national accelerator laboratory

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SEXTUPOLE CONFIGURATIONS FOR HIGH RESOLUTION BEAM M6

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I. Introduction

High momentum resolution is a primary criterion by which the meson laboratory beam M6 is designed. It is a three-stage beam with a momentum defining slit at the end of the first stage. The dispersion is maximum at this point to give good resolution. The beam may be made essentially monochromatic by stopping down a slit located here. Recombination is done in the second and third stages with moderately high dispersion at the end of the second stage. For a larger momentum band pass, momentum determination may be done by placing counters at this point. Further description of the beam line and its potential uses may be found elsewhere.[1,2]

The minimum momentum interval carried by the beam will be 0.03% of the central momentum. This figure also then represents the maximum momentum resolution obtainable. However the beam line can transmit a total momentum interval of 2% of the central momentum. To maximize the analyzing power of any experiment utilizing the beam, it is desirable to have this resolution capability for the entire momentum interval carried by the beam. One therefore must eliminate aberrations which cause variation of the spot size at the momentum focus with either momentum or initial angle.

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In Section II below we describe the principal aberrations inherent in the design of the beam. Sections III and IV present schemes for eliminating some of these aberrations to second order. Finally in Section V we examine each of the solutions including the effect of higher order terms.

II. The Beam and Principal Aberrations

A. Basic Beam Geometry

Each of the three stages of the beam contains two quadrupole doublets. The first focuses from point to parallel, while the second refocuses the beam to a point. For both doublets the horizontally defocusing quad is placed nearer the focus. This both maximizes the resolution and helps match the beam profile with the bending magnet apertures. Between the doublets, in the parallel region, are placed the bending magnets whose purpose is either to disperse or recombine the beam in momentum. At high energies with zero gradient bending magnets, we may, for purposes of this discussion, safely ignore the focusing properties of the bending magnets. At each focus is placed a field lens quadrupole which further aids in obtaining complete momentum recombination.

For a doublet focusing point to parallel, as shown in Figure 1, two principal planes are relevant.[3] The figure is drawn with the horizontally defocusing quadrupole nearer the focus, as is the case in beam line M6. If ℓ is the distance from the focus to the first quadrupoles, s is the distance between the centers of the quadrupoles, and f_1 and f_2 are their respective focal lengths, then in a thin lens approximation

we have:

$$f_1 = \ell \sqrt{s/(\ell + s)} \tag{1}$$

$$f_2 = \sqrt{s(\ell + s)}$$

The distances from the focus to the horizontal and vertical principal planes respectively are:

$$h_x = \ell + s + f_2 \tag{2}$$

$$h_y = \ell + s - f_2$$

The magnitude of the sine-like ray in each plane in the parallel section is equal to the distance from the focus to the corresponding principal plane.

B. Principal Aberrations

At high energies the important aberrations occurring in a beam line arise from three sources:[4] chromatic aberrations from the quadrupoles, the effect of particles traversing a bending magnet at an angle to the central ray, and the influence of sextupoles. Since in this beam the bending magnets are placed in the parallel sections we may safely ignore the second item. We will now concentrate our attention on the chromatic aberrations of the quadrupoles.

The principal impediment to achieving high resolution over the entire momentum band carried by the beam is the variation with momentum of the focusing strength of the quads. For a point-to-point image this variation is measured by the second-order matrix elements T_{126} and T_{346}. For this case Brown[4] has shown that the matrix element T_{126} is given by:

$$T_{126} = M_x \int_0 s_x'^2 \, dz \tag{3}$$

where M_x is the horizontal magnification and s'_x the slope of the horizontal sine-like ray. The integral is taken over the entire distance between foci. The term T_{346} may be evaluated similarly.

We now depict in Figure 2 a section of the beam, with principal planes shown for each doublet. For a thin lens approximation it may be shown that

$$T_{126} = 2(h_2 + h_3) \qquad (4)$$

$$T_{346} = 2(h_1 + h_4)$$

An exact numerical calculation shows that for NAL beams this result should be accurate to within a few percent. For the optical mode used in beam line M6 the chromatic aberration will clearly be significantly greater in the horizontal than in the vertical plane.

For a two-stage beam the chromatic aberration of each stage will be affected by the magnification of the other, but the result for each stage is unchanged.

III. Two Sextupole Solution

We now address ourselves to the problem of eliminating chromatic aberration at the end of the second section.[5] First we consider a solution which reduces the term T_{126} to zero but ignores the effect on T_{346}. As shown in the previous section chromatic aberration is larger in the horizontal plane. It is also in the horizontal plane that chromatic aberration affects the momentum resolution.

In Figure 3 we designate the positions of four sextupoles placed in the second stage of the beam, labeling them with the letters a, b, c, and d. The sextupoles straddle the doublets in pairs, sextupoles a and d being as close to the quadrupoles as possible. The dispersion ray d_x is also shown, with its crossover in the vicinity of sextupole c. In this section we consider the use of only sextupoles b and c. A solution using all four sextupoles will be discussed in Section IV.

A sextupole placed in a beam line to correct for chromatic aberrations will introduce geometric aberrations. The principal ones affecting beam spot size in this beam are T_{122} and T_{144}. Therefore we must include at least two sextupoles so their contributions to geometric terms will cancel while eliminating chromatic terms.

The changes in the relevant matrix elements due to a single sextupole are:[4]

$$\Delta T_{122} = M_x s_x{}^3 S \tag{5}$$

$$\Delta T_{144} = -M_x s_x s_y{}^2 S$$

$$\Delta T_{126} = 2M_x s_x{}^2 d_x S$$

where M_x is the horizontal magnification, s_x and s_y are the sine-like rays in each plane and d_x is the dispersion ray. The quantity S is a measure of the strength of the sextupole and is equal to $qB\ell/a^2p_0$, where B is the pole tip field, a the half aperture, and ℓ the length of the sextupole, and q and p_0 represent the charge and central momentum of the particles.

Since the sextupoles are both placed in the parallel section the two sine-like rays s_x and s_y have the same magnitude

for each of them. Hence by setting their strengths to be equal and opposite we may cancel the contributions to T_{122} and T_{144}. Letting $S = S_b = -S_c$ we can eliminate the T_{126} term by setting:

$$2M_x s_{xb}^2 S(d_{xb} - d_{xc}) = -T_{126} \tag{6}$$

Actual determination of the sextupole strengths was done using the program TRANSPORT.[6,7] Using sextupoles which are 2.5 feet long and have a half aperture of 5 cm, a pole tip field of 2.774 kilogauss is required.

IV. Four Sextupole Solution

To eliminate chromatic aberration to second order in both planes, four sextupoles are required. In addition to the chromatic term T_{346}, the geometric term T_{324} now becomes important. The coupling of a sextupole to these additional terms is given by:

$$\Delta T_{324} = -2M_y s_x s_y^2 S \tag{7}$$

$$\Delta T_{346} = -2M_y s_y^2 d_x S$$

where now s_y is the vertical sine-like ray and M_y is the vertical magnification. We see that the difference in coupling to the terms T_{144} and T_{324} lies only in the magnification term, which is a property of the entire beam line and is therefore the same for all sextupoles. Therefore if the sextupoles are set so that T_{144} is equal to zero, then T_{324} will also equal zero. We now have four terms to eliminate with four sextupoles. It remains to determine if the four couplings are sufficiently independent to guarantee that the solution will result in reasonable pole tip fields.

We may now write the equation to be solved in the form:

$$MS + T = 0 \tag{8}$$

where S is a vector giving the four sextupole strengths, T a vector made up of the uncorrected second order terms T_{122}, T_{144}, T_{126}, T_{346} respectively, and M is a matrix of the coupling terms. The uncorrected T matrix terms are those which occur when no sextupoles are included. The element M_{11} of this matrix, for example will have the form $M_x s_{xa}^3$, where s_{xa} is the magnitude of the horizontal sine-like ray at point a. By defining a new vector $\overline{T}$ as a renormalized T whose elements are given as:

$$\overline{T} = \begin{pmatrix} T_{122}/M_x \\ -T_{144}/M_x \\ T_{126}/2M_x \\ -T_{346}/2M_y \end{pmatrix} \tag{9}$$

we may introduce a simpler Matrix $\overline{M}$ and rewrite equation (8) as:

$$\overline{M}S + \overline{T} = 0 \tag{8a}$$

where now exhibit $\overline{M}$ explicitly as:

$$\overline{M} = \begin{pmatrix} s_{xa}^3 & s_{xb}^3 & s_{xc}^3 & s_{xd}^3 \\ s_{xa}s_{ya}^2 & s_{xb}s_{yb}^2 & s_{xc}s_{yc}^2 & s_{xd}s_{yd}^2 \\ s_{xa}^2 d_{xa} & s_{xb}^2 d_{xb} & s_{xc}^2 d_{xc} & s_{xd}^2 d_{xd} \\ s_{ya}^2 d_{xa} & s_{yb}^2 d_{xb} & s_{yc}^2 d_{xc} & s_{yd}^2 d_{xd} \end{pmatrix} \tag{10}$$

and label the submatrices as follows:

$$\overline{M} = \begin{pmatrix} M_{11} & M_{12}U \\ M_{21} & M_{22}U \end{pmatrix} \tag{10a}$$

where the matrix U, given by:

$$U = \begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix} \tag{11}$$

functions simply to interchange the columns of the matrix that multiplies it. With this definition, if the second stage of the beam were symmetric, so that the two doublets were mirror images of each other, we would have $M_{11} = M_{12}$.

Now if the matrix $\overline{M}$ is non-singular a solution will exist. Roughly, we may say that if the determinant of $\overline{M}$ is large, the resulting sextupole strengths will be small. Consider first the situation which would occur if the momentum recombination were done entirely in the second stage. Then we would have $d_{xc} = d_{xd} = 0$ and therefore $M_{22} = 0$. This would give us $\det(\overline{M}) = -\det(M_{12}) \cdot \det(M_{21})$, so by examining the structure of the submatrices we can gain understanding of the entire problem.

