BNL-104072-2014-TECH
AGS.SN196;BNL-104072-2014-IR

Extraction Losses Produced by the H10 Septum Magnet Fringe Field

E. Bleser

November 1985

Collider Accelerator Department
Brookhaven National Laboratory

U.S. Department of Energy
USDOE Office of Science (SC)

DISCLAIMER

AGS STUDIES REPORT

Date 11/14-15/85 Time 1600-0600
Experimenters: E. Bleser, W. Glenn, P. Ingrassia, J. Ryan, S. Tanaka,
Reported by: E. Bleser
Subject: Extraction Losses Produced by the H10 Septum Magnet Fringe Field

I. Summary

With the H5 extraction kicker turned off, a low intensity beam can be made to just scrape the H10 septum, producing losses at both H10 and H5. Surprisingly , these losses are reduced by increasing the current in the H10 septum, suggesting there is a fringe field which pushes the beam away from the septum , thereby reducing the losses. However for a high intensity beam, increasing the current in H10 greatly increases the losses, suggesting there is a component of the fringe field which very much perturbs the high intensity beam. Since the vast bulk of these losses occur after the firing time of the H5 kicker they do not appear as extraction losses.

II. Introduction

Measurements were made to study the effect of the fringe field of the H10 septum magnet on the beam. We are able to hypothesize a scenario which explains the observed losses, and we propose this scenario as the simplest explanation of the data. Recognizing that the data are not complete, we can easily confirm the scenario with some additional measurements. In this note we only attempt to show that the fringe field affects the beam. We make no attempt to develop a full model which would explain how and why the fringe field produces the observed results. Such a model is plainly needed and may be developed after we measure the actual magnetic fields.

III. Scenario

Establish a low intensity beam, 2 to 3 TP. Turn on the bump at H5 so that the beam now goes through the aperture of the H5 kicker magnet, which at 0.5 inches becomes the limiting vertical aperture in the ring. Move the H10 septum magnet in closer to the beam. Eventually the beam will scrape on the septum producing losses on the H10 loss monitor and on the H5 loss monitor since particles scattered at H10 will be cleaned up at H5, the limiting aperture. This is shown in Figure 1. The amplitude of the losses is clearly a function of the position of the septum magnet.

Now turn on the H10 septum magnet. Surprisingly the losses go down, even though they are still spread over both H5 and H10, as is shown in Figure 2. We postulate that the fringe field pushes the beam away from the septum, reducing the losses. Figure 3 shows a prediction of the time distribution of the losses resulting from the competing effects of the slow H5 bump and the fast H10 extraction septum. This pattern should be very distinctive and should be easily observed. In this note we make no attempt to explain the effect of the fringe field on the closed orbit.

We now increase the beam intensity to 8 or 9 TP and with the H10 septum off position it to give low losses while still close to the beam. If we now turn on the H10 septum, we find that the losses instead of decreasing as they did above , increase rapidly with the H10 current as is shown in Figure 4, but now the losses occur only at H5 and not at H10. In addition they only start after the H10 current pulse has peaked, and they seem to reach a maximum as the current pulse goes to zero as is shown in Figure 5. Our conclusion is that on the down pulse a component of the fringe field, presumably from eddy currents and therefore of opposite sign from the field on the current rise, blows the beam up, perhaps by moving it on to a resonance, and produces scraping on H5, the limiting aperture. This effect is strongly intensity dependent as is shown in Figure 6, but we are unprepared to say if this is just a geometry effect or if it is indicative of something else. Since we normally fire the kicker and extract the beam 150 microseconds after the peak of the H10 bump, we never see the bulk of these losses in normal operations.

The point of the scenario we have constructed here is that there are two loss mechanisms which we must distinguish. If we pick conditions, beam scraping slightly and of moderate intensity - 5TP, we can see both effects as a function of the septum current, as is shown in Figures 7 an 8.

In this note we display the evidence which is suggestive of this scenario. Further projects to be done are:

1. More data to confirm this scenario;
2. Measure the fringe field of a septum magnet;
3. Understand the beam dynamics produced by the fringe field.

At this point we will have an understanding of the present situation and perhaps some guidance for the future.

Since this work was all done at relatively low intensity the actual operating conditions may well involve additional effects.

FIGURE CAPTIONS

In this experiment there were three parameters that we varied:

i. The position of the H10 septum;
ii. The current in the H10 septum;
iii. The AGS beam intensity.

Most of these figures show the losses on H5 and H10 as we vary one of these parameters while holding the other two fixed. This table is given as a guide to this 4 dimensional space.

