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The QTUNE Program--The AGS Extracted Beam Transport Program

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U.S. Department of Energy

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AGS Division Technical Note
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Introduction

The purpose of this Technical Note is to document the extracted beam transport program called "QTUNE". This program can be used to calculate beam sizes in the four SEB lines and the FEB line from the ring to the primary targets using the known power supply and magnet characteristics. Typical TTY and Versatec outputs for the "U" line and "C" line are shown in Figures 1 and 2. The program is run with the R-R QTUNE command when in the operations area.

Discussion

The primary purpose of this program is to calculate the horizontal and vertical beam sizes in the various beam lines using the present settings of the power supplies and the best known values of beam emittance. Beam splitting is not considered. All beam is assumed going down each line when calculating beam sizes. The magnetic data is calculated from the calculated magnet current using a 4th order power series. Power supply and magnet current limitations for the beam lines are included. Various groups of quadrupoles in the beam lines can be tuned to vary waist locations and sizes.

This program uses 5 by 5 matrices to include momentum dispersion effects. Because this program is similar to a first order "TRANSPORT" run, one output option will write on the "MATRIC-DAT" data file matrices and beam sizes in a similar format to "TRANSPORT". All other output data is written on the "QTUNE-DAT" data file which should be printed after exiting from the program.

Program Options

The various program options are shown on the HELP file in Figure 3.

The "A" command will print on the "MATRIC-DAT" file the transport matrices and emittances using the beam line chosen with the constant BFILE and the power supply data chosen with constraints IAGSFG and IENUT. Figures 4A-B show a part of this file.

The "B command prints the calculated currents and fields in the magnets. The power supply values are chosen with the constants BFILE, IAGSFG and IENUT. Figures 5A-B show this file for the "C" line.

The "H", "D", "E", "K" and "L" command descriptions are shown on Figure 3.

The "C" command is used to change one or more constants shown in Figure 6 using the NAMELIST feature. These constants only have numerical values. Those that effect the graphics output are XYRANG, ZRANGE, LFRAME, AND TEKVER. The input beam at H13 (FEB) or F13 (SEB) is described with PBEAM, ABEF13, ABEH13, DPP and H13MOM (FEB only). The beam line is chosen with BFILE, and IAGSFG selects if the power supply command or readback is used to calculate the magnet current. An off-line program, "ENUTQ", can be chosen to supply the power supply values and is selected using constant IENUT. This program, similar to "AGAST", rather than the TTY option, should be used for off-line communication since these values can be easily transferred to and from the on-line program "AGAST". The constant TEGFG is used to change to a different "ENUTQ" file.

The "G" command is used to plot beam sizes as on Figures 1, 2 or 7. An "E" will exit from this option. During FEB or SEB operation the constants are initialized so that a "G" command will plot the "U" line or "C" line beam sizes. The values of certain parameters are printed on the graph, "QTUNE-DAT", and sent to "AGAST" or "ENUTQ". These are shown in Figure 8 and defined in Figure 9.

The "P" and "M" commands will print on "QTUNE-DAT" the constants of the beam line and magnets as shown in Figures 10 and 11.

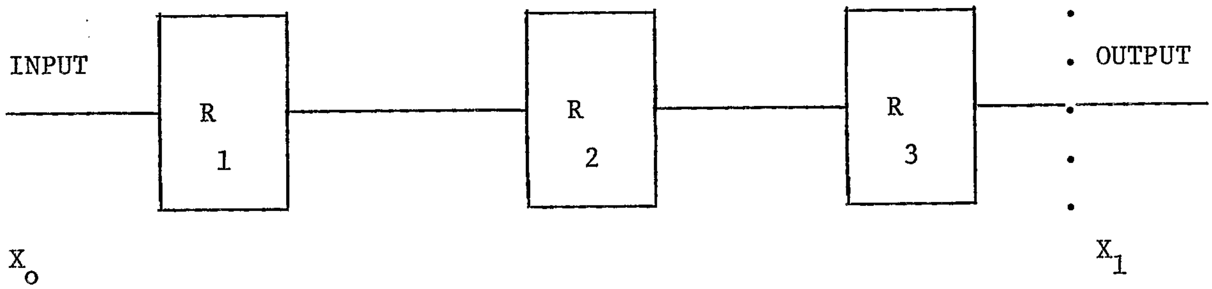
The "T" command, shown in Figure 12, is used to tune various groups of quads to meet desired values of waist parameters described in Figure 9. The beam sizes at the targets cannot be used to tune the quads before the targets, but can be varied by changing the waist locations and sizes. If tuning is mathematically successful and the program is on-line, the quad power supplies will be changed.

The "W" command calculates the values of the FEB or SEB parameters without plotting the graph.

Theory and Units

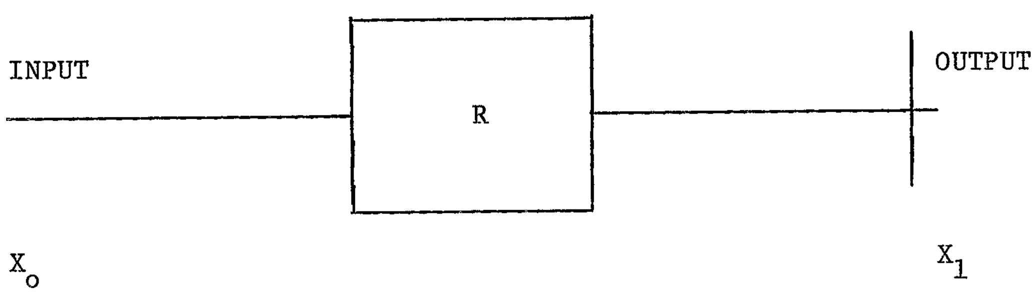
The beam is considered a collection of particles traveling down a beam line with the magnetic elements described with a matrix R_i.