From the locations of the principal planes we see that:

$$\begin{aligned} s_{xa} &< s_{xb} \\ s_{ya} &> s_{yb} \\ s_{xd} &< s_{xc} \\ s_{yd} &> s_{yc} \end{aligned} \tag{12}$$

Examination of the coupling terms shows that sextupoles b and c will couple most strongly to T_{122} and T_{126} while sextupoles a and d couple more strongly to T_{144} and T_{346}. In essence what we are doing is first to correct T_{126} and T_{346} with sextupoles b and a respectively. Then we correct the resultant T_{122} and T_{144} terms with sextupoles c and d respectively. Examining the determinants of the submatrices and referring to equations (12) we find:

$$-\det(M_{12}) = s_{xc}s_{xd}(s_{xc}^2\, s_{yd}^2 - s_{yc}^2\, s_{xd}^2) > 0 \qquad (13)$$

$$\det\,(M_{21}) = d_{xa}d_{xb}(s_{xa}^2\, s_{yb}^2 - s_{ya}^2\, s_{xb}^2) > 0$$

If we now define the two component vectors $\overline{T}_1$ and $\overline{T}_2$ as giving the upper and lower (geometric and chromatic) parts of $\overline{T}$ and S_1 and S_2 as:

$$S_1 = \begin{pmatrix} S_a \\ S_b \end{pmatrix} \qquad S_2 = \begin{pmatrix} S_d \\ S_c \end{pmatrix} \qquad (14)$$

As explained in Section II, the components of $\overline{T}_1$ will be zero so we arrive at the solution:

$$S_1 = -M_{21}^{-1}\overline{T}_2 \qquad (15)$$

$$S_2 = -M_{12}^{-1}M_{11}S_1$$

Now, of course, momentum recombination is not all accomplished in the second stage and the conditions $d_{xc} = 0$ and $d_{xd} = 0$ cannot simultaneously be true. However if we adjust the field lens to place the momentum crossover in the region of sextupole c, then the situation should not differ too greatly from the previous case and solution should still be possible. We must now solve the simultaneous equations:

$$M_{11}S_1 + M_{12}S_2 = 0 \qquad (16)$$

$$M_{21}S_1 + M_{22}S_2 = -\overline{T}_2$$

We define a new two-component vector X as:

$$X = M_{11}S_1 \; . \qquad (17)$$

The arguments used above to show M_{12} to be non-singular apply also to M_{11} and from the first of equations (16) we get:

$$S_1 = M_{11}^{-1}X \tag{18}$$

$$S_2 = -M_{12}^{-1}X$$

Substituting into the second of equations (16) gives:

$$(M_{21}M_{11}^{-1} - M_{22}M_{12}^{-1})X = -\overline{T}_2 \tag{19}$$

Each of the submatrices M_{11}, M_{12}, M_{21}, and M_{22} is factorizable and, for example, we have:

$$M_{11} = \begin{pmatrix} s_{xa}^2 & s_{xb}^2 \\ s_{ya}^2 & s_{yb}^2 \end{pmatrix} \begin{pmatrix} s_{xa} & 0 \\ 0 & s_{xb} \end{pmatrix} \tag{20}$$

$$M_{21} = \begin{pmatrix} s_{xa}^2 & s_{xb}^2 \\ s_{ya}^2 & s_{yb}^2 \end{pmatrix} \begin{pmatrix} d_{xa} & 0 \\ 0 & d_{xb} \end{pmatrix}$$

The first matrix on the right side is the same in each equation so that in equation (19) we have:

$$M_{21}M_{11}^{-1} - M_{22}M_{12}^{-1} = \begin{pmatrix} \frac{d_{xa}}{s_{xa}} - \frac{d_{xd}}{s_{xd}} & 0 \\ 0 & \frac{d_{xb}}{s_{xb}} - \frac{d_{xc}}{s_{xc}} \end{pmatrix}$$

Since $s_{xb} = s_{xc}$, the lower right term is $(d_{xb} - d_{xc})/s_{xb}$, indicating that here, just as for the two sextupole case, only the difference in the magnitude of the dispersion ray at the two points is important. Also by setting the momentum crossover point at sextupole c, we see that d_{xd} will be negative. Thus

we are insured that both terms are non-zero, and a solution is indeed possible. Numerical values were once again obtained with the program TRANSPORT. For sextupoles with dimensions as before, we get pole tip fields as shown:

Sextupole	Pole Tip Field
S_a	-3.053 kg
S_b	7.203 kg
S_c	-6.829 kg
S_d	2.750 kg

V. Higher Order Effects

Both the two- and the four-sextupole solutions work perfectly to second order. The obvious question, of course, is the influence of higher order effects. Such effects were examined with the use of the program TURTLE,[8] and the resulting histograms are shown in Figures 4-17. Both horizontal and vertical planes are shown at both second and third foci. The solutions described minimize the second order terms at the second focus. The effect on the beam spot at the third focus is of interest since that is the position at the final target. All runs were made using the recombined mode of the beam as adapted to the needs of experiment no. 96.

In Figure 4 are shown respectively the vertical and horizontal beam profiles at the second focus, using the central design momentum and no sextupoles. The horizontal and vertical spots respectively at the third focus for the same beam configuration are shown in Figure 5. These profiles represent essentially

the first order beam spot. The aim of introducing correcting elements is to make the off-momentum profiles appear essentially the same.

In Figures 6 and 7 are shown the same set of profiles for a momentum one-half percent above the design central momentum. Figures 8 and 9 are the same for a momentum 1% above the design central momentum. All cases are with no sextupoles. As we get away from the central momentum all profiles begin to broaden due to chromatic aberration. As explained in Section II, the broadening in the vertical plane is substantially less than in the horizontal plane.

In Figures 10-15 we see repeated the same set of profiles, but with the two sextupole solution. We are correcting for chromatic aberration on the horizontal plane at the second focus. As can be seen, the horizontal profile at the second focus is now essentially the same for all momenta. A tail, due to higher order effects, appears, even in the on-momentum profile, but is negligible. In the horizontal plane at the third focus the chromatic aberration is greatly reduced. Some deterioration of the beam profile in the vertical plane at both foci is observed. However, if we examine the coupling terms of the sextupoles to the vertical aberrations, we discover that, with the beam geometry used, they are much smaller than those for the horizontal aberrations. Therefore the loss in the vertical plane is not nearly as great as the gain in the horizontal.

The profiles for the four sextupole solution are shown in Figures 16 and 17 for only the central momentum. The higher order terms due to coupling of sextupoles produce a substantial deterioration of the horizontal beam spot, at both second and third foci. This deterioration is, for a large fraction of the momentum band, at least as great as the effect being corrected. It cannot therefore be used as a practical solution. The conclusion is that, for this beam, one must be satisfied correcting in only the horizontal plane and accepting a small deterioration in the vertical.

References

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8. D. C. Carey, NAL Report No. 64 (1971).

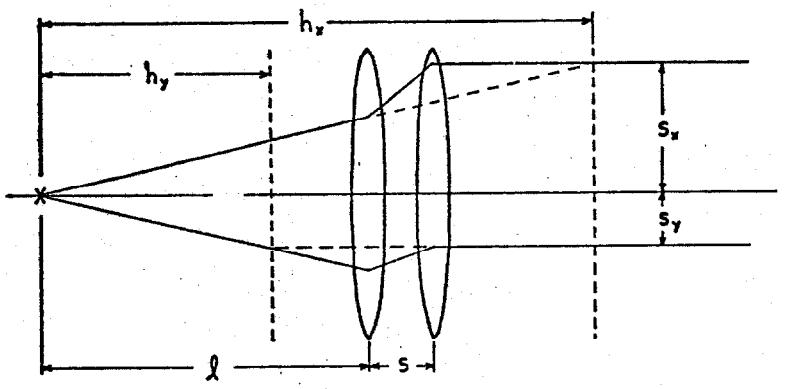

Figure 1. Doublet focusing point to parallel. The horizontally defocusing quadrupole is nearer the focus. Principal planes and sine-like rays are shown in the horizontal (x) and vertical (y) planes.

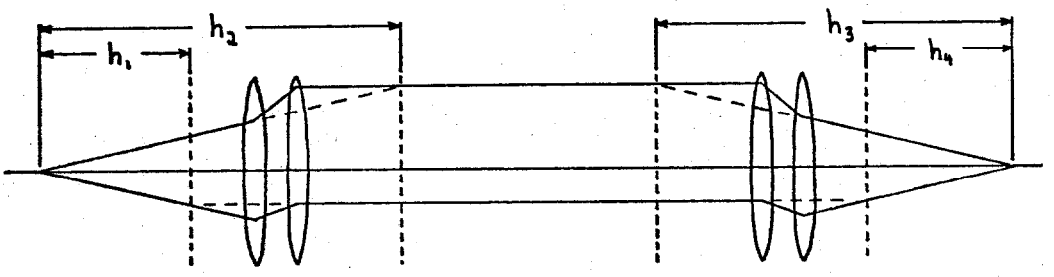

Figure 2. A section of beam line M6 omitting bending magnets. Principal planes are shown for each doublet. Sine-like rays in both planes are also included.

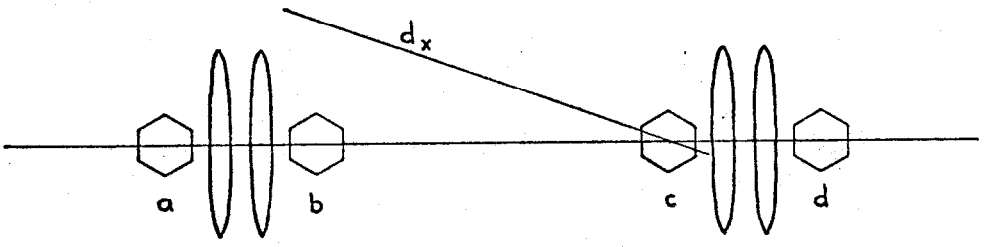

Figure 3. Second stage of beam line M6. Positions of four sextupoles a, b, c, and d are shown. The dispersion ray d_x is drawn in.