Fig. No.	Septum Position	Septum Current	Beam Intensity
1	VARY	off	2.7 TP
2	VARY	on	2.7 TP
6	normal	on	VARY
4	normal	VARY	7 TP
7	in by 0.1"	VARY	5.5 TP
8	in by 0.2"	VARY	5.5 TP

Figure 1. The normalized losses on H5 and H10 as a function of the position of the H10 septum magnet with the H10 magnet off. This is the position of the upstream end of H10 where we have assumed that each count of the readback corresponds to 0.001 inches. The downstream end was maintained 0.25 inches inside of the upstream position. The normalized losses, always reported here, are simply the loss monitor readback divided by the AGS intensity. The close numerical agreement shown here between H5 and H10 is quite accidental although convenient. While the fraction of the beam that survived these losses was always recorded, the beam actually lost was small and we do not have a good calibration, but very roughly we assume that 100 units on the normalized loss scale corresponds to 5% loss from the circulating beam.

Figure 2. The normalized losses on H5 and H10 as a function of the position of the H10 septum magnet with the H10 magnet on at its normal setting.

Figure 3. An imagined picture of how the losses vary in time as the amplitude of the current in H10 is varied. At the bottom is shown the long slow H5 bump, with losses occuring when it is large enough to scrape the beam against the septum. In the middle we show H10 at half its current, suppressing the losses near its peak when it is large enough to push the beam away from the septum. At the top we show H10 on full, suppressing losses over most of its range. This time distribution has not been observed but might be interesting to look for.

Figure 4. Losses versus septum current. At this higher intensity the losses are concentrated on H5 and occur with the septum on.

Figure 5. This is a tracing of a polaroid of a scope display showing:

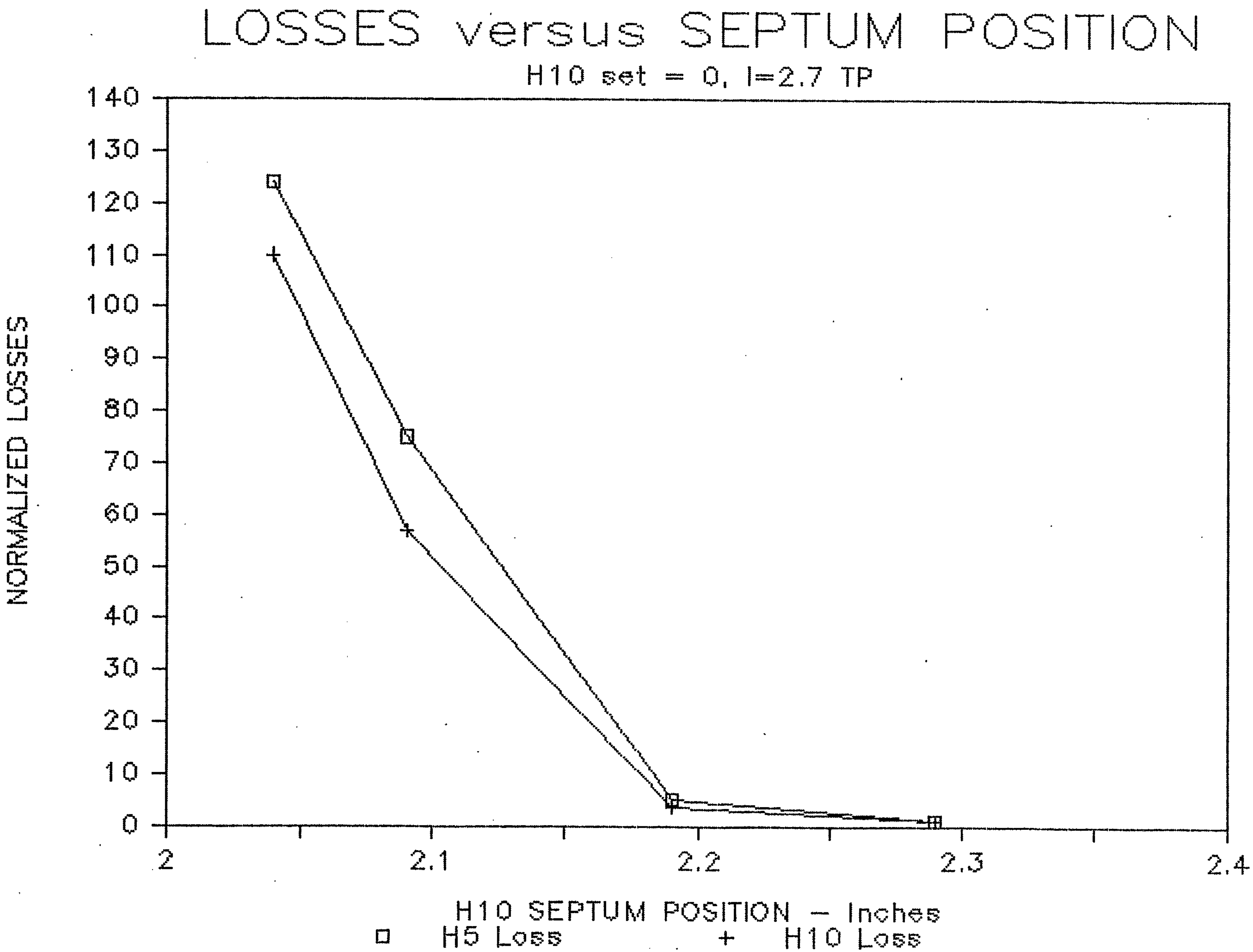
a. The H5 bump current;
b. The H10 septum current;
c. The H5 loss monitor.