→ BEAM DIRECTION →



Or

→ BEAM DIRECTION →



$$[R] = [R_3] \times [R_2] \times [R_1] \tag{1}$$
$$\text{DET } [R] = 1$$

The characteristics of the beam particles at the output can be determined from the following matrix equation:

$$[X_1] = [R] \times [X_o] \tag{2}$$

"QTUNE" uses a 5x5 order matrix for the magnetic elements, $[R]$. Equation 2 can be expanded to:

$$\begin{bmatrix} X_1 \\ \theta_1 \\ Y_1 \\ \phi_1 \\ \delta_1 \end{bmatrix} = \begin{bmatrix} R_{11} & R_{12} & R_{13} & R_{14} & R_{15} \\ R_{21} & R_{22} & R_{23} & R_{24} & R_{25} \\ R_{31} & R_{32} & R_{33} & R_{34} & R_{35} \\ R_{41} & R_{42} & R_{43} & R_{44} & R_{45} \\ R_{51} & R_{52} & R_{53} & R_{54} & R_{55} \end{bmatrix} \times \begin{bmatrix} X_o \\ \theta_o \\ Y_o \\ \phi_o \\ \delta_o \end{bmatrix} \qquad (3)$$

where standard TRANSPORT definitions apply to the particle characteristics:

X_o---- horizontal displacement of input ray, in inches, with respect to assumed central trajectory.

θ_o---- the angle (mr) that this input ray makes in horizontal plane with respect to central trajectory.

Y_o---- vertical displacement of input ray (inches) with respect to central trajectory.

ϕ_o---- the angle (mr) that this input ray makes in vertical plane with respect to central trajectory.

δ_o---- $\Delta P/P$ = fractional momentum deviation (%) of this input ray and the assumed central trajectory.

The units for the [R] matrix are:

$$\begin{array}{lllll}
R_{11}\left(\frac{\text{In X}}{\text{In X}}\right) & R_{12}\left(\frac{\text{In X}}{\text{mr X}}\right) & R_{13}\left(\frac{\text{In X}}{\text{In Y}}\right) & R_{14}\left(\frac{\text{In X}}{\text{mr Y}}\right) & R_{15}\left(\frac{\text{In X}}{\%}\right) \\
R_{21}\left(\frac{\text{mr X}}{\text{In X}}\right) & R_{22}\left(\frac{\text{mr X}}{\text{mr X}}\right) & R_{23}\left(\frac{\text{mr X}}{\text{In Y}}\right) & R_{24}\left(\frac{\text{mr X}}{\text{mr Y}}\right) & R_{25}\left(\frac{\text{mr X}}{\%}\right) \\
R_{31}\left(\frac{\text{In Y}}{\text{In X}}\right) & R_{32}\left(\frac{\text{In Y}}{\text{mr X}}\right) & R_{33}\left(\frac{\text{In Y}}{\text{In Y}}\right) & R_{34}\left(\frac{\text{In Y}}{\text{mr Y}}\right) & R_{35}\left(\frac{\text{In Y}}{\%}\right) \\
R_{41}\left(\frac{\text{mr Y}}{\text{In X}}\right) & R_{42}\left(\frac{\text{mr Y}}{\text{mr X}}\right) & R_{43}\left(\frac{\text{mr Y}}{\text{In Y}}\right) & R_{44}\left(\frac{\text{mr Y}}{\text{mr Y}}\right) & R_{45}\left(\frac{\text{mr Y}}{\%}\right) \\
R_{51}\left(\frac{\%}{\text{In X}}\right) & R_{52}\left(\frac{\%}{\text{mr X}}\right) & R_{53}\left(\frac{\%}{\text{In Y}}\right) & R_{54}\left(\frac{\%}{\text{mr Y}}\right) & R_{55}\left(\frac{\%}{\%}\right)
\end{array}$$

Figures 4A-B show the individual element matrix and total [R] matrix at different points in the "C" line. "QTUNE" calculates matrices for drift spaces, horizontal and vertical focussing quadrupoles, wedge dipole and pitching magnets without edge focusing, and rectangular dipole and pitching magnets with edge focussing.

The beam is considered an array of particles that is described with a 5th order symmetrical sigma ellipsoid. For historical reasons the program uses a rms beam and then converts this to a 99% beam. The symmetric SIGMA matrix at at the beam line input is:

$$[\sigma_o] \quad \begin{bmatrix} \sigma_{11} & \sigma_{21} & \sigma_{31} & \sigma_{41} & \sigma_{51} \\ \sigma_{21} & \sigma_{22} & \sigma_{32} & \sigma_{42} & \sigma_{52} \\ \sigma_{31} & \sigma_{32} & \sigma_{33} & \sigma_{43} & \sigma_{53} \\ \sigma_{41} & \sigma_{42} & \sigma_{43} & \sigma_{44} & \sigma_{54} \\ \sigma_{51} & \sigma_{52} & \sigma_{53} & \sigma_{54} & \sigma_{55} \end{bmatrix} \tag{4}$$

$\sqrt{\sigma_{11}}$ = X_{max} = maximum (half) width of the beam envelop in the X (bend) plane at the given point (inches).