Recombined - no sexts
$\Delta p/p = 0$

(1)

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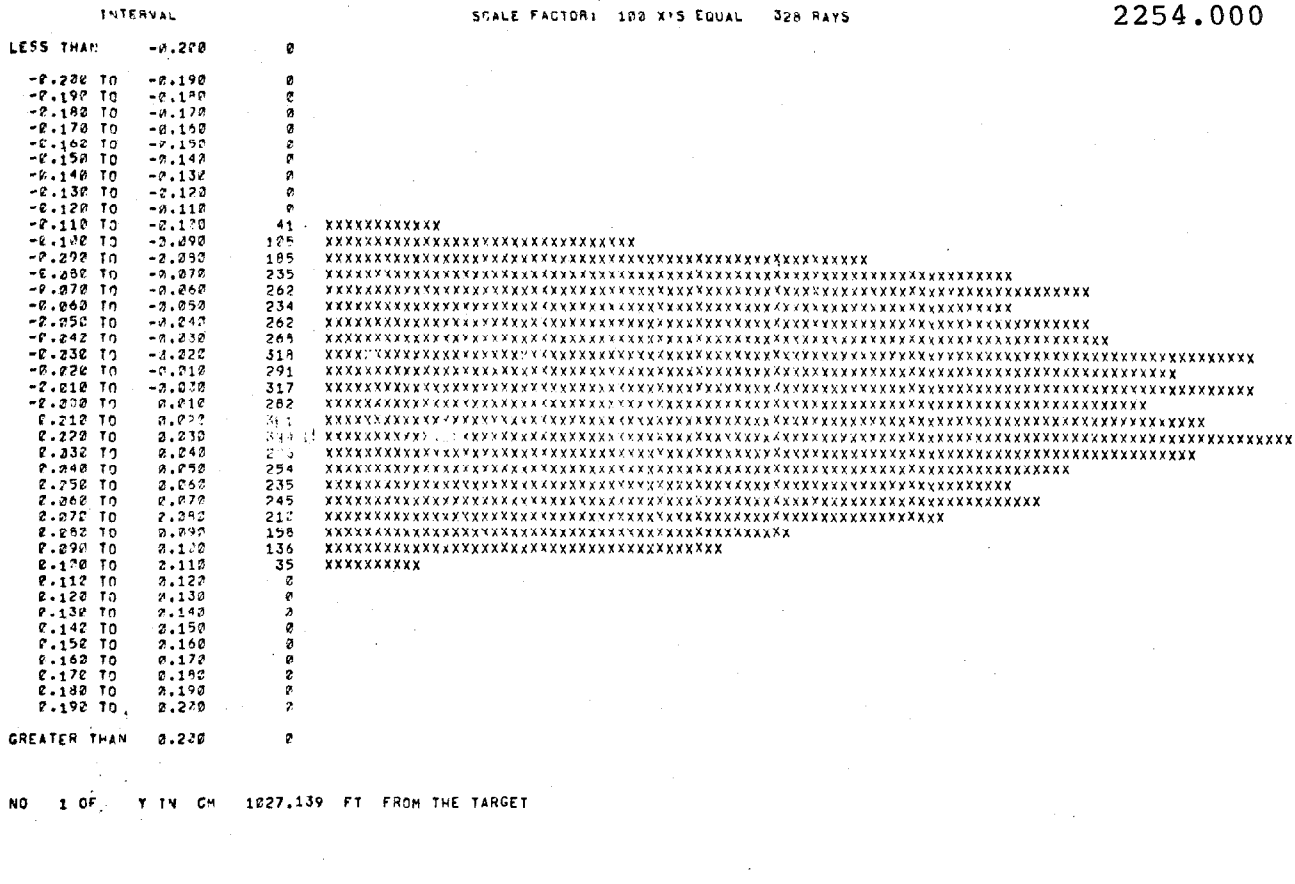
THE FOLLOWING IS A HISTOGRAM OF Y FOR 5000 RAYS

SCALE FACTOR: 100 X'S EQUAL 328 RAYS



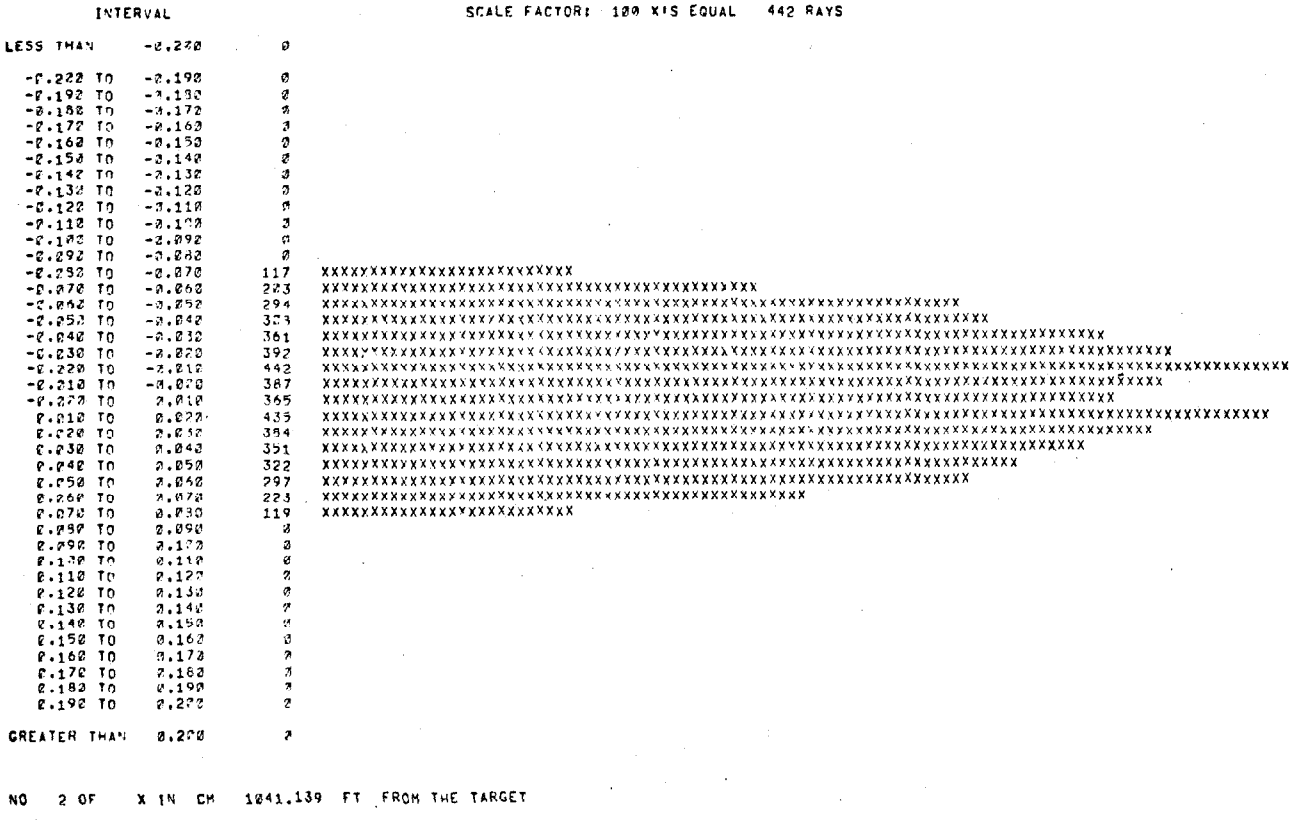
INTERVAL		
LESS THAN	-0.200	0
-0.200 TO	-0.190	0
-0.190 TO	-0.180	0
-0.180 TO	-0.170	0
-0.170 TO	-0.160	0
-0.160 TO	-0.150	0
-0.150 TO	-0.140	0
-0.140 TO	-0.130	0
-0.130 TO	-0.120	0
-0.120 TO	-0.110	0
-0.110 TO	-0.100	41
-0.100 TO	-0.090	105
-0.090 TO	-0.080	185
-0.080 TO	-0.070	235
-0.070 TO	-0.060	262
-0.060 TO	-0.050	234
-0.050 TO	-0.040	262
-0.040 TO	-0.030	269
-0.030 TO	-0.020	318
-0.020 TO	-0.010	291
-0.010 TO	-0.000	317
-0.000 TO	0.010	282
0.010 TO	0.020	[illegible]
0.020 TO	0.030	[illegible]
0.030 TO	0.040	[illegible]
0.040 TO	0.050	254
0.050 TO	0.060	235
0.060 TO	0.070	245
0.070 TO	0.080	212
0.080 TO	0.090	158
0.090 TO	0.100	136
0.100 TO	0.110	35
0.110 TO	0.120	0
0.120 TO	0.130	0
0.130 TO	0.140	0
0.140 TO	0.150	0
0.150 TO	0.160	0
0.160 TO	0.170	0
0.170 TO	0.180	0
0.180 TO	0.190	0
0.190 TO	0.200	0
GREATER THAN	0.200	0

NO 1 OF Y IN CM 1027.139 FT FROM THE TARGET

(2)

THE FOLLOWING IS A HISTOGRAM OF X FOR 5000 RAYS

SCALE FACTOR: 100 X'S EQUAL 442 RAYS



INTERVAL		
LESS THAN	-0.200	0
-0.200 TO	-0.190	0
-0.190 TO	-0.180	0
-0.180 TO	-0.170	0
-0.170 TO	-0.160	0
-0.160 TO	-0.150	0
-0.150 TO	-0.140	0
-0.140 TO	-0.130	0
-0.130 TO	-0.120	0
-0.120 TO	-0.110	0
-0.110 TO	-0.100	0
-0.100 TO	-0.090	0
-0.090 TO	-0.080	0
-0.080 TO	-0.070	117
-0.070 TO	-0.060	223
-0.060 TO	-0.050	294
-0.050 TO	-0.040	333
-0.040 TO	-0.030	361
-0.030 TO	-0.020	392
-0.020 TO	-0.010	442
-0.010 TO	-0.000	387
-0.000 TO	0.010	365
0.010 TO	0.020	435
0.020 TO	0.030	384
0.030 TO	0.040	351
0.040 TO	0.050	322
0.050 TO	0.060	297
0.060 TO	0.070	223
0.070 TO	0.080	119
0.080 TO	0.090	0
0.090 TO	0.100	0
0.100 TO	0.110	0
0.110 TO	0.120	0
0.120 TO	0.130	0
0.130 TO	0.140	0
0.140 TO	0.150	0
0.150 TO	0.160	0
0.160 TO	0.170	0
0.170 TO	0.180	0
0.180 TO	0.190	0
0.190 TO	0.200	0
GREATER THAN	0.200	0

NO 2 OF X IN CM 1041.139 FT FROM THE TARGET

Figure 4. Beam profiles at the second focus in the vertical and horizontal planes respectively. No sextupoles are included and the momentum is the central design value.

