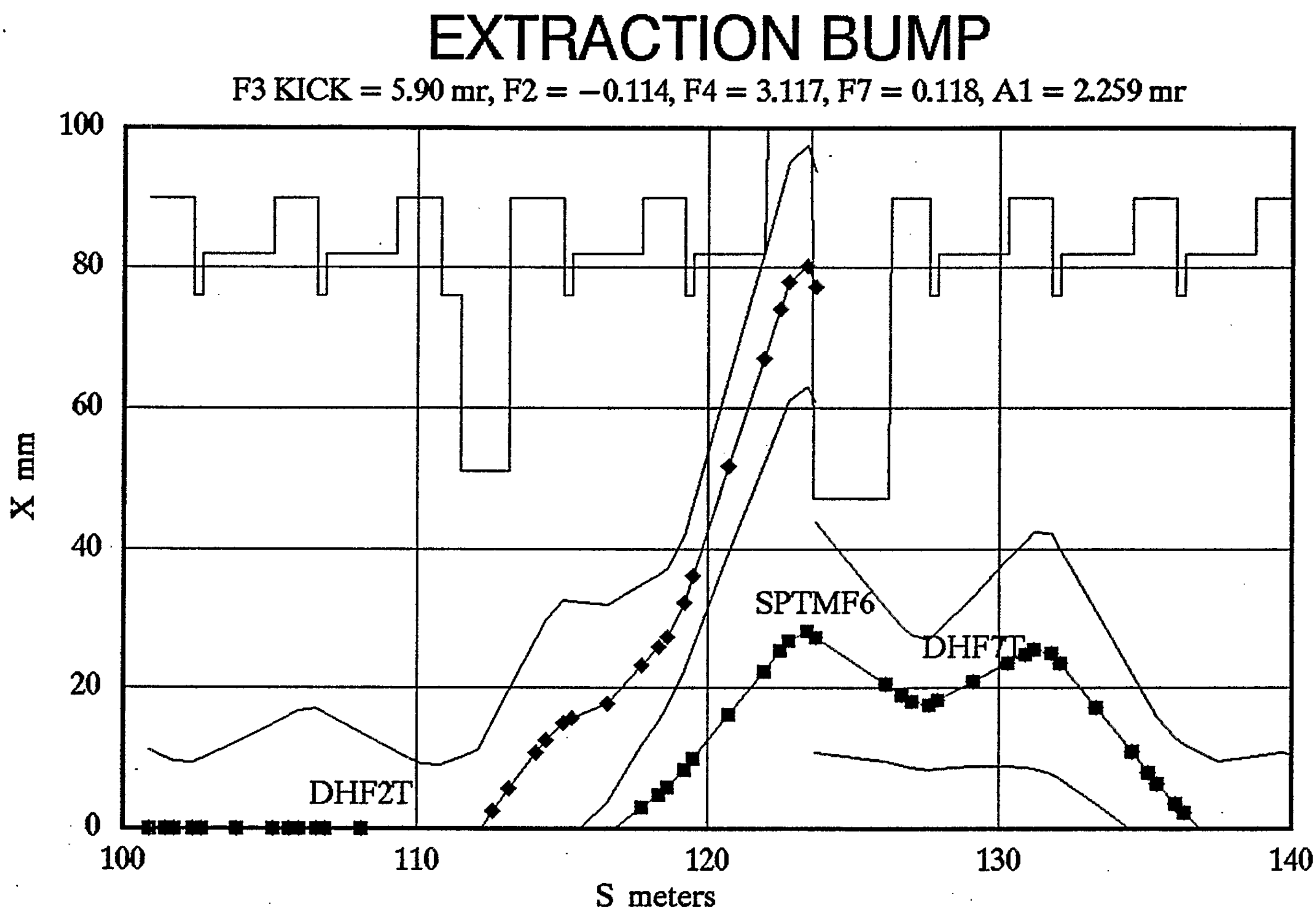


c:\study86\scan1A.wk3; FIGURE 4
30–Sep

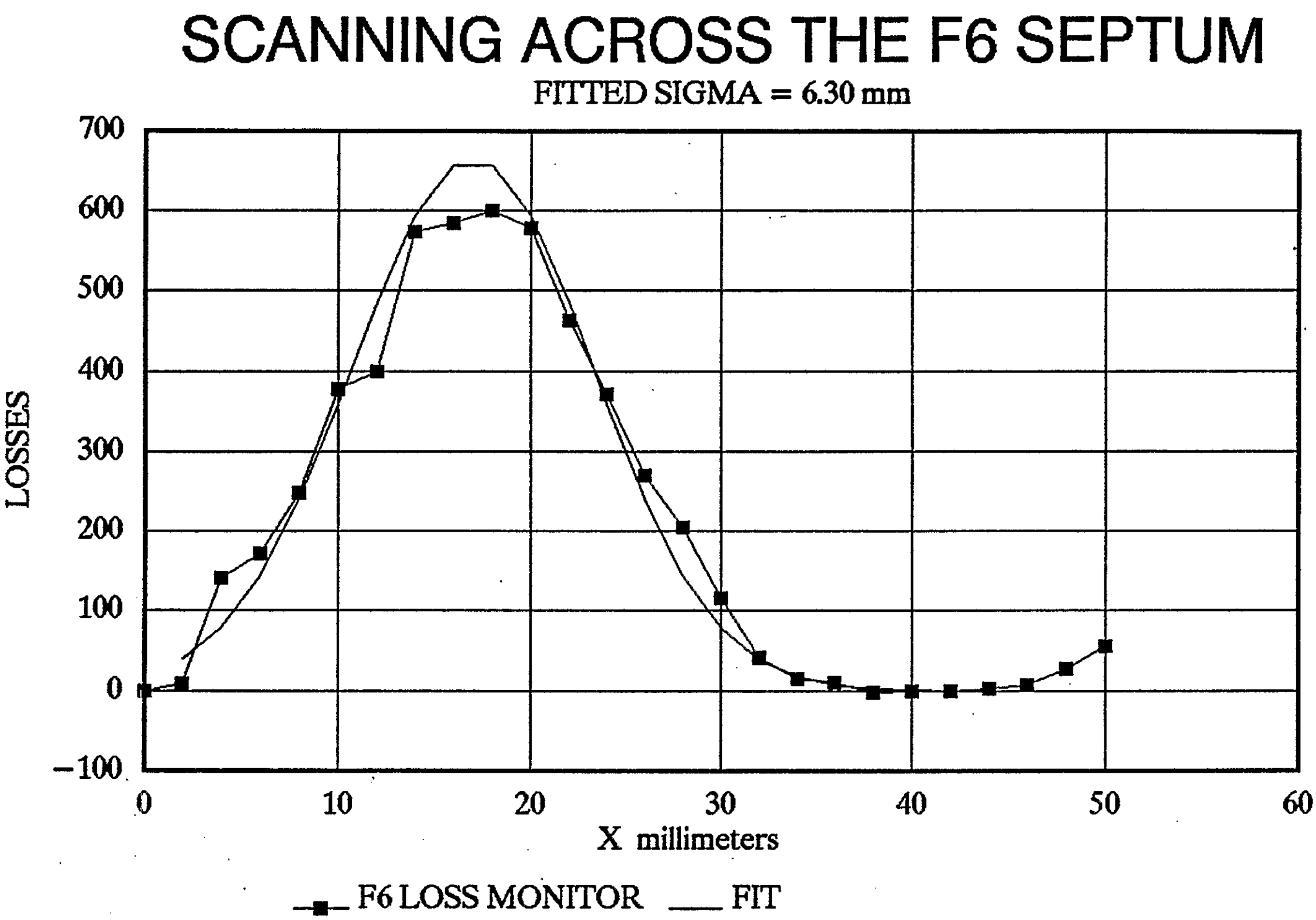

ACCEPTANCE AT F6 EXTRACTION SEPTUM
R = 20.0 mm, DHF2T = −1.01 mr, DHF4T = 3.71 mr, X2DHF3 = 3.00 mr
Septum = 47 mm
X' radians
X meters
0.015
0.01
0.005
0
−0.005
−0.01
−0.015
−0.1
−0.05
0
0.05
0.1
72 mm ACCEPTANCE
33 mm VERTICAL APERTURE
EXTRACTION BUMPS AND KICK
EXTRACTED BEAM
30−Sep−92
C:\EXT\ACCEPT.WK3; FIGURE 5