$\sqrt{\sigma_{22}}$ = θ_{max} = maximum (half) angular divergence of the beam envelope in the X-bend plane.

$\sqrt{\sigma_{33}}$ = Y_{max} = maximum (half) height of the beam envelope.

$\sqrt{\sigma_{44}}$ = ϕ_{max} = maximum (half) angular divergence of the beam envelope in the Y (non-bend) plane.

$\sqrt{\sigma_{55}}$ = δ_{max} = half-width (1/2 $\Delta P/P$) of the momentum interval being transmitted by the system.

The coupling elements are the σ_{ij} elements for i not equal to j.

"QTUNE" assumes that the input beam for the SEB or FEB lines have no input X-Y coupling or:

$$[\sigma_o] \quad \begin{bmatrix} \sigma_{11} & \sigma_{21} & 0 & 0 & 0 \\ \sigma_{21} & \sigma_{22} & 0 & 0 & 0 \\ 0 & 0 & \sigma_{33} & \sigma_{43} & 0 \\ 0 & 0 & \sigma_{43} & \sigma_{44} & 0 \\ 0 & 0 & 0 & 0 & \sigma_{55} \end{bmatrix} \tag{5}$$

The input FEB beam is also assumed to have input momentum dispersion or the R_{15} and R_{25} elements are non-zero at H13.

At any point in the beam line, the SIGMA matrix $[\sigma_1]$ can be found from the input matrix $[\sigma_o]$ and the total $[R]$ matrix to this point:

$$[\sigma_1] = [R] \times [\sigma_o] \times [R^T] \tag{6}$$

where $[R^T]$ is the transpose of $[R]$.

The graphs of Figures 1 and 2 are obtained by plotting $\sqrt{\sigma_{11}}$ and $\sqrt{\sigma_{33}}$ along the beam line for a 99% beam. The program also plots the horizontal momentum dispersion parameters, R_{15} and R_{25}, along the beam line.

The input SIGMA matrix, $[\sigma_o]$ is obtained from the constants ABEF13 or ABEH13 and DPP. For no X-Y coupling, the horizontal part of $[\sigma_o]$ is:

$$\begin{bmatrix} \sigma_{11} & \sigma_{21} \\ \sigma_{21} & \sigma_{22} \end{bmatrix} = \varepsilon_H \begin{bmatrix} \beta_H & -\alpha_H \\ -\alpha_H & \gamma_H \end{bmatrix} \tag{7}$$

$$\sigma_{11} = \varepsilon_H\beta_H \qquad \varepsilon = \mathrm{DET}\begin{pmatrix} \sigma_{11} & \sigma_{21} \\ \sigma_{21} & \sigma_{22} \end{pmatrix}$$

$$\sigma_{21} = -\varepsilon_H\alpha_H$$

$$\sigma_{22} = \varepsilon_H\gamma_H = \varepsilon_H\left(\frac{1 + \alpha_H^2}{\beta_H}\right)$$

where α, β, and ε are the rms beam Twiss parameters as specified in ABEF13 or ABEH13. These are initialized to the best know values of the emittance at F13 (from H. Weisberg) or H13 (W. Weng).

α - dimensionless

β - kiloinch

ε - epislon = rms emittance (inch-mrad)

The 99% beam emittance = 9.2103 ε_{rms}

The 99% beam width plotted = 3.0348 (beam width for rms beam)

The vertical $[\sigma_o]$ elements, σ_{33}, σ_{43}, and σ_{44} are obtained in a similar way.

If X-Y coupling occurs downstream, the beam ellipsoid is assumed to have the same 5th order volume or no losses are assumed. THe horizontal and vertical emittances may change. To determine the location of a waist, the emittance in that plane is needed at the entrance to the drift space. The emittance is the projection of the ellipsoid on that plane or

$$\varepsilon_H = \mathrm{DET} \begin{pmatrix} \sigma_{11} & \sigma_{21} \\ \sigma_{21} & \sigma_{22} \end{pmatrix} \quad \text{or} \quad \varepsilon_V = \mathrm{DET} \begin{pmatrix} \sigma_{33} & \sigma_{43} \\ \sigma_{43} & \sigma_{44} \end{pmatrix} \tag{8}$$

where DET is the determinant.

Equation (6) can be expanded and simplified for an input beam with no X-Y coupling (Equation (5)).

$$[\sigma]_1 = [R] \times [\sigma]_o \times [R^T] \tag{6}$$

At Point 1

$$\begin{aligned}(\sigma_{11})_1 = (X_{max})^2 = {} & (\sigma_{11})_o R_{11}^2 + 2(\sigma_{21}) R_{11}R_{12} + (\sigma_{22})_o R_{12}^2 \\ & + (\sigma_{33})_o R_{13}^2 + 2(\sigma_{43})_o R_{13}R_{14} + (\sigma_{44})_o R_{14}^2 \\ & + (\sigma_{66})_o R_{16}^2\end{aligned} \tag{7}$$

$$\begin{aligned}(\sigma_{33})_1 = (Y_{max})^2 = {} & (\sigma_{11})_o R_{31}^2 + 2(\sigma_{21})_o R_{32}R_{31} + (\sigma_{22})_o R_{32}^2 \\ & + (\sigma_{33})_o R_{33}^2 + 2(\sigma_{43})_o R_{34}R_{33} + (\sigma_{44})_o R_{34}^2 \\ & + (\sigma_{66})_o R_{36}^2\end{aligned} \tag{8}$$

$$\begin{aligned}(\sigma_{13})_1 = \text{tilt component} = {} & (\sigma_{11})_o R_{11}R_{31} + (\sigma_{21})_o (R_{12}R_{31} + R_{11}R_{32}) \\ & + (\sigma_{22})_o R_{12}R_{32} + (\sigma_{33})_o R_{13}R_{33} + (\sigma_{43})_o \times \\ & (R_{14}R_{33} + R_{13}R_{34}) \\ & + (\sigma_{44})_o R_{14}R_{34} + (\sigma_{66})_o R_{16}R_{36}\end{aligned} \tag{9}$$