(3)

THE FOLLOWING IS A HISTOGRAM OF X FOR 5000 RAYS

SCALE FACTOR: 100 X'S EQUAL 436 RAYS

INTERVAL		
LESS THAN	-0.200	0
-0.200 TO	-0.190	0
-0.190 TO	-0.180	0
-0.180 TO	-0.170	0
-0.170 TO	-0.160	0
-0.160 TO	-0.150	0
-0.150 TO	-0.140	0
-0.140 TO	-0.130	0
-0.130 TO	-0.120	0
-0.120 TO	-0.110	0
-0.110 TO	-0.100	0
-0.100 TO	-0.090	0
-0.090 TO	-0.080	0
-0.080 TO	-0.070	123
-0.070 TO	-0.060	220
-0.060 TO	-0.050	320
-0.050 TO	-0.040	323
-0.040 TO	-0.030	348
-0.030 TO	-0.020	381
-0.020 TO	-0.010	436
-0.010 TO	-0.000	369
-0.000 TO	0.010	384
0.010 TO	0.020	436
0.020 TO	0.030	395
0.030 TO	0.040	362
0.040 TO	0.050	310
0.050 TO	0.060	292
0.060 TO	0.070	204
0.070 TO	0.080	121
0.080 TO	0.090	0
0.090 TO	0.100	0
0.100 TO	0.110	0
0.110 TO	0.120	0
0.120 TO	0.130	0
0.130 TO	0.140	0
0.140 TO	0.150	0
0.150 TO	0.160	0
0.160 TO	0.170	0
0.170 TO	0.180	0
0.180 TO	0.190	0
0.190 TO	0.200	0
GREATER THAN	0.200	0

NO 3 OF X IN CM 1470.000 FT FROM THE TARGET

(4)

THE FOLLOWING IS A HISTOGRAM OF Y FOR 5000 RAYS

SCALE FACTOR: 100 X'S EQUAL 501 RAYS

INTERVAL		
LESS THAN	-0.200	0
-0.200 TO	-0.190	0
-0.190 TO	-0.180	0
-0.180 TO	-0.170	0
-0.170 TO	-0.160	0
-0.160 TO	-0.150	0
-0.150 TO	-0.140	0
-0.140 TO	-0.130	0
-0.130 TO	-0.120	0
-0.120 TO	-0.110	0
-0.110 TO	-0.100	0
-0.100 TO	-0.090	0
-0.090 TO	-0.080	0
-0.080 TO	-0.070	0
-0.070 TO	-0.060	71
-0.060 TO	-0.050	243
-0.050 TO	-0.040	354
-0.040 TO	-0.030	392
-0.030 TO	-0.020	452
-0.020 TO	-0.010	501
-0.010 TO	-0.000	469
-0.000 TO	0.010	489
0.010 TO	0.020	494
0.020 TO	0.030	429
0.030 TO	0.040	397
0.040 TO	0.050	396
0.050 TO	0.060	234
0.060 TO	0.070	79
0.070 TO	0.080	0
0.080 TO	0.090	0
0.090 TO	0.100	0
0.100 TO	0.110	0
0.110 TO	0.120	0
0.120 TO	0.130	0
0.130 TO	0.140	0
0.140 TO	0.150	0
0.150 TO	0.160	0
0.160 TO	0.170	0
0.170 TO	0.180	0
0.180 TO	0.190	0
0.190 TO	0.200	0
GREATER THAN	0.200	

NO 4 OF Y IN CM 1470.000 FT FROM THE TARGET

Figure 5. Beam profiles at the third focus in the horizontal and vertical planes respectively. No sextupoles are included and the momentum is the central design value.

THE FOLLOWING IS A HISTOGRAM OF Y FOR 5000 RAYS

INTERVAL — SCALE FACTOR: 100 X'S EQUAL 294 RAYS

INTERVAL		RAYS
LESS THAN	-0.200	0
-0.200 TO	-0.190	0
-0.190 TO	-0.180	3
-0.180 TO	-0.170	4
-0.170 TO	-0.160	14
-0.160 TO	-0.150	19
-0.150 TO	-0.140	31
-0.140 TO	-0.130	60
-0.130 TO	-0.120	69
-0.120 TO	-0.110	98
-0.110 TO	-0.100	114
-0.100 TO	-0.090	140
-0.090 TO	-0.080	148
-0.080 TO	-0.070	164
-0.070 TO	-0.060	162
-0.060 TO	-0.050	176
-0.050 TO	-0.040	227
-0.040 TO	-0.030	259
-0.030 TO	-0.020	264
-0.020 TO	-0.010	261
-0.010 TO	-0.000	294
-0.000 TO	0.010	265
0.010 TO	0.020	249
0.020 TO	0.030	256
0.030 TO	0.040	250
0.040 TO	0.050	242
0.050 TO	0.060	218
0.060 TO	0.070	182
0.070 TO	0.080	147
0.080 TO	0.090	146
0.090 TO	0.100	135
0.100 TO	0.110	126
0.110 TO	0.120	80
0.120 TO	0.130	56
0.130 TO	0.140	50
0.140 TO	0.150	42
0.150 TO	0.160	22
0.160 TO	0.170	18
0.170 TO	0.180	8
0.180 TO	0.190	1
0.190 TO	0.200	0
GREATER THAN	0.200	0

NO 1 OF Y IN CM 1027.139 FT FROM THE TARGET

(6)

THE FOLLOWING IS A HISTOGRAM OF X FOR 5000 RAYS

INTERVAL — SCALE FACTOR: 100 X'S EQUAL 233 RAYS

INTERVAL		RAYS
LESS THAN	-2.400	7
-2.400 TO	-2.390	10
-2.390 TO	-2.380	15
-2.380 TO	-2.370	28
-2.370 TO	-2.360	37
-2.360 TO	-2.350	43
-2.350 TO	-2.340	55
-2.340 TO	-2.330	80
-2.330 TO	-2.320	99
-2.320 TO	-2.310	120
-2.310 TO	-2.300	98
-2.300 TO	-2.290	134
-2.290 TO	-2.280	175
-2.280 TO	-2.270	152
-2.270 TO	-2.260	189
-2.260 TO	-2.250	186
-2.250 TO	-2.240	175
-2.240 TO	-2.230	171
-2.230 TO	-2.220	169
-2.220 TO	-2.210	228
-2.210 TO	-2.200	233
-2.200 TO	-2.190	227
-2.190 TO	-2.180	201
-2.180 TO	-2.170	209
-2.170 TO	-2.160	208
-2.160 TO	-2.150	220
-2.150 TO	-2.140	189
-2.140 TO	-2.130	179
-2.130 TO	-2.120	163
-2.120 TO	-2.110	166
-2.110 TO	-2.100	143
-2.100 TO	-2.090	139
-2.090 TO	-2.080	111
-2.080 TO	-2.070	101
-2.070 TO	-2.060	77
-2.060 TO	-2.050	71
-2.050 TO	-2.040	65
-2.040 TO	-2.030	49
-2.030 TO	-2.020	33
-2.020 TO	-2.010	19
-2.010 TO	-2.000	15
GREATER THAN	-2.000	11

NO 2 OF X IN CM 1041.139 FT FROM THE TARGET

Figure 6. Beam profiles at the second focus in the vertical and horizontal planes respectively. No sextupoles are included and the momentum is one-half percent above the central design value.

(7)

THE FOLLOWING IS A HISTOGRAM OF X FOR 5000 RAYS

INTERVAL			SCALE FACTOR: 100 X'S EQUAL 197 RAYS
LESS THAN	-0.200	80	
-0.200 TO	-0.190	39	
-0.190 TO	-0.180	53	
-0.180 TO	-0.170	67	
-0.170 TO	-0.160	70	
-0.160 TO	-0.150	83	
-0.150 TO	-0.140	97	
-0.140 TO	-0.130	97	
-0.130 TO	-0.120	111	
-0.120 TO	-0.110	138	
-0.110 TO	-0.100	121	
-0.100 TO	-0.090	136	
-0.090 TO	-0.080	137	
-0.080 TO	-0.070	154	
-0.070 TO	-0.060	171	
-0.060 TO	-0.050	159	
-0.050 TO	-0.040	164	
-0.040 TO	-0.030	166	
-0.030 TO	-0.020	178	
-0.020 TO	-0.010	175	
-0.010 TO	-0.000	188	
-0.000 TO	0.010	197	
0.010 TO	0.020	180	
0.020 TO	0.030	151	
0.030 TO	0.040	148	
0.040 TO	0.050	134	
0.050 TO	0.060	132	
0.060 TO	0.070	166	
0.070 TO	0.080	148	
0.080 TO	0.090	144	
0.090 TO	0.100	142	
0.100 TO	0.110	128	
0.110 TO	0.120	111	
0.120 TO	0.130	106	
0.130 TO	0.140	102	
0.140 TO	0.150	100	
0.150 TO	0.160	85	
0.160 TO	0.170	61	
0.170 TO	0.180	39	
0.180 TO	0.190	47	
0.190 TO	0.200	33	
GREATER THAN	0.200	62	

NO 3 OF X IN CM 1470.000 FT FROM THE TARGET

(9)

THE FOLLOWING IS A HISTOGRAM OF Y FOR 5000 RAYS

INTERVAL			SCALE FACTOR: 100 X'S EQUAL 394 RAYS
LESS THAN	-0.200	0	
-0.200 TO	-0.190	0	
-0.190 TO	-0.180	0	
-0.180 TO	-0.170	0	
-0.170 TO	-0.160	0	
-0.160 TO	-0.150	0	
-0.150 TO	-0.140	0	
-0.140 TO	-0.130	0	
-0.130 TO	-0.120	3	
-0.120 TO	-0.110	21	
-0.110 TO	-0.100	34	
-0.100 TO	-0.090	73	
-0.090 TO	-0.080	87	
-0.080 TO	-0.070	165	
-0.070 TO	-0.060	170	
-0.060 TO	-0.050	243	
-0.050 TO	-0.040	251	
-0.040 TO	-0.030	319	
-0.030 TO	-0.020	391	
-0.020 TO	-0.010	360	
-0.010 TO	-0.000	385	
-0.000 TO	0.010	394	
0.010 TO	0.020	365	
0.020 TO	0.030	369	
0.030 TO	0.040	288	
0.040 TO	0.050	258	
0.050 TO	0.060	223	
0.060 TO	0.070	193	
0.070 TO	0.080	169	
0.080 TO	0.090	106	
0.090 TO	0.100	72	
0.100 TO	0.110	30	
0.110 TO	0.120	16	
0.120 TO	0.130	3	
0.130 TO	0.140	0	
0.140 TO	0.150	0	
0.150 TO	0.160	0	
0.160 TO	0.170	0	
0.170 TO	0.180	0	
0.180 TO	0.190	0	
0.190 TO	0.200	0	
GREATER THAN	0.200	0	

NO 4 OF Y IN CM 1470.000 FT FROM THE TARGET

Figure 7. Beam profiles at the third focus in the horizontal and vertical planes respectively. No sextupoles are included and the momentum is one-half percent above the central design value.