The loss monitor is very badly saturated. The vertical line shows roughly where we normally extract by firing the H5 kicker. The bulk of the losses occur after this point but some may occur before.

Figure 6. Losses versus beam intensity for normal operating conditions except we are not firing the extraction kicker. These losses are read out well before the beam proper is dumped. Note that significent losses at H5 do not scatter down to H10. The reader can decide for himself whether we have a threshold followed by a linear rise, or if we have normalized losses going as about the third power of the beam intensity.

Figure 7. Losses versus septum current. Compared to Figure 4, the beam intensity is less and therefore the losses at high septum current settings are less, but the septum is moved in by 0.1 inches and we see significent scraping losses, which decrease with increasing septum current. The resulting loss curve is the sum of these two processes.

Figure 8. Losses versus septum current. Compared to Figure 7 the septum has been moved in by another 0.1 inches. The scraping losses are very large, note the scale change, and are saturated at the highest values. At the high septum current the increase due to the fringe field is about the same as in Figure 7, though the data seem to be too imprecise to answer the question does the effect increase as the beam moves closer to the septum. The increasing losses at H10 at high septum current do not fit in with the scenario developed in this note.



LOSSES versus SEPTUM POSITION
H10 set = 0, I=2.7 TP
NORMALIZED LOSSES
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
2
2.1
2.2
2.3
2.4
H10 SEPTUM POSITION – Inches
H5 Loss
H10 Loss