Where the $(\sigma_{ij})_o$ are the input beam components and the R_{ij} are the total matrix elements from the input to the Point 1 in the beam line. The input beam Twiss parameters (α, β, ε) can be found experimentally by fitting several beam width measurements to Equation (6) or (7) knowing the elements of the $[R]$ matrix at the measurement point.

mn

Distribution: Dept. Admin.
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AGS Div. Engineers

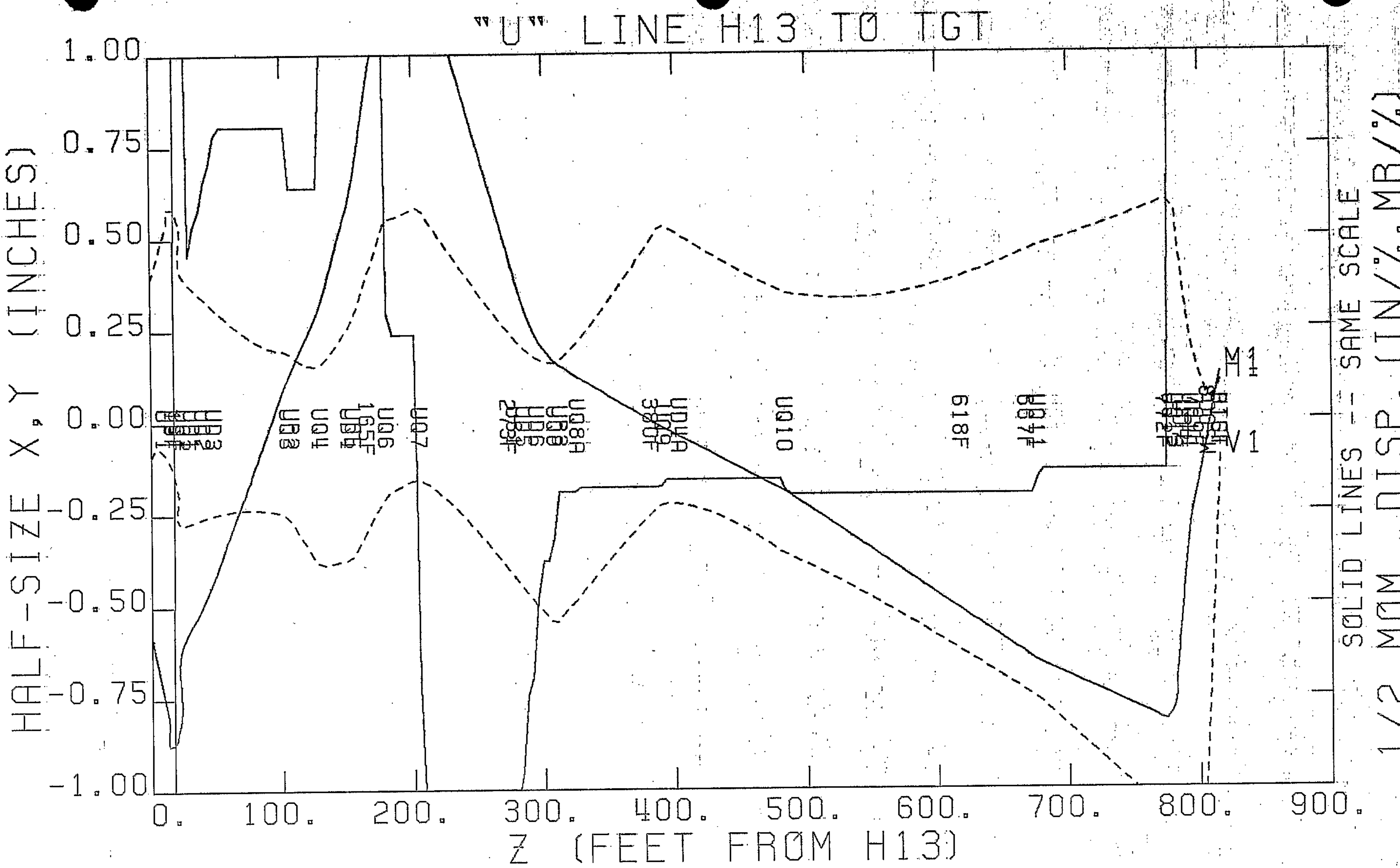
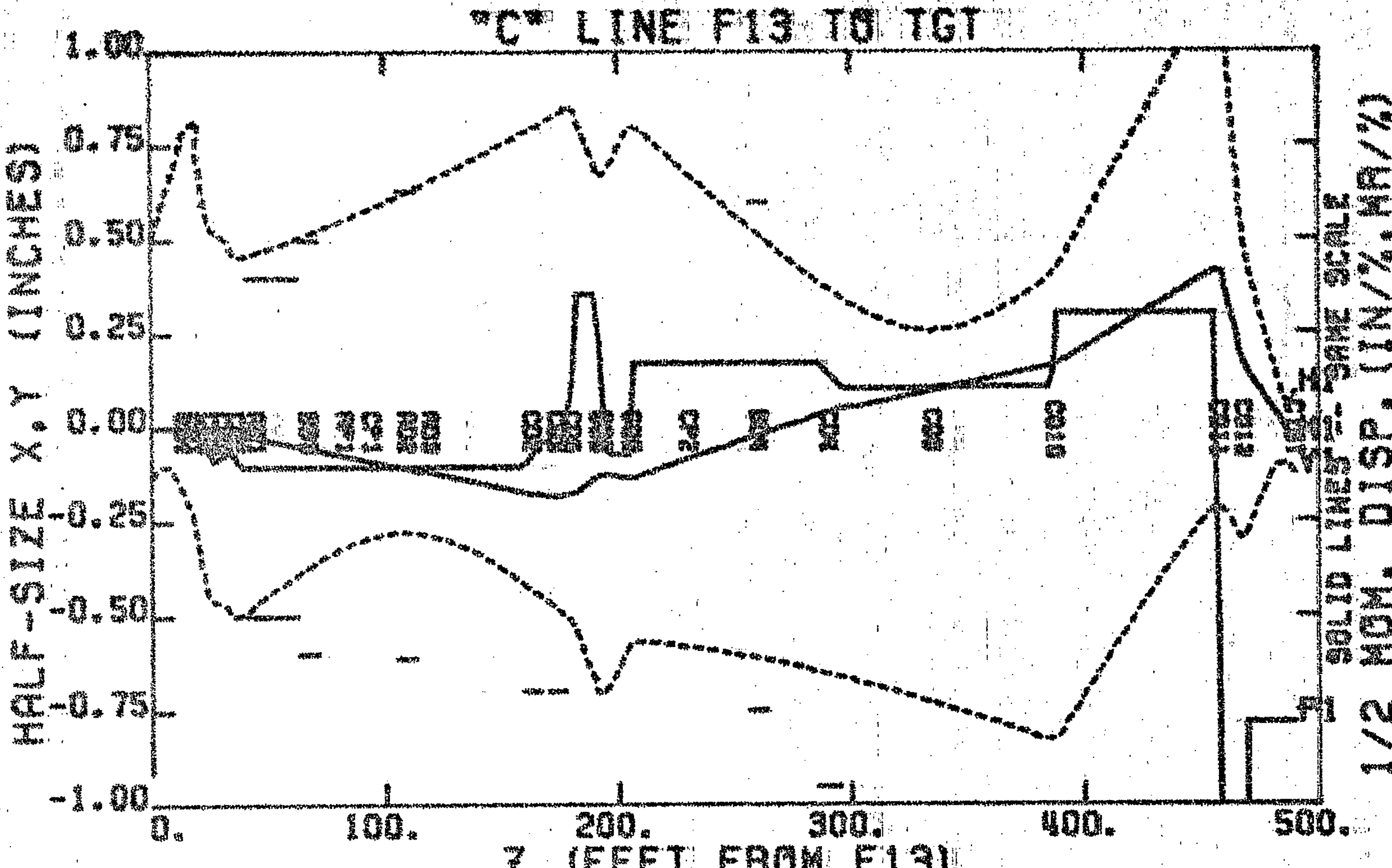