THE FOLLOWING IS A HISTOGRAM OF Y FOR 5000 RAYS

SCALE FACTOR: 100 X'S EQUAL 188 RAYS

INTERVAL		
LESS THAN	-0.200	82
-0.200 TO	-0.190	47
-0.190 TO	-0.180	50
-0.180 TO	-0.170	63
-0.170 TO	-0.160	77
-0.160 TO	-0.150	98
-0.150 TO	-0.140	86
-0.140 TO	-0.130	81
-0.130 TO	-0.120	115
-0.120 TO	-0.110	116
-0.110 TO	-0.100	122
-0.100 TO	-0.090	114
-0.090 TO	-0.080	153
-0.080 TO	-0.070	152
-0.070 TO	-0.060	134
-0.060 TO	-0.050	177
-0.050 TO	-0.040	152
-0.040 TO	-0.030	159
-0.030 TO	-0.020	158
-0.020 TO	-0.010	167
-0.010 TO	-0.000	164
-0.000 TO	0.010	188
0.010 TO	0.020	144
0.020 TO	0.030	172
0.030 TO	0.040	187
0.040 TO	0.050	168
0.050 TO	0.060	151
0.060 TO	0.070	159
0.070 TO	0.080	153
0.080 TO	0.090	147
0.090 TO	0.100	148
0.100 TO	0.110	131
0.110 TO	0.120	114
0.120 TO	0.130	101
0.130 TO	0.140	88
0.140 TO	0.150	97
0.150 TO	0.160	74
0.160 TO	0.170	82
0.170 TO	0.180	66
0.180 TO	0.190	34
0.190 TO	0.200	43
GREATER THAN	0.200	103

NO 1 OF Y IN CM 1027.139 FT FROM THE TARGET

THE FOLLOWING IS A HISTOGRAM OF X FOR 5000 RAYS

SCALE FACTOR: 100 X'S EQUAL 766 RAYS

INTERVAL		
LESS THAN	-4.600	351
-4.600 TO	-4.590	77
-4.590 TO	-4.580	73
-4.580 TO	-4.570	68
-4.570 TO	-4.560	77
-4.560 TO	-4.550	85
-4.550 TO	-4.540	77
-4.540 TO	-4.530	93
-4.530 TO	-4.520	99
-4.520 TO	-4.510	99
-4.510 TO	-4.500	87
-4.500 TO	-4.490	89
-4.490 TO	-4.480	90
-4.480 TO	-4.470	95
-4.470 TO	-4.460	102
-4.460 TO	-4.450	87
-4.450 TO	-4.440	111
-4.440 TO	-4.430	108
-4.430 TO	-4.420	92
-4.420 TO	-4.410	101
-4.410 TO	-4.400	97
-4.400 TO	-4.390	114
-4.390 TO	-4.380	118
-4.380 TO	-4.370	116
-4.370 TO	-4.360	102
-4.360 TO	-4.350	114
-4.350 TO	-4.340	124
-4.340 TO	-4.330	132
-4.330 TO	-4.320	107
-4.320 TO	-4.310	109
-4.310 TO	-4.300	103
-4.300 TO	-4.290	114
-4.290 TO	-4.280	100
-4.280 TO	-4.270	92
-4.270 TO	-4.260	99
-4.260 TO	-4.250	96
-4.250 TO	-4.240	84
-4.240 TO	-4.230	77
-4.230 TO	-4.220	101
-4.220 TO	-4.210	96
-4.210 TO	-4.200	80
GREATER THAN	-4.200	766

NO 2 OF X IN CM 1041.139 FT FROM THE TARGET

Figure 8. Beam profiles at the second focus in the vertical and horizontal planes respectively. No sextupoles are included and the momentum is one percent above the central design value.

(11)

THE FOLLOWING IS A HISTOGRAM OF X FOR 5000 RAYS

SCALE FACTOR: 100 X'S EQUAL 1032 RAYS

INTERVAL		
LESS THAN	-0.200	1032
-0.200 TO	-0.190	73
-0.190 TO	-0.180	64
-0.180 TO	-0.170	67
-0.170 TO	-0.160	86
-0.160 TO	-0.150	73
-0.150 TO	-0.140	78
-0.140 TO	-0.130	78
-0.130 TO	-0.120	82
-0.120 TO	-0.110	85
-0.110 TO	-0.100	84
-0.100 TO	-0.090	93
-0.090 TO	-0.080	98
-0.080 TO	-0.070	102
-0.070 TO	-0.060	94
-0.060 TO	-0.050	75
-0.050 TO	-0.040	101
-0.040 TO	-0.030	81
-0.030 TO	-0.020	88
-0.020 TO	-0.010	99
-0.010 TO	-0.000	98
-0.000 TO	0.010	81
0.010 TO	0.020	83
0.020 TO	0.030	76
0.030 TO	0.040	57
0.040 TO	0.050	79
0.050 TO	0.060	63
0.060 TO	0.070	96
0.070 TO	0.080	91
0.080 TO	0.090	81
0.090 TO	0.100	82
0.100 TO	0.110	82
0.110 TO	0.120	65
0.120 TO	0.130	80
0.130 TO	0.140	59
0.140 TO	0.150	78
0.150 TO	0.160	59
0.160 TO	0.170	93
0.170 TO	0.180	75
0.180 TO	0.190	60
0.190 TO	0.200	74
GREATER THAN	0.200	726

NO 3 OF X IN CM 1472.000 FT FROM THE TARGET

(12)

THE FOLLOWING IS A HISTOGRAM OF Y FOR 5000 RAYS

SCALE FACTOR: 100 X'S EQUAL 237 RAYS

INTERVAL		
LESS THAN	-0.200	0
-0.200 TO	-0.190	0
-0.190 TO	-0.180	2
-0.180 TO	-0.170	10
-0.170 TO	-0.160	22
-0.160 TO	-0.150	34
-0.150 TO	-0.140	51
-0.140 TO	-0.130	63
-0.130 TO	-0.120	96
-0.120 TO	-0.110	118
-0.110 TO	-0.100	124
-0.100 TO	-0.090	134
-0.090 TO	-0.080	162
-0.080 TO	-0.070	217
-0.070 TO	-0.060	193
-0.060 TO	-0.050	225
-0.050 TO	-0.040	227
-0.040 TO	-0.030	224
-0.030 TO	-0.020	231
-0.020 TO	-0.010	237
-0.010 TO	-0.000	224
-0.000 TO	0.010	221
0.010 TO	0.020	211
0.020 TO	0.030	214
0.030 TO	0.040	214
0.040 TO	0.050	216
0.050 TO	0.060	194
0.060 TO	0.070	172
0.070 TO	0.080	182
0.080 TO	0.090	164
0.090 TO	0.100	143
0.100 TO	0.110	130
0.110 TO	0.120	121
0.120 TO	0.130	108
0.130 TO	0.140	61
0.140 TO	0.150	57
0.150 TO	0.160	22
0.160 TO	0.170	22
0.170 TO	0.180	6
0.180 TO	0.190	2
0.190 TO	0.200	0
GREATER THAN	0.200	0

NO 4 OF Y IN CM 1472.000 FT FROM THE TARGET

Figure 9. Beam profiles at the third focus in the horizontal and vertical planes respectively. No sextupoles are included and the momentum is one percent above the central design value.

2 sexts - Δp/p = 0 (13)

THE FOLLOWING IS A HISTOGRAM OF Y FOR 5000 RAYS

SCALE FACTOR: 100 X'S EQUAL 318 RAYS

INTERVAL		
LESS THAN	-0.200	0
-0.200 TO	-0.190	0
-0.190 TO	-0.180	0
-0.180 TO	-0.170	0
-0.170 TO	-0.160	0
-0.160 TO	-0.150	0
-0.150 TO	-0.140	0
-0.140 TO	-0.130	0
-0.130 TO	-0.120	0
-0.120 TO	-0.110	5
-0.110 TO	-0.100	54
-0.100 TO	-0.090	123
-0.090 TO	-0.080	17[illegible]
-0.080 TO	-0.070	234
-0.070 TO	-0.060	261
-0.060 TO	-0.050	238
-0.050 TO	-0.040	245
-0.040 TO	-0.030	29[illegible]
-0.030 TO	-0.020	295
-0.020 TO	-0.010	299
-0.010 TO	-0.000	303
-0.000 TO	0.010	275
0.010 TO	0.020	318
0.020 TO	0.030	312
0.030 TO	0.040	302
0.040 TO	0.050	247
0.050 TO	0.060	243
0.060 TO	0.070	225
0.070 TO	0.080	211
0.080 TO	0.090	177
0.090 TO	0.100	112
0.100 TO	0.110	61
0.110 TO	0.120	2
0.120 TO	0.130	0
0.130 TO	0.140	0
0.140 TO	0.150	0
0.150 TO	0.160	0
0.160 TO	0.170	0
0.170 TO	0.180	0
0.180 TO	0.190	0
0.190 TO	0.200	0
GREATER THAN	0.200	0

NO 1 OF Y IN CM 1027.139 FT FROM THE TARGET

(14)