FIGURE 1

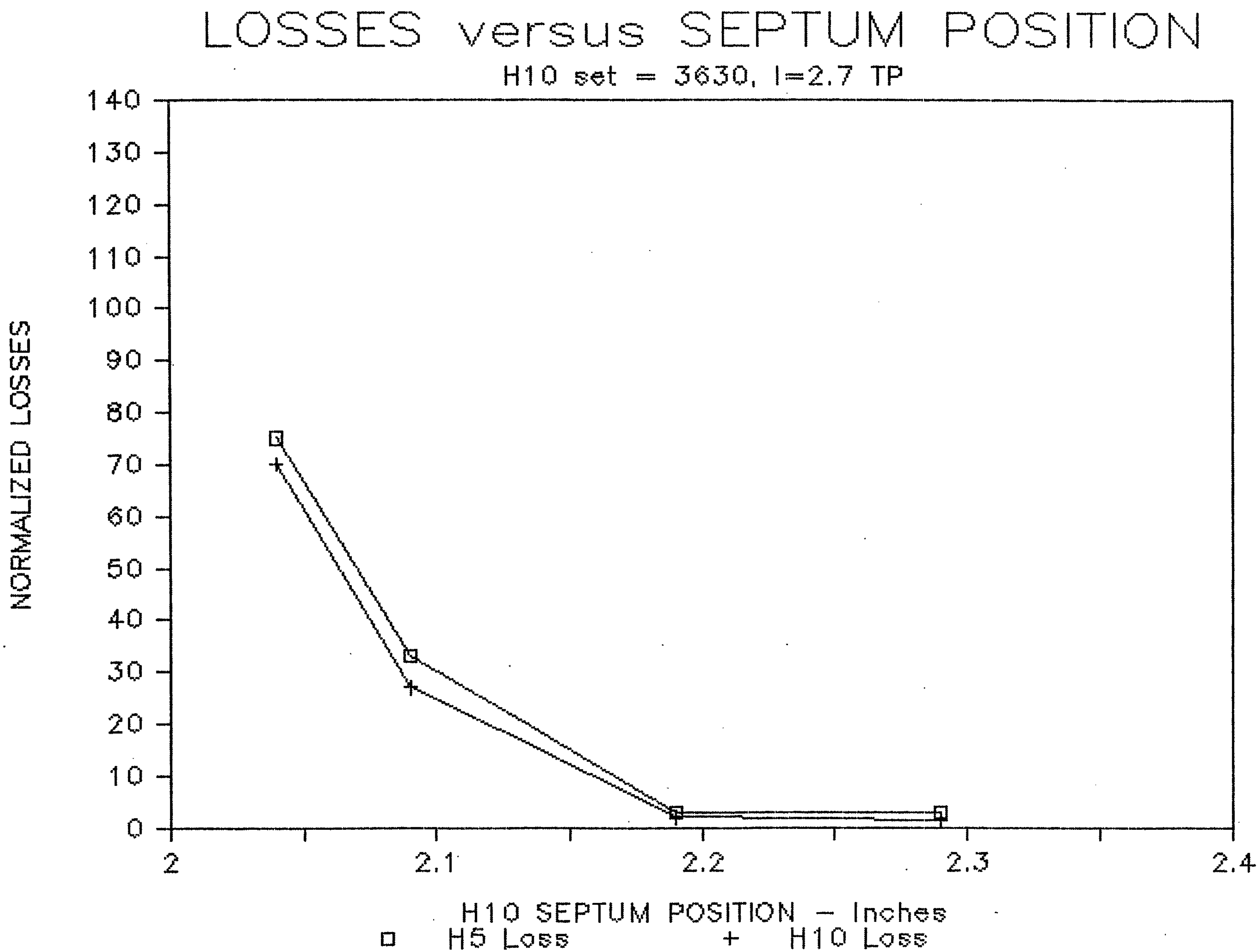

LOSSES versus SEPTUM POSITION
H10 set = 3630, I=2.7 TP
NORMALIZED LOSSES
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
2
2.1
2.2
2.3
2.4
H10 SEPTUM POSITION – Inches
H5 Loss
H10 Loss

FIGURE 2

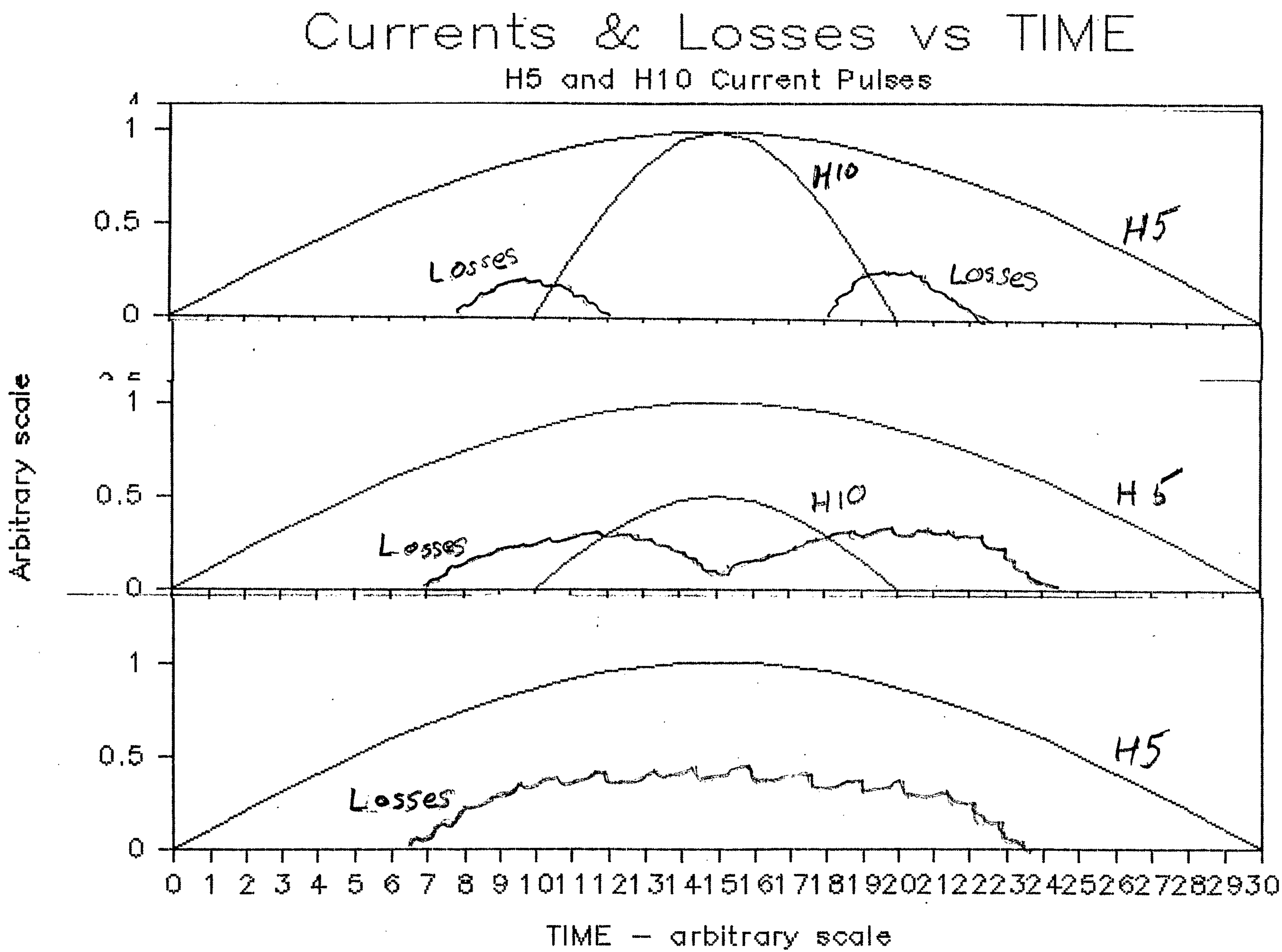

Currents & Losses vs TIME
H5 and H10 Current Pulses
H10
H5
Losses
Losses
H10
H5
Losses
H5
Losses
Arbitrary scale
TIME — arbitrary scale
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
0
0.5
1