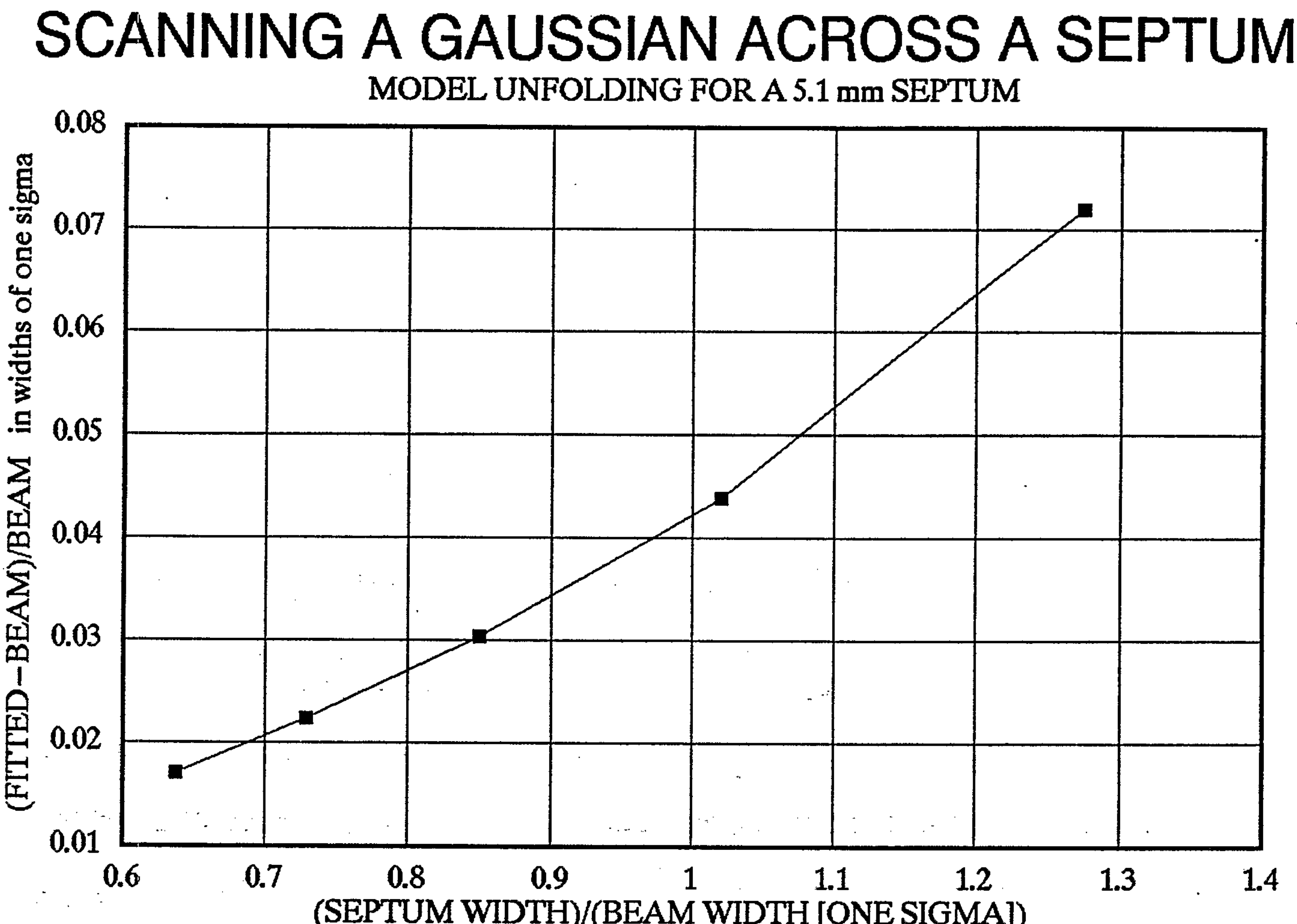
C:\EXT\EXTBMP.WK3; FIGURE 6
30–Sep–92



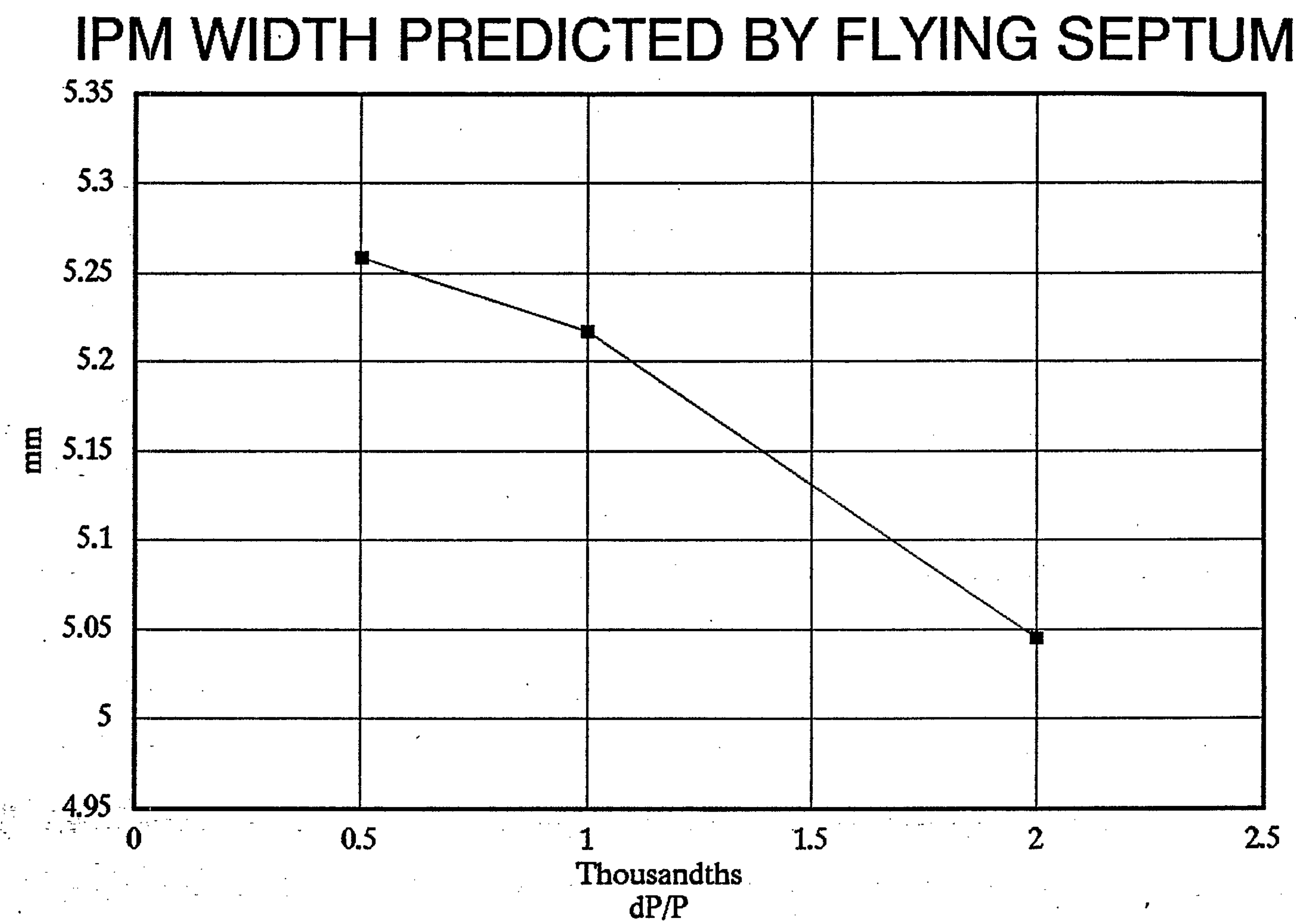
C:\EXT\EXTBMP.WK3; FIGURE 7
30−Sep−92



c:\study86\scan1A.wk3; FIGURE 8
30–Sep



C:\STUDY86\ERRORF.WK3; FIGURE 9



C:\STUDY86\SCAN1.WK3; FIGURE10