THE FOLLOWING IS A HISTOGRAM OF X FOR 5000 RAYS

SCALE FACTOR: 100 X'S EQUAL 400 RAYS

INTERVAL		
LESS THAN	-0.200	0
-0.200 TO	-0.190	0
-0.190 TO	-0.180	0
-0.180 TO	-0.170	0
-0.170 TO	-0.160	0
-0.160 TO	-0.150	0
-0.150 TO	-0.140	0
-0.140 TO	-0.130	0
-0.130 TO	-0.120	4
-0.120 TO	-0.110	7
-0.110 TO	-0.100	12
-0.100 TO	-0.090	26
-0.090 TO	-0.080	64
-0.080 TO	-0.070	112
-0.070 TO	-0.060	199
-0.060 TO	-0.050	225
-0.050 TO	-0.040	304
-0.040 TO	-0.030	337
-0.030 TO	-0.020	383
-0.020 TO	-0.010	40[illegible]
-0.010 TO	-0.000	386
-0.000 TO	0.010	357
0.010 TO	0.020	396
0.020 TO	0.030	378
0.030 TO	0.040	369
0.040 TO	0.050	328
0.050 TO	0.060	262
0.060 TO	0.070	227
0.070 TO	0.080	139
0.080 TO	0.090	46
0.090 TO	0.100	24
0.100 TO	0.110	10
0.110 TO	0.120	3
0.120 TO	0.130	0
0.130 TO	0.140	0
0.140 TO	0.150	0
0.150 TO	0.160	0
0.160 TO	0.170	0
0.170 TO	0.180	0
0.180 TO	0.190	0
0.190 TO	0.200	0
GREATER THAN	0.200	0

NO 2 OF X IN CM 1041.139 FT FROM THE TARGET

Figure 10. Beam profiles at the second focus in the vertical and horizontal planes respectively. Two sextupoles are used and the momentum is the central design value.

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THE FOLLOWING IS A HISTOGRAM OF    X    FOR    5000 RAYS

        INTERVAL                          SCALE FACTOR:  100 X'S EQUAL   398 RAYS

LESS THAN      -0.200        0

  -0.200 TO   -0.190        0
  -0.190 TO   -0.180        0
  -0.180 TO   -0.170        0
  -0.170 TO   -0.160        0
  -0.160 TO   -0.150        0
  -0.150 TO   -0.140        0
  -0.140 TO   -0.130        0
  -0.130 TO   -0.120        0
  -0.120 TO   -0.110        3
  -0.110 TO   -0.100       10   XX
  -0.100 TO   -0.090       24   XXXXXX
  -0.090 TO   -0.080       46   XXXXXXXXXXX
  -0.080 TO   -0.070      144   XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
  -0.070 TO   -0.060      225   XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
  -0.060 TO   -0.050      262   XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
  -0.050 TO   -0.040      328   XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
  -0.040 TO   -0.030      369   XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
  -0.030 TO   -0.020      377   XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
  -0.020 TO   -0.010      397   XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
  -0.010 TO    0.000      349   XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
  -0.000 TO    0.010      391   XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
   0.010 TO    0.020      393   XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
   0.020 TO    0.030      382   XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
   0.030 TO    0.040      335   XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
   0.040 TO    0.050      303   XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
   0.050 TO    0.060      224   XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
   0.060 TO    0.070      202   XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
   0.070 TO    0.080      114   XXXXXXXXXXXXXXXXXXXXXXXXXXXX
   0.080 TO    0.090       63   XXXXXXXXXXXXXXX
   0.090 TO    0.100       33   XXXXXXXX
   0.100 TO    0.110       13   XXX
   0.110 TO    0.120        6   X
   0.120 TO    0.130        5   X
   0.130 TO    0.140        0
   0.140 TO    0.150        0
   0.150 TO    0.160        0
   0.160 TO    0.170        0
   0.170 TO    0.180        0
   0.180 TO    0.190        0
   0.190 TO    0.200        0

GREATER THAN    0.200        0


NO    3 OF     X IN   CM    1470.000   FT   FROM THE TARGET
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(16)

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THE FOLLOWING IS A HISTOGRAM OF    Y    FOR    5000 RAYS

        INTERVAL                          SCALE FACTOR:  100 X'S EQUAL   498 RAYS

LESS THAN      -0.200        0

  -0.200 TO   -0.190        0
  -0.190 TO   -0.180        0
  -0.180 TO   -0.170        0
  -0.170 TO   -0.160        0
  -0.160 TO   -0.150        0
  -0.150 TO   -0.140        0
  -0.140 TO   -0.130        0
  -0.130 TO   -0.120        0
  -0.120 TO   -0.110        0
  -0.110 TO   -0.100        0
  -0.100 TO   -0.090        0
  -0.090 TO   -0.080        0
  -0.080 TO   -0.070        0
  -0.070 TO   -0.060       98   XXXXXXXXXXXXXXXXXXX
  -0.060 TO   -0.050      245   XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
  -0.050 TO   -0.040      346   XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
  -0.040 TO   -0.030      384   XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
  -0.030 TO   -0.020      447   XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
  -0.020 TO   -0.010      498   XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
  -0.010 TO   -0.000      467   XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
  -0.000 TO    0.010      478   XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
   0.010 TO    0.020      491   XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
   0.020 TO    0.030      424   XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
   0.030 TO    0.040      402   XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
   0.040 TO    0.050      381   XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
   0.050 TO    0.060      252   XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
   0.060 TO    0.070       85   XXXXXXXXXXXXXXXXX
   0.070 TO    0.080        2
   0.080 TO    0.090        0
   0.090 TO    0.100        0
   0.100 TO    0.110        0
   0.110 TO    0.120        0
   0.120 TO    0.130        0
   0.130 TO    0.140        0
   0.140 TO    0.150        0
   0.150 TO    0.160        0
   0.160 TO    0.170        0
   0.170 TO    0.180        0
   0.180 TO    0.190        0
   0.190 TO    0.200        0

GREATER THAN    0.200        0


NO    4 OF     Y IN   CM    1470.000   FT   FROM THE TARGET
```

Figure 11. Beam profiles at the third focus in the horizontal and vertical planes respectively. Two sextupoles are used and the momentum is the central design value.

```
THE FOLLOWING IS A HISTOGRAM OF     Y     FOR     5000 RAYS

        INTERVAL                              SCALE FACTOR:  100 X'S EQUAL   238 RAYS

LESS THAN      -0.200          3

   -0.200 TO   -0.190          9    XXX
   -0.190 TO   -0.180         14    XXXXX
   -0.180 TO   -0.170         20    XXXXXXXX
   -0.170 TO   -0.160         29    XXXXXXXXXXXX
   -0.160 TO   -0.150         53    XXXXXXXXXXXXXXXXXXXXXX
   -0.150 TO   -0.140         53    XXXXXXXXXXXXXXXXXXXXXX
   -0.140 TO   -0.130         94    XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
   -0.130 TO   -0.120         92    XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
   -0.120 TO   -0.110        112    XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
   -0.110 TO   -0.100        115    XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
   -0.100 TO   -0.090        123    XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
   -0.090 TO   -0.080        142    XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
   -0.080 TO   -0.070        158    XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
   -0.070 TO   -0.060        170    XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
   -0.060 TO   -0.050        183    XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
   -0.050 TO   -0.040        198    XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
   -0.040 TO   -0.030        228    XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
   -0.030 TO   -0.020        230    XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
   -0.020 TO   -0.010        210    XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
   -0.010 TO   -0.000        238    XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
   -0.000 TO    0.010        219    XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
    0.010 TO    0.020        235    XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
    0.020 TO    0.030        231    XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
    0.030 TO    0.040        221    XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
    0.040 TO    0.050        227    XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
    0.050 TO    0.060        211    XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
    0.060 TO    0.070        183    XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
    0.070 TO    0.080        139    XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
    0.080 TO    0.090        144    XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
    0.090 TO    0.100        166    XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
    0.100 TO    0.110         93    XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
    0.110 TO    0.120         97    XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
    0.120 TO    0.130         93    XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
    0.130 TO    0.140         85    XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
    0.140 TO    0.150         46    XXXXXXXXXXXXXXXXXXX
    0.150 TO    0.160         47    XXXXXXXXXXXXXXXXXXX
    0.160 TO    0.170         38    XXXXXXXXXXXXXXX
    0.170 TO    0.180         19    XXXXXXX
    0.180 TO    0.190         13    XXXXX
    0.190 TO    0.200         14    XXXXX

GREATER THAN    0.200          5    XX

NO   1 OF    Y IN  CM   1027.139  FT  FROM THE TARGET
```

(18)

```
THE FOLLOWING IS A HISTOGRAM OF     X     FOR     5000 RAYS

        INTERVAL                              SCALE FACTOR:  100 X'S EQUAL   395 RAYS

LESS THAN      -2.400          0

   -2.400 TO   -2.390          0
   -2.390 TO   -2.380          0
   -2.380 TO   -2.370          0
   -2.370 TO   -2.360          0
   -2.360 TO   -2.350          0
   -2.350 TO   -2.340          0
   -2.340 TO   -2.330          1
   -2.330 TO   -2.320          7    X
   -2.320 TO   -2.310          7    X
   -2.310 TO   -2.300         17    XXXX
   -2.300 TO   -2.290         33    XXXXXXXX
   -2.290 TO   -2.280         92    XXXXXXXXXXXXXXXXXXXXXXX
   -2.280 TO   -2.270        151    XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
   -2.270 TO   -2.260        210    XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
   -2.260 TO   -2.250        254    XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
   -2.250 TO   -2.240        331    XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
   -2.240 TO   -2.230        356    XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
   -2.230 TO   -2.220        394    XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
   -2.220 TO   -2.210        394    XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
   -2.210 TO   -2.200        371    XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
   -2.200 TO   -2.190        390    XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
   -2.190 TO   -2.180        360    XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
   -2.180 TO   -2.170        395    XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
   -2.170 TO   -2.160        344    XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
   -2.160 TO   -2.150        292    XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
   -2.150 TO   -2.140        260    XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
   -2.140 TO   -2.130        195    XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
   -2.130 TO   -2.120         94    XXXXXXXXXXXXXXXXXXXXXXX
   -2.120 TO   -2.110         35    XXXXXXXX
   -2.110 TO   -2.100         10    XX
   -2.100 TO   -2.090          7    X
   -2.090 TO   -2.080          0
   -2.080 TO   -2.070          0
   -2.070 TO   -2.060          0
   -2.060 TO   -2.050          0
   -2.050 TO   -2.040          0
   -2.040 TO   -2.030          0
   -2.030 TO   -2.020          0
   -2.020 TO   -2.010          0
   -2.010 TO   -2.000          0