FIGURE 3

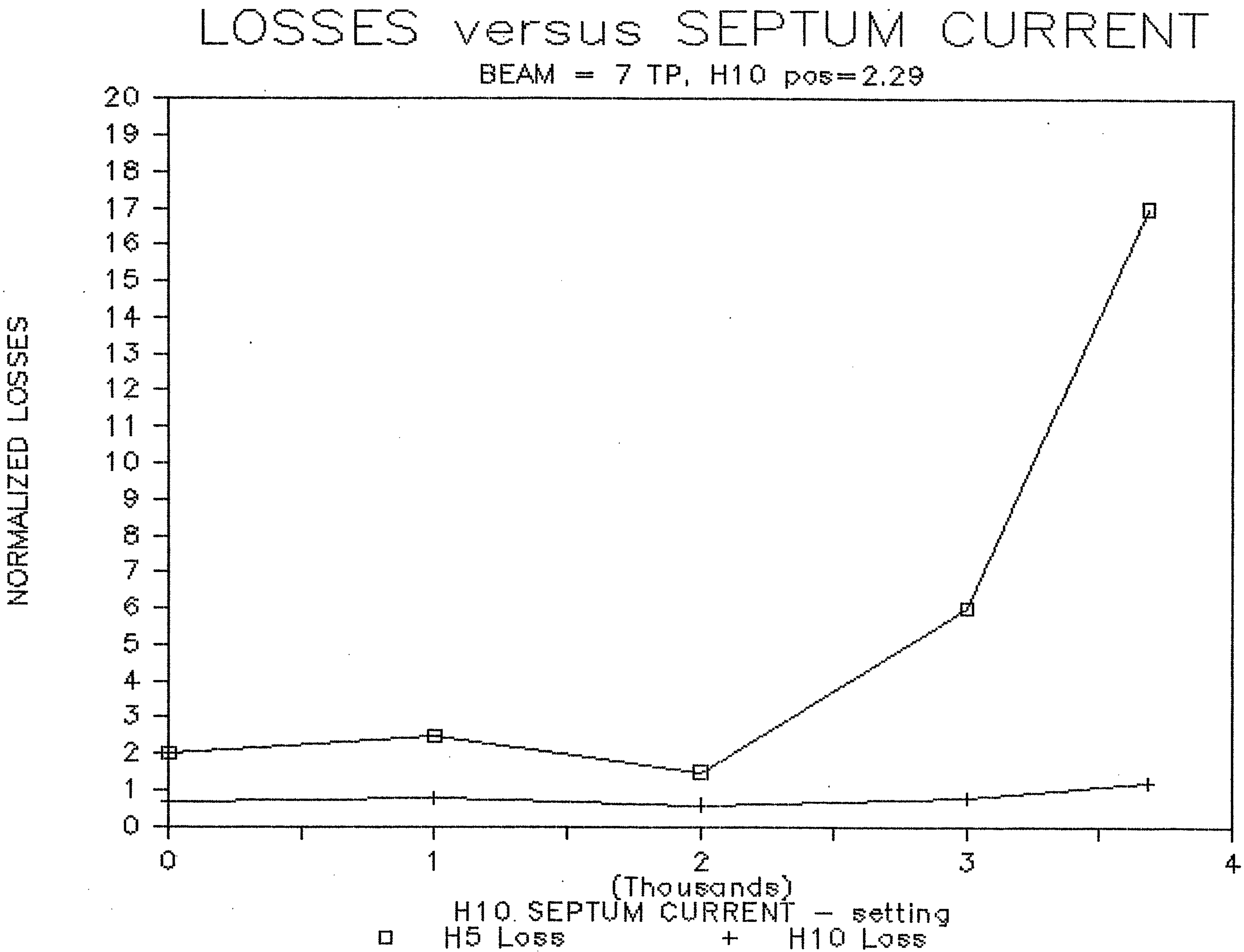

LOSSES versus SEPTUM CURRENT
BEAM = 7 TP, H10 pos=2.29
NORMALIZED LOSSES
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
0
1
2
3
4
(Thousands)
H10 SEPTUM CURRENT - setting
H5 Loss
H10 Loss