"U" LINE H13 TO TGT
HALF-SIZE X,Y (INCHES)
1.00
0.75
0.50
0.25
0.00
-0.25
-0.50
-0.75
-1.00
0.
100.
200.
300.
400.
500.
600.
700.
800.
900.
Z (FEET FROM H13)
SOLID LINES -- SAME SCALE
1/2 MOM. DISP. (IN/%,MR/%)
M1
V1
UQ10
618F

Figure 1



CM%HZ	CM%HX	CM%VZ	CM%VX	CA%HI	CA%HO	CA%VI	CA%VO
-199.8	404.0	1297.0	277.0	-1858.7	2977.5	-1533.4	-162.7
CT%HZ	CT%HX	CT%VZ	CT%VX	BT%HZ	BT%HX	BT%VZ	BT%VX
-33.4	62.5	-56.6	95.3	-1.0	62.0	3.0	32.0
AT%HZ	AT%HX	AT%VZ	AT%VX	BMDIV	TG%CH	TG%CV	
854.0	224.0	-1592.0	127.0	86.5	93.0	125.8	

Figure 2

```
VALID COMMANDS:
-------------------------------------------
H <CR> -- TYPES THIS HELP MESSAGE.
A <CR> -- PRINT OUT TRANSPORT MATRICES & EMITTANCES ON "MATRIC.DAT".
B <CR> -- PRINT ON "QTUNE.DAT" BEAM LINE DATA WITH FIELDS &  CURRENTS IN
               MAGNETS.
C <CR> -- CHANGE THE CONSTANTS.
D <CR> -- DELETE (START OVER) ON THE "QTUNE.DAT" FILE.
E <CR> -- EXIT.
G <CR> -- PLOT BEAM PROFILES & GET WAIST PARAMETERS FROM  PRESENT
               MAGNET SETTINGS.
K <CR> -- TYPE OUT CONSTANTS AND THEIR DEFINITIONS.
L <CR> -- LIST (PRINT) ON "QTUNE.DAT" CONSTANTS & DEFINITIONS.
M <CR> -- PRINT ON "QTUNE.DAT" MAGNET LENGTHS & FIELD VS CURRENT POWER
              SERIES COEFF. FOR BEAM LINE MAGNETS.
P <CR> -- PRINT ON "QTUNE.DAT" POWER SUPPLY PARAMETERS FOR BEAM LINE
              MAGNETS.
T <CR> -- TUNE THE QUADS BY VARYING THE QUADS OR WAIST PARAMETERS ON
              AGAST AND PLOT BEAM PROFILES.
W <CR> -- CALCULATES WAIST PARAMETERS FROM AGAST COMMANDS & SEND WAIST
              INFORMATION TO AGAST FOR MORNING REPORT; NO PLOTS MADE.
-------------------------------------------

 COMMAND: ( A, B, C, D, E, G, H, K, L, M, P, T, W, ) :
```