GREATER THAN   -2.000          0

NO   2 OF    X IN  CM   1041.139  FT  FROM THE TARGET
```

Figure 12. Beam profiles at the second focus in the vertical and horizontal planes respectively. Two sextupoles are used and the momentum is one-half percent above the central design value.

THE FOLLOWING IS A HISTOGRAM OF X FOR 5000 RAYS

SCALE FACTOR: 100 X'S EQUAL 417 RAYS

INTERVAL			COUNT
LESS THAN		-0.200	0
-0.200	TO	-0.190	0
-0.190	TO	-0.180	0
-0.180	TO	-0.170	0
-0.170	TO	-0.160	0
-0.160	TO	-0.150	0
-0.150	TO	-0.140	0
-0.140	TO	-0.130	0
-0.130	TO	-0.120	0
-0.120	TO	-0.110	0
-0.110	TO	-0.100	0
-0.100	TO	-0.090	0
-0.090	TO	-0.080	26
-0.080	TO	-0.070	79
-0.070	TO	-0.060	167
-0.060	TO	-0.050	265
-0.050	TO	-0.040	322
-0.040	TO	-0.030	376
-0.030	TO	-0.020	393
-0.020	TO	-0.010	396
-0.010	TO	-0.000	417
-0.000	TO	0.010	377
0.010	TO	0.020	396
0.020	TO	0.030	395
0.030	TO	0.040	396
0.040	TO	0.050	378
0.050	TO	0.060	289
0.060	TO	0.070	266
0.070	TO	0.080	156
0.080	TO	0.090	49
0.090	TO	0.100	8
0.100	TO	0.110	0
0.110	TO	0.120	0
0.120	TO	0.130	0
0.130	TO	0.140	0
0.140	TO	0.150	0
0.150	TO	0.160	0
0.160	TO	0.170	0
0.170	TO	0.180	0
0.180	TO	0.190	0
0.190	TO	0.200	0
GREATER THAN		0.200	0

NO 3 OF X IN CM 1470.000 FT FROM THE TARGET

(20)

THE FOLLOWING IS A HISTOGRAM OF Y FOR 5000 RAYS

SCALE FACTOR: 100 X'S EQUAL 332 RAYS

INTERVAL			COUNT
LESS THAN		-0.200	0
-0.200	TO	-0.190	0
-0.190	TO	-0.180	0
-0.180	TO	-0.170	0
-0.170	TO	-0.160	0
-0.160	TO	-0.150	0
-0.150	TO	-0.140	1
-0.140	TO	-0.130	15
-0.130	TO	-0.120	23
-0.120	TO	-0.110	40
-0.110	TO	-0.100	73
-0.100	TO	-0.090	99
-0.090	TO	-0.080	146
-0.080	TO	-0.070	148
-0.070	TO	-0.060	214
-0.060	TO	-0.050	219
-0.050	TO	-0.040	269
-0.040	TO	-0.030	303
-0.030	TO	-0.020	332
-0.020	TO	-0.010	326
-0.010	TO	-0.000	327
-0.000	TO	0.010	325
0.010	TO	0.020	313
0.020	TO	0.030	289
0.030	TO	0.040	295
0.040	TO	0.050	258
0.050	TO	0.060	217
0.060	TO	0.070	193
0.070	TO	0.080	171
0.080	TO	0.090	154
0.090	TO	0.100	126
0.100	TO	0.110	74
0.110	TO	0.120	30
0.120	TO	0.130	22
0.130	TO	0.140	7
0.140	TO	0.150	3
0.150	TO	0.160	0
0.160	TO	0.170	0
0.170	TO	0.180	0
0.180	TO	0.190	0
0.190	TO	0.200	0
GREATER THAN		0.200	0

NO 4 OF Y IN CM 1470.000 FT FROM THE TARGET

Figure 13. Beam profiles at the third focus in the horizontal and vertical planes respectively. Two sextupoles are used and the momentum is one-half percent above the central design value.

THE FOLLOWING IS A HISTOGRAM OF Y FOR 5000 RAYS

SCALE FACTOR: 100 X'S EQUAL 316 RAYS

INTERVAL		RAYS
LESS THAN	-0.200	316
-0.200 TO	-0.190	65
-0.190 TO	-0.180	84
-0.180 TO	-0.170	86
-0.170 TO	-0.160	77
-0.160 TO	-0.150	96
-0.150 TO	-0.140	88
-0.140 TO	-0.130	113
-0.130 TO	-0.120	102
-0.120 TO	-0.110	104
-0.110 TO	-0.100	105
-0.100 TO	-0.090	106
-0.090 TO	-0.080	112
-0.080 TO	-0.070	131
-0.070 TO	-0.060	121
-0.060 TO	-0.050	137
-0.050 TO	-0.040	129
-0.040 TO	-0.030	125
-0.030 TO	-0.020	116
-0.020 TO	-0.010	125
-0.010 TO	-0.000	110
-0.000 TO	0.010	132
0.010 TO	0.020	146
0.020 TO	0.030	133
0.030 TO	0.040	133
0.040 TO	0.050	135
0.050 TO	0.060	113
0.060 TO	0.070	123
0.070 TO	0.080	117
0.080 TO	0.090	137
0.090 TO	0.100	125
0.100 TO	0.110	95
0.110 TO	0.120	122
0.120 TO	0.130	122
0.130 TO	0.140	109
0.140 TO	0.150	102
0.150 TO	0.160	98
0.160 TO	0.170	82
0.170 TO	0.180	71
0.180 TO	0.190	84
0.190 TO	0.200	63
GREATER THAN	0.200	314

NO 1 OF Y IN CM 1027.139 FT FROM THE TARGET

(22)

THE FOLLOWING IS A HISTOGRAM OF X FOR 5000 RAYS

SCALE FACTOR: 100 X'S EQUAL 401 RAYS

INTERVAL		RAYS
LESS THAN	-4.600	0
-4.600 TO	-4.590	0
-4.590 TO	-4.580	0
-4.580 TO	-4.570	0
-4.570 TO	-4.560	0
-4.560 TO	-4.550	0
-4.550 TO	-4.540	0
-4.540 TO	-4.530	1
-4.530 TO	-4.520	9
-4.520 TO	-4.510	11
-4.510 TO	-4.500	19
-4.500 TO	-4.490	52
-4.490 TO	-4.480	92
-4.480 TO	-4.470	164
-4.470 TO	-4.460	244
-4.460 TO	-4.450	283
-4.450 TO	-4.440	333
-4.440 TO	-4.430	358
-4.430 TO	-4.420	401
-4.420 TO	-4.410	378
-4.410 TO	-4.400	377
-4.400 TO	-4.390	368
-4.390 TO	-4.380	375
-4.380 TO	-4.370	393
-4.370 TO	-4.360	327
-4.360 TO	-4.350	289
-4.350 TO	-4.340	262
-4.340 TO	-4.330	165
-4.330 TO	-4.320	74
-4.320 TO	-4.310	21
-4.310 TO	-4.300	8
-4.300 TO	-4.290	1
-4.290 TO	-4.280	0
-4.280 TO	-4.270	0
-4.270 TO	-4.260	0
-4.260 TO	-4.250	0
-4.250 TO	-4.240	0
-4.240 TO	-4.230	0
-4.230 TO	-4.220	0
-4.220 TO	-4.210	0
-4.210 TO	-4.200	0
GREATER THAN	-4.200	0

NO 2 OF X IN CM 1041.139 FT FROM THE TARGET

Figure 14. Beam profiles at the second focus in the vertical and horizontal planes respectively. Two sextupoles are used and the momentum is one percent above the central design value.

THE FOLLOWING IS A HISTOGRAM OF X FOR 5000 RAYS

SCALE FACTOR: 100 X'S EQUAL 386 RAYS

INTERVAL		
LESS THAN	-0.200	0
-0.200 TO	-0.190	0
-0.190 TO	-0.180	0
-0.180 TO	-0.170	0
-0.170 TO	-0.160	0
-0.160 TO	-0.150	0
-0.150 TO	-0.140	0
-0.140 TO	-0.130	0
-0.130 TO	-0.120	0
-0.120 TO	-0.110	0
-0.110 TO	-0.100	3
-0.100 TO	-0.090	27
-0.090 TO	-0.080	67
-0.080 TO	-0.070	122
-0.070 TO	-0.060	127
-0.060 TO	-0.050	154
-0.050 TO	-0.040	197
-0.040 TO	-0.030	265
-0.030 TO	-0.020	323
-0.020 TO	-0.010	364
-0.010 TO	-0.000	369
-0.000 TO	0.010	386
0.010 TO	0.020	367
0.020 TO	0.030	380
0.030 TO	0.040	365
0.040 TO	0.050	343
0.050 TO	0.060	304
0.060 TO	0.070	266
0.070 TO	0.080	213
0.080 TO	0.090	151
0.090 TO	0.100	112
0.100 TO	0.110	76
0.110 TO	0.120	34
0.120 TO	0.130	5
0.130 TO	0.140	0
0.140 TO	0.150	0
0.150 TO	0.160	0
0.160 TO	0.170	0
0.170 TO	0.180	0
0.180 TO	0.190	0
0.190 TO	0.200	0
GREATER THAN	0.200	0

NO 3 OF X IN CM 1470.000 FT FROM THE TARGET

(24)

THE FOLLOWING IS A HISTOGRAM OF Y FOR 5000 RAYS

SCALE FACTOR: 100 X'S EQUAL 192 RAYS

INTERVAL		
LESS THAN	-0.200	12
-0.200 TO	-0.190	24
-0.190 TO	-0.180	31
-0.180 TO	-0.170	43
-0.170 TO	-0.160	64
-0.160 TO	-0.150	87
-0.150 TO	-0.140	93
-0.140 TO	-0.130	95
-0.130 TO	-0.120	118
-0.120 TO	-0.110	14[illegible]
-0.110 TO	-0.100	141
-0.100 TO	-0.090	148
-0.090 TO	-0.080	156
-0.080 TO	-0.070	145
-0.070 TO	-0.060	191
-0.060 TO	-0.050	176
-0.050 TO	-0.040	151
-0.040 TO	-0.030	172
-0.030 TO	-0.020	187
-0.020 TO	-0.010	192
-0.010 TO	-0.000	165
-0.000 TO	0.010	168
0.010 TO	0.020	171
0.020 TO	0.030	175
0.030 TO	0.040	186
0.040 TO	0.050	177
0.050 TO	0.060	172
0.060 TO	0.070	139
0.070 TO	0.080	155
0.080 TO	0.090	165
0.090 TO	0.100	129
0.100 TO	0.110	128
0.110 TO	0.120	126
0.120 TO	0.130	124
0.130 TO	0.140	121
0.140 TO	0.150	99
0.150 TO	0.160	72
0.160 TO	0.170	66
0.170 TO	0.180	48
0.180 TO	0.190	22
0.190 TO	0.200	20
GREATER THAN	0.200	8

NO 4 OF Y IN CM 1470.000 FT FROM THE TARGET

Figure 15. Beam profiles at the third focus in the horizontal and vertical planes respectively. Two sextupoles are used and the momentum is one percent above the central design value.

4 sextus · Δp/p = 0 (15)

TM-374

2254.000

THE FOLLOWING IS A HISTOGRAM OF Y FOR 5000 RAYS

SCALE FACTOR: 100 X'S EQUAL 304 RAYS

INTERVAL			
LESS THAN	-0.270	2	
-0.200 TO	-0.190	0	
-0.190 TO	-0.180	0	
-0.180 TO	-0.170	0	
-0.170 TO	-0.160	0	
-0.160 TO	-0.150	0	
-0.150 TO	-0.140	6	X
-0.140 TO	-0.130	12	XXX
-0.130 TO	-0.120	31	XXXXXXXXXX
-0.120 TO	-0.110	41	XXXXXXXXXXXX
-0.110 TO	-0.100	87	XXXXXXXXXXXXXXXXXXXXXXXX
-0.100 TO	-0.090	118	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
-0.090 TO	-0.080	182	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
-0.080 TO	-0.070	222	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
-0.070 TO	-0.060	237	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
-0.060 TO	-0.050	230	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
-0.050 TO	-0.040	244	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
-0.040 TO	-0.030	257	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
-0.030 TO	-0.020	291	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
-0.020 TO	-0.010	292	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
-0.010 TO	-0.000	269	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
-0.000 TO	0.010	304	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
0.010 TO	0.020	274	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
0.020 TO	0.030	283	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
0.030 TO	0.040	272	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
0.040 TO	0.050	271	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
0.050 TO	0.060	223	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
0.060 TO	0.070	233	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
0.070 TO	0.080	186	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