FIGURE 4

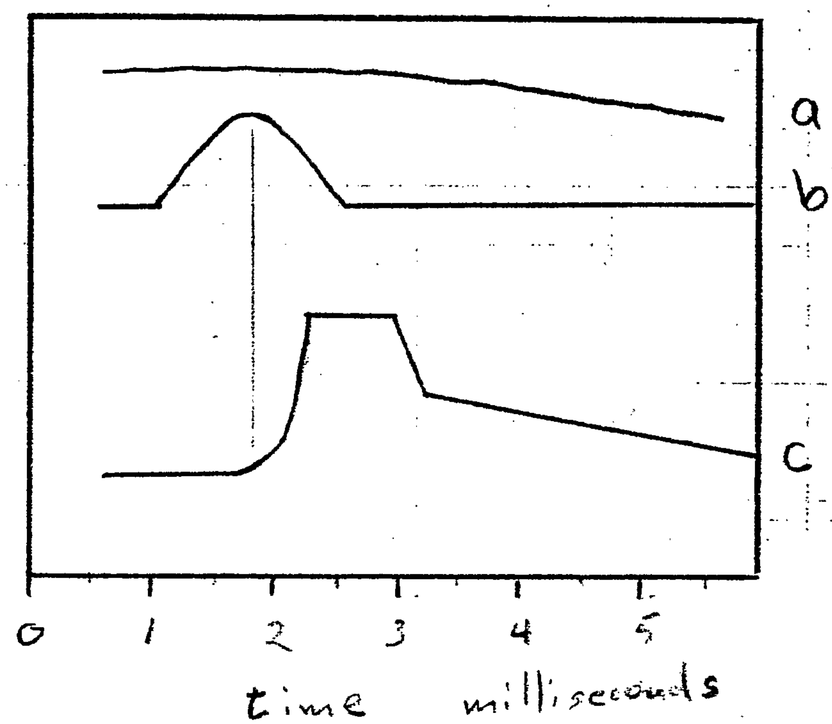


FIGURE 5