Figure 3

15-Jul-82 14:13

ORMS PARAMETERS:
ALPHA, BETA, EPSILON (H,V) AT F13: -6.3388 1.9952 0.0140 0.8708 0.1279 0.0150

CD1 (-2243) CQ1 (-1898) CQ2 (1073) CQ3 (-303) CQ4 (687) CD283(3269) CD283(3269) CQ588(-1105) CQ687(1000) CQ687(1000) CQ588(-1105) CD4 (-2681) CQ9 (1) CQ10 (2658) CQ11 (-3502) CQ12 (2390) CD3T (0)

ELEMENT	Z(INCHES)	ELEMENT OR TOTAL MATRIX FROM START					TRANSPORT BEAM MATRIX				
		1.00000	0.00000	0.00000	0.00000	0.00000					
		0.00000	1.00000	0.00000	0.00000	0.00000					
START ===		0.00000	0.00000	1.00000	0.00000	0.00000					
		0.00000	0.00000	0.00000	1.00000	0.00000					
		0.00000	0.00000	0.00000	0.00000	1.00000					
	0.000 INCHES										
		1.00000	0.00000	0.00000	0.00000	0.00000	0.507 IN				
		0.00000	1.00000	0.00000	0.00000	0.00000	1.631 MR	0.988			
TOTAL MATRIX ===		0.00000	0.00000	1.00000	0.00000	0.00000	0.133 IN	0.000	0.000		
		0.00000	0.00000	0.00000	1.00000	0.00000	1.378 MR	0.000	0.000	-0.657	
		0.00000	0.00000	0.00000	0.00000	1.00000	0.000 PC	0.000	0.000	0.000	0.000
	0.000 INCHES										
		1.00000	0.14383	0.00000	0.00000	0.00000					
		0.00000	1.00000	0.00000	0.00000	0.00000					
===		0.00000	0.00000	1.00000	0.14383	0.00000					
		0.00000	0.00000	0.00000	1.00000	0.00000					
		0.00000	0.00000	0.00000	0.00000	1.00000					
	143.825 INCHES										
		1.00000	0.14383	0.00000	0.00000	0.00000	0.740 IN				
		0.00000	1.00000	0.00000	0.00000	0.00000	1.631 MR	0.994			
TOTAL MATRIX ===		0.00000	0.00000	1.00000	0.14383	0.00000	0.150 IN	0.000	0.000		
		0.00000	0.00000	0.00000	1.00000	0.00000	1.378 MR	0.000	0.000	0.742	
		0.00000	0.00000	0.00000	0.00000	1.00000	0.000 PC	0.000	0.000	0.000	0.000
	143.825 INCHES										
		1.00000	0.03435	0.00000	0.00000	-0.00201					
		-0.00000	1.00000	0.00000	0.00000	-0.11699					
CD1 ===		0.00000	0.00000	0.99993	0.03435	0.00000					
		0.00000	0.00000	-0.00398	0.99993	0.00000					
		0.00000	0.00000	0.00000	0.00000	1.00000					
	178.175 INCHES										
		1.00000	0.17817	0.00000	0.00000	-0.00201	0.796 IN				
		-0.00000	1.00000	0.00000	0.00000	-0.11699	1.631 MR	0.995			
TOTAL MATRIX ===		0.00000	0.00000	0.99993	0.17817	0.00000	0.187 IN	0.000	0.000		
		0.00000	0.00000	-0.00398	0.99936	0.00000	1.378 MR	0.000	0.000	0.845	
		0.00000	0.00000	0.00000	0.00000	1.00000	0.000 PC	0.000	0.000	0.000	0.000
	178.175 INCHES										
		1.00000	0.00808	0.00000	0.00000	0.00000					
		0.00000	1.00000	0.00000	0.00000	0.00000					
===		0.00000	0.00000	1.00000	0.00808	0.00000					
		0.00000	0.00000	0.00000	1.00000	0.00000					
		0.00000	0.00000	0.00000	0.00000	1.00000					
	186.250 INCHES										
		1.00000	0.18625	0.00000	0.00000	-0.00295	0.809 IN				
		-0.00000	1.00000	0.00000	0.00000	-0.11699	1.631 MR	0.995			
TOTAL MATRIX ===		0.00000	0.00000	0.99990	0.18623	0.00000	0.197 IN	0.000	0.000		
		0.00000	0.00000	-0.00398	0.99936	0.00000	1.378 MR	0.000	0.000	0.860	
		0.00000	0.00000	0.00000	0.00000	1.00000	0.000 PC	0.000	0.000	0.000	0.000
	186.250 INCHES										