0.080 TO	0.090	158	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
0.090 TO	0.100	123	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
0.100 TO	0.110	86	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
0.110 TO	0.120	51	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
0.120 TO	0.130	16	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
0.130 TO	0.140	12	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
0.140 TO	0.150	5	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
0.150 TO	0.160	1	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
0.160 TO	0.170	0	
0.170 TO	0.180	0	
0.180 TO	0.190	0	
0.190 TO	0.200	0	
GREATER THAN	0.200	0	

NO 1 OF Y IN CM 1027.139 FT FROM THE TARGET

(16)

THE FOLLOWING IS A HISTOGRAM OF X FOR 5000 RAYS

SCALE FACTOR: 100 X'S EQUAL 296 RAYS

INTERVAL			
LESS THAN	-0.200	135	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
-0.200 TO	-0.190	32	XXXXXXXXXX
-0.190 TO	-0.180	31	XXXXXXXXXX
-0.180 TO	-0.170	30	XXXXXXXXXX
-0.170 TO	-0.160	39	XXXXXXXXXXXXX
-0.160 TO	-0.150	38	XXXXXXXXXXXX
-0.150 TO	-0.140	41	XXXXXXXXXXXXX
-0.140 TO	-0.130	42	XXXXXXXXXXXXXX
-0.130 TO	-0.120	57	XXXXXXXXXXXXXXXXXXX
-0.120 TO	-0.110	59	XXXXXXXXXXXXXXXXXXX
-0.110 TO	-0.100	66	XXXXXXXXXXXXXXXXXXXXX
-0.100 TO	-0.090	69	XXXXXXXXXXXXXXXXXXXXXX
-0.090 TO	-0.080	94	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
-0.080 TO	-0.070	109	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
-0.070 TO	-0.060	163	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
-0.060 TO	-0.050	174	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
-0.050 TO	-0.040	222	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
-0.040 TO	-0.030	242	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
-0.030 TO	-0.020	246	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
-0.020 TO	-0.010	296	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
-0.010 TO	-0.000	281	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
-0.000 TO	0.010	244	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
0.010 TO	0.020	257	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
0.020 TO	0.030	262	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
0.030 TO	0.040	241	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
0.040 TO	0.050	239	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
0.050 TO	0.060	194	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
0.060 TO	0.070	176	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
0.070 TO	0.080	136	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
0.080 TO	0.090	110	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
0.090 TO	0.100	73	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
0.100 TO	0.110	74	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
0.110 TO	0.120	59	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
0.120 TO	0.130	69	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
0.130 TO	0.140	53	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
0.140 TO	0.150	34	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
0.150 TO	0.160	32	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
0.160 TO	0.170	28	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
0.170 TO	0.180	24	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
0.180 TO	0.190	31	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
0.190 TO	0.200	28	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
GREATER THAN	0.200	173	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

NO 2 OF X IN CM 1041.139 FT FROM THE TARGET

Figure 16. Beam profiles at the second focus in the vertical and horizontal planes respectively. Four sextupoles are used and the momentum is the central design value.

THE FOLLOWING IS A HISTOGRAM OF X FOR 5000 RAYS

INTERVAL			SCALE FACTOR: 100 X'S EQUAL 294 RAYS
LESS THAN	-0.200	173	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
-0.200 TO	-0.190	30	XXXXXXXXXX
-0.190 TO	-0.180	31	XXXXXXXXXX
-0.180 TO	-0.170	26	XXXXXXXX
-0.170 TO	-0.160	28	XXXXXXXXX
-0.160 TO	-0.150	29	XXXXXXXXX
-0.152 TO	-0.140	35	XXXXXXXXXXX
-0.140 TO	-0.130	57	XXXXXXXXXXXXXXXXXX
-0.130 TO	-0.120	69	XXXXXXXXXXXXXXXXXXXXX
-0.120 TO	-0.110	57	XXXXXXXXXXXXXXXXXX
-0.110 TO	-0.100	73	XXXXXXXXXXXXXXXXXXXXXX
-0.100 TO	-0.090	73	XXXXXXXXXXXXXXXXXXXXXX
-0.090 TO	-0.080	111	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
-0.080 TO	-0.070	139	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
-0.070 TO	-0.060	172	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
-0.060 TO	-0.050	196	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
-0.050 TO	-0.040	238	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
-0.040 TO	-0.030	238	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
-0.030 TO	-0.020	261	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
-0.020 TO	-0.010	258	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
-0.010 TO	-0.000	242	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
-0.000 TO	0.010	282	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
0.010 TO	0.020	294	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
0.020 TO	0.030	246	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
0.030 TO	0.040	244	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
0.040 TO	0.050	217	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
0.050 TO	0.060	171	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
0.060 TO	0.070	167	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
0.070 TO	0.080	109	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
0.080 TO	0.090	97	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
0.090 TO	0.100	71	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
0.100 TO	0.110	63	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
0.110 TO	0.120	61	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
0.120 TO	0.130	57	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
0.130 TO	0.140	42	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
0.140 TO	0.150	38	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
0.150 TO	0.160	44	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
0.160 TO	0.170	42	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
0.170 TO	0.180	37	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
0.180 TO	0.190	33	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
0.190 TO	0.200	31	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
GREATER THAN	0.200	136	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

NO 3 OF X IN CM 1470.000 FT FROM THE TARGET

THE FOLLOWING IS A HISTOGRAM OF Y FOR 5000 RAYS

INTERVAL			SCALE FACTOR: 100 X'S EQUAL 477 RAYS
LESS THAN	-0.200	0	
-0.200 TO	-0.190	0	
-0.190 TO	-0.180	0	
-0.180 TO	-0.170	0	
-0.170 TO	-0.160	0	
-0.160 TO	-0.150	0	
-0.150 TO	-0.140	0	
-0.140 TO	-0.130	0	
-0.130 TO	-0.120	0	
-0.120 TO	-0.110	0	
-0.110 TO	-0.100	0	
-0.100 TO	-0.090	1	
-0.090 TO	-0.080	15	XXX
-0.080 TO	-0.070	47	XXXXXXXXX
-0.070 TO	-0.060	142	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
-0.060 TO	-0.050	233	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
-0.050 TO	-0.040	314	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
-0.040 TO	-0.030	380	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
-0.030 TO	-0.020	442	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
-0.020 TO	-0.010	444	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
-0.010 TO	-0.000	477	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
-0.000 TO	0.010	463	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
0.010 TO	0.020	455	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
0.020 TO	0.030	394	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
0.030 TO	0.040	378	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
0.040 TO	0.050	354	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
0.050 TO	0.060	255	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
0.060 TO	0.070	131	XXXXXXXXXXXXXXXXXXXXXXXXXXXX
0.070 TO	0.080	54	XXXXXXXXXXXX
0.080 TO	0.090	15	XXX
0.090 TO	0.100	6	X
0.100 TO	0.110	0	
0.110 TO	0.120	0	
0.120 TO	0.130	0	
0.130 TO	0.140	0	
0.140 TO	0.150	0	
0.150 TO	0.160	0	
0.160 TO	0.170	0	
0.170 TO	0.180	0	
0.180 TO	0.190	0	
0.190 TO	0.200	0	
GREATER THAN	0.200	0	

NO 4 OF Y IN CM 1470.000 FT FROM THE TARGET

Figure 17. Beam profiles at the third focus in the horizontal and vertical planes respectively. Four sextupoles are used and the momentum is the central design value.