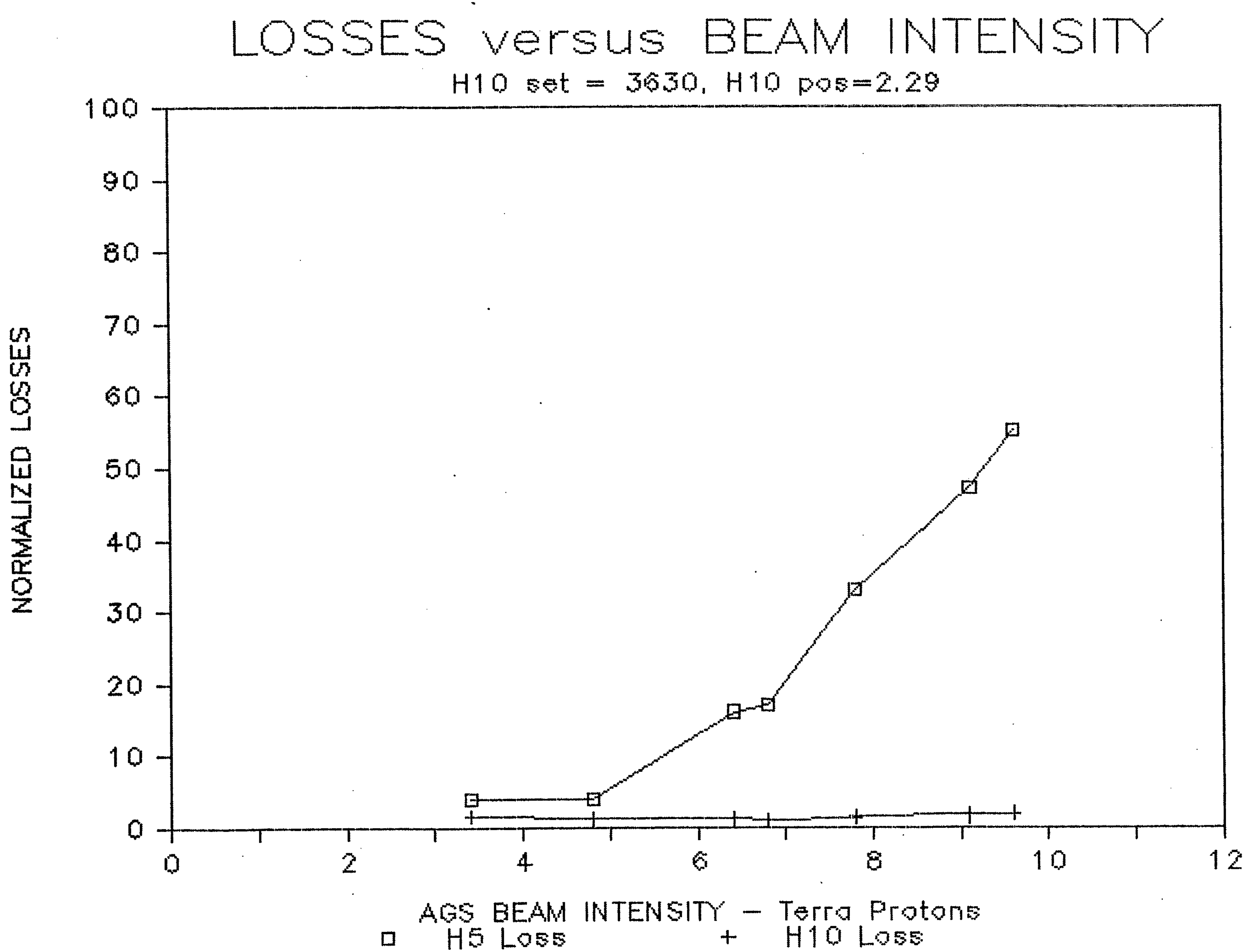
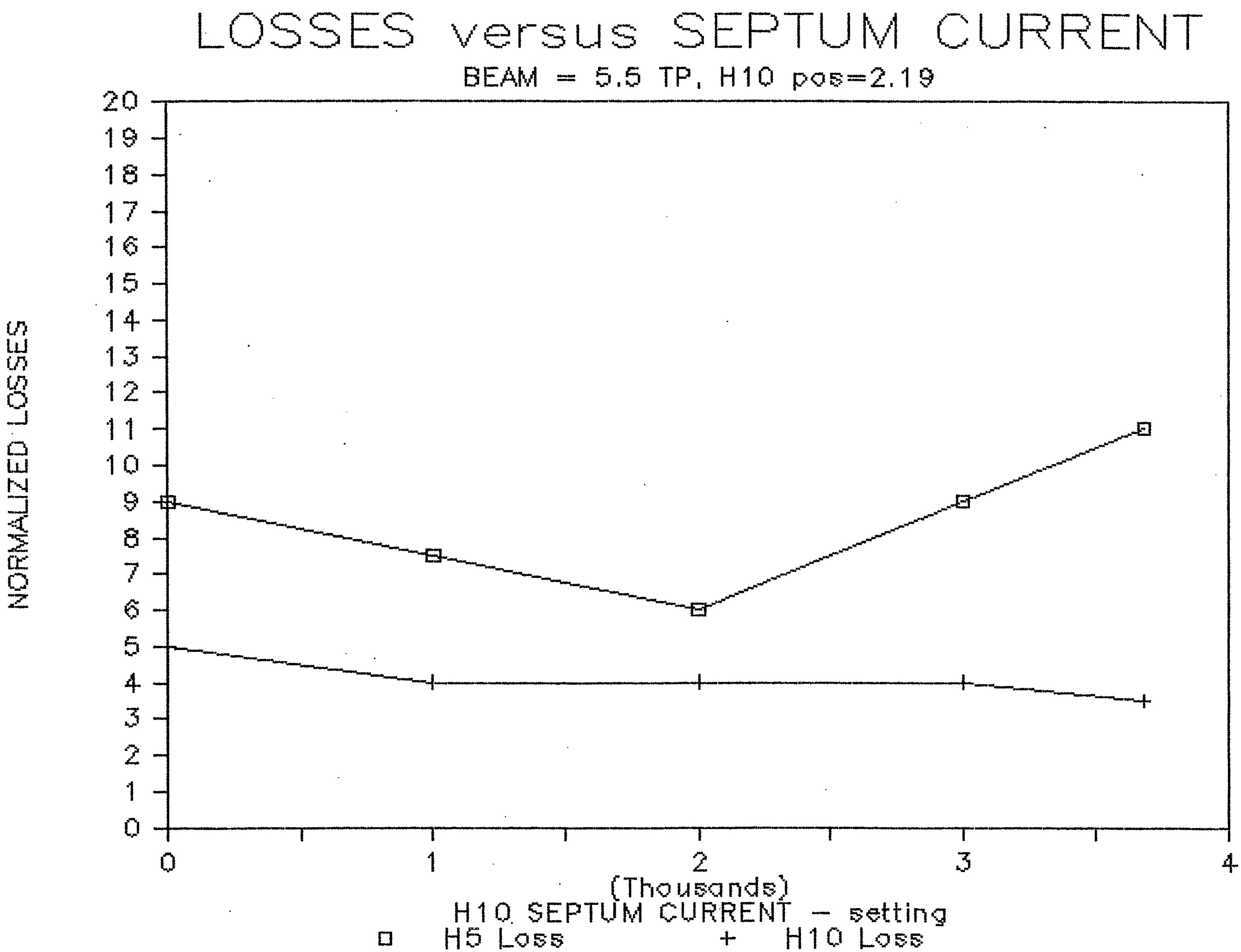