Figure 4A

	0.88149	0.03601	0.00000	0.00000	0.00000							
	-6.19288	0.88149	0.00000	0.00000	0.00000							
CQ1 ===	0.00000	0.00000	1.12339	0.03903	0.00000							
	0.00000	0.00000	6.71290	1.12339	0.00000							
	0.00000	0.00000	0.00000	0.00000	1.00000							
223.750 INCHES												
	0.88149	0.20018	0.00000	0.00000	-0.00682	0.771	IN					
	-6.19288	-0.27193	0.00000	0.00000	-0.08483	3.580	MR	-0.999				
TOTAL MATRIX ===	0.00000	0.00000	1.12312	0.24822	0.00000	0.269	IN	0.000	0.000			
	0.00000	0.00000	6.70775	2.37285	0.00000	2.767	MR	0.000	0.000	0.983		
	0.00000	0.00000	0.00000	0.00000	1.00000	0.000	PC	0.000	0.000	0.000	0.000	
223.750 INCHES												
	1.00000	0.04650	0.00000	0.00000	0.00000							
	0.00000	1.00000	0.00000	0.00000	0.00000							
===	0.00000	0.00000	1.00000	0.04650	0.00000							
	0.00000	0.00000	0.00000	1.00000	0.00000							
	0.00000	0.00000	0.00000	0.00000	1.00000							
270.250 INCHES												
	0.59352	0.18754	0.00000	0.00000	-0.01076	0.605	IN					
	-6.19288	-0.27193	0.00000	0.00000	-0.08483	3.580	MR	-0.998				
TOTAL MATRIX ===	0.00000	0.00000	1.43503	0.35856	0.00000	0.396	IN	0.000	0.000			
	0.00000	0.00000	6.70775	2.37285	0.00000	2.767	MR	0.000	0.000	0.992		
	0.00000	0.00000	0.00000	0.00000	1.00000	0.000	PC	0.000	0.000	0.000	0.000	
270.250 INCHES												
	1.16467	0.05219	0.00000	0.00000	0.00000							
	6.88020	1.16467	0.00000	0.00000	0.00000							
CQ2 ===	0.00000	0.00000	0.84390	0.04690	0.00000							
	0.00000	0.00000	-6.13762	0.84390	0.00000							
	0.00000	0.00000	0.00000	0.00000	1.00000							
319.750 INCHES												
	0.36805	0.20423	0.00000	0.00000	-0.01696	0.518	IN					
	-3.15883	0.96421	0.00000	0.00000	-0.17229	0.250	MR	-0.095				
TOTAL MATRIX ===	0.00000	0.00000	1.52559	0.41386	0.00000	0.463	IN	0.000	0.000			
	0.00000	0.00000	-3.14701	-0.19824	0.00000	0.315	MR	0.000	0.000	-0.326		
	0.00000	0.00000	0.00000	0.00000	1.00000	0.000	PC	0.000	0.000	0.000	0.000	
319.750 INCHES												
	1.00000	0.02050	0.00000	0.00000	0.00000							
	0.00000	1.00000	0.00000	0.00000	0.00000							
===	0.00000	0.00000	1.00000	0.02050	0.00000							
	0.00000	0.00000	0.00000	1.00000	0.00000							
	0.00000	0.00000	0.00000	0.00000	1.00000							
340.250 INCHES												
	0.30330	0.22399	0.00000	0.00000	-0.02049	0.518	IN					
	-3.15883	0.96421	0.00000	0.00000	-0.17229	0.250	MR	-0.085				
TOTAL MATRIX ===	0.00000	0.00000	1.46108	0.40980	0.00000	0.461	IN	0.000	0.000			
	0.00000	0.00000	-3.14701	-0.19824	0.00000	0.315	MR	0.000	0.000	-0.313		
	0.00000	0.00000	0.00000	0.00000	1.00000	0.000	PC	0.000	0.000	0.000	0.000	
340.250 INCHES												
	0.95560	0.04877	0.00000	0.00000	0.00000							
	-1.78052	0.95560	0.00000	0.00000	0.00000							
CQ3 ===	0.00000	0.00000	1.04507	0.05024	0.00000							
	0.00000	0.00000	1.83441	1.04507	0.00000							
	0.00000	0.00000	0.00000	0.00000	1.00000							
389.750 INCHES												
	0.13579	0.26107	0.00000	0.00000	-0.02798	0.494	IN					
	-3.55861	0.52257	0.00000	0.00000	-0.12816	0.972	MR	-0.963				
TOTAL MATRIX ===	0.00000	0.00000	1.36881	0.41831	0.00000	0.477	IN	0.000	0.000			
	0.00000	0.00000	-0.60861	0.54457	0.00000	0.806	MR	0.000	0.000	0.933		
	0.00000	0.00000	0.00000	0.00000	1.00000	0.000	PC	0.000	0.000	0.000	0.000	
389.750 INCHES												