LOSSES versus BEAM INTENSITY
H10 set = 3630, H10 pos=2.29
NORMALIZED LOSSES
100
90
80
70
60
50
40
30
20
10
0
0
2
4
6
8
10
12
AGS BEAM INTENSITY — Terra Protons
H5 Loss
H10 Loss

FIGURE 6



LOSSES versus SEPTUM CURRENT
BEAM = 5.5 TP, H10 pos=2.19
NORMALIZED LOSSES
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
0
1
2
3
4
(Thousands)
H10 SEPTUM CURRENT - setting
H5 Loss
H10 Loss

FIGURE 7

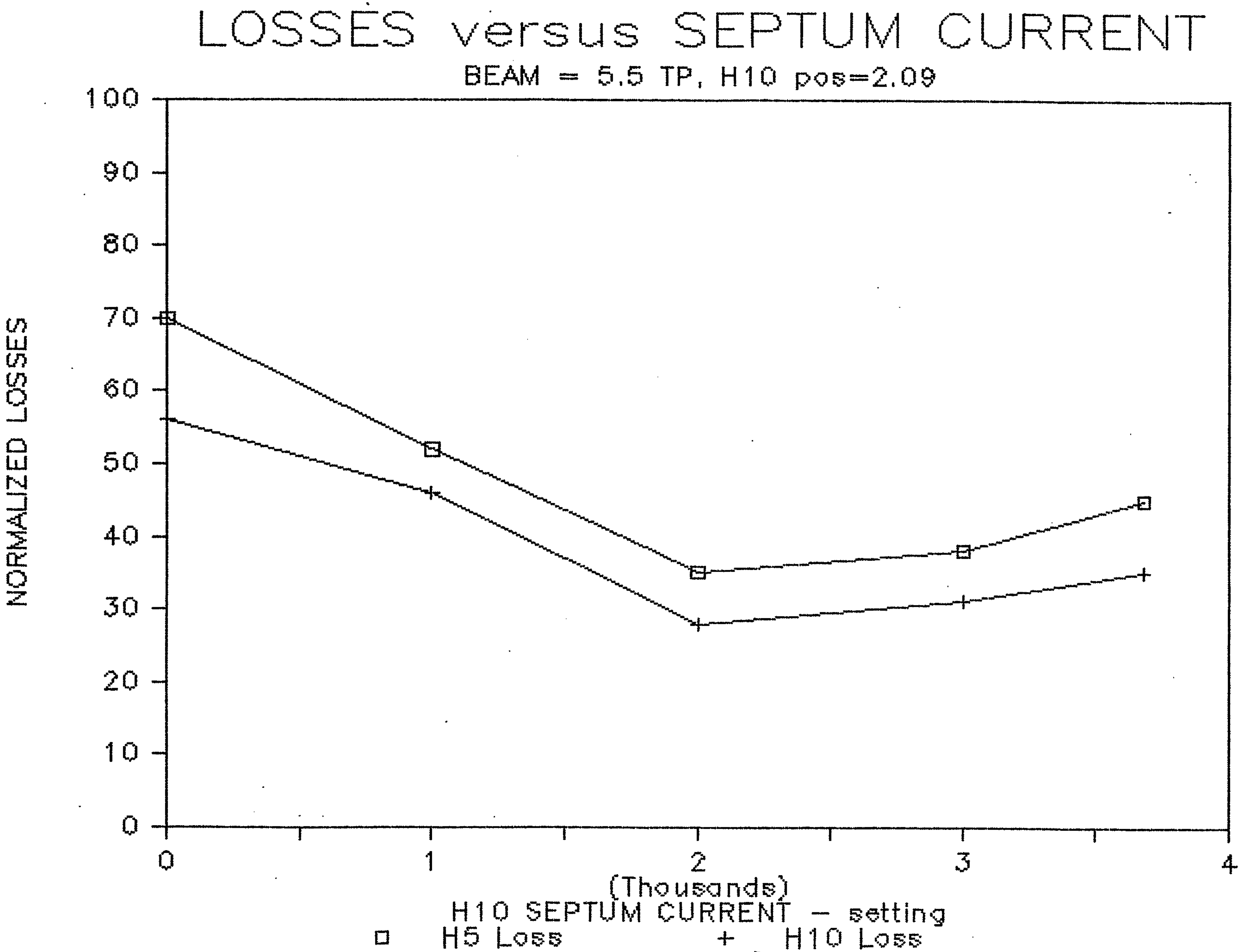

LOSSES versus SEPTUM CURRENT
BEAM = 5.5 TP, H10 pos=2.09
NORMALIZED LOSSES
100
90
80
70
60
50
40
30
20
10
0
0
1
2
3
4
(Thousands)
H10 SEPTUM CURRENT – setting
H5 Loss
H10 Loss

FIGURE 8