Figure 4B

15-Jul-82 14:07

"C" LINE MAGNETS FROM F13 TO C TARGET

---ELEMENT--- #	NAME	LABEL	---MAGNET KIND	---POWER SUPPLY DATA--- DDF1	CMD/RDBK	DDF2	CMD/RDBK	--MAGNET DATA FOR 29.000 GEV/C-- CURRENT(KA)	KG-IN OR KG/IN	GAIN(GEL)
1			DRIFT							0.0
2	CD1	CD1	RDPOL	CD1	-2243		0	1.40188	-445.5247	-0.67027
3			DRIFT							0.0
4	CQ1	CQ1	QUAD	CQ1	-1898		0	1.42350	-6.5502	-6.55019
5			DRIFT							0.0
6	CQ2	CQ2	QUAD	CQ2	1073		0	1.07300	4.9843	4.98428
7			DRIFT							0.0
8	CQ3	CQ3	QUAD	CQ3	-303		0	0.30300	-1.3905	-1.39052
9			DRIFT							0.0
10	CQ4	CQ4	QUAD	CQ4	687		0	0.51525	2.3747	2.37467
11			DRIFT							0.0
12		AB1	DRIFT							0.0
13			DRIFT							0.0
14		BB3	DRIFT							0.0
15			DRIFT							0.0
16		AP1	DRIFT							0.0
17			DRIFT							0.0
18		CP1	DRIFT							0.0
19			DRIFT							0.0
20		AD2	DRIFT							0.0
21			DRIFT							0.0
22		AD3	DRIFT							0.0
23			DRIFT							0.0
24	CD2	CD2	RDPOL	CD283	3269		0	1.22588	510.3198	0.76775
25			DRIFT							0.0
26	CD3	CD3	RDPOL	CD283	3269	CD3T	0	1.22588	510.3198	0.76775
27			DRIFT							0.0
28	CQ5	CQ5	QUAD	CQ588	-1105		0	0.27625	-4.0898	-4.08979
29			DRIFT							0.0
30	CQ6	CQ6	QUAD	CQ687	1000		0	0.25000	3.7738	3.77383
31			DRIFT							0.0
32	CQ7	CQ7	QUAD	CQ687	1000		0	0.25000	3.7738	3.77383
33			DRIFT							0.0
34	CQ8	CQ8	QUAD	CQ588	-1105		0	0.27625	-4.0898	-4.08979
35			DRIFT							0.0
36		CP2	DRIFT							0.0
37			DRIFT							0.0
38		BD4	DRIFT							0.0
39			DRIFT							0.0
40	CD4	CD4	RDPOL	CD4	-2681		0	1.00537	-514.3780	-0.77386
41			DRIFT							0.0
42	CQ9	CQ9	QUAD	CQ9	1		0	0.00006	0.0126	0.01256
43			DRIFT							0.0
44	CQ10	CQ10	QUAD	CQ10	2658		0	0.99675	1.2642	1.26418
45			DRIFT							0.0
46	CQ11	CQ11	QUAD	CQ11	-3502		0	1.31325	-6.0712	-6.07116
47			DRIFT							0.0
48	CQ12	CQ12	QUAD	CQ12	2390		0	1.79250	8.0039	8.00388
49			DRIFT							0.0
50		CTGT	DRIFT							0.0

NOTE *****
A) CMD/RDBK -- READINGS ARE FROM AGAST CMDS; THE "A" RDBK IS NEGATIVE -- IE. 2140A = -2140.
B) DDF2 (SECONDARY P.S. READBACKS) ARE SA3 RDBKS WITH THE POLARITY OF NORMAL READBACK.

Figure 5A

C) KGI — KG/IN FOR QUADS; KG-IN FOR DIPOLES.
D) GEL — = 0 FOR DRIFT; -KG/IN FOR H.F. QUAD; +KG/IN FOR V.F. QUAD; BEND ANGLE (DEGREES) FOR DIPOLES (+ = EAST).
(+ = DOWN FOR PITCH)

Figure 5B

15-Jul-82 13:56

```
BFILE  (BEAM FILE NUMBER; 1=A,2=B,3=C,4=D,5=U)                              3
PBEAM  (BEAM MOMENTUM, GEV/C)                                           29.00
ABEF13 (ALPHA, BETA (KILOINCH), EPSILON (INCH-MRAD, RMS) AT F13
       HORIZONTAL:                              -6.3388    1.9952      0.0140
       VERTICAL:                                 0.8708    0.1279      0.0150
ABEH13 (ALPHA, BETA (KILOINCH), EPSILON (INCH-MRAD, RMS) AT H13
       HORIZONTAL:                              -5.6700    2.2620      0.0064
       VERTICAL:                                 0.9870    0.1457      0.0064
DPP    ((DELTA P/P) OR MOMEN.FRACT. IN % FOR 99% BEAM)                 0.0000
H13MOM (INPUT HORZ. MOMEN. DISPERSION AT H13; INCH/%,MR/%)
                  -1.1650 -2.9500
TEKVER (=1 FOR TEKTRONIX PLOTS,=2(MODEL 1200) OR -2(MODEL
                1100) VERSATEK & NO TUNING)                                 1
LFRAME (=0 OR NEG. TO SUPPRESS FRAMES & LABELS ON GRAPHS;
              -1,0 OR 1 FOR ALL GRAPHS; -2 OR 2 FOR NO MOMEN.
              DISPERSION PLOTS)                                             1
IACSFG (ACS FLAG;=1 FOR MAGNET VALUES FROM TTY,=2 FOR
        AGAST RDBKS,=3 FOR AGAST COMMANDS)                                  3
PSTIME (POWER SUPPLY READ TIME IN MS AFTER T0)                           1100
ZRANGE (PLOTTING RANGE IN BEAM LINE FEET (MIN,MAX) )
                    0.000 (STARTING POINT OR 0 FEET FROM F13)
                10000.000 (END POINT OR END OF BEAM LINE)
IENUT (0="AGAST" OR TTY; -1 = OFFLINE "ENUTQ")                              0
TEGFG (0=USE CURRENT "ENUTQ" "QTUNE.TEG" FILE;-1 TO
            CHANGE FILE NAME)                                               0
XYRANG (MAX. BEAM HALF SIZE FOR PLOTTING,INCH)                         1.0000
```

Figure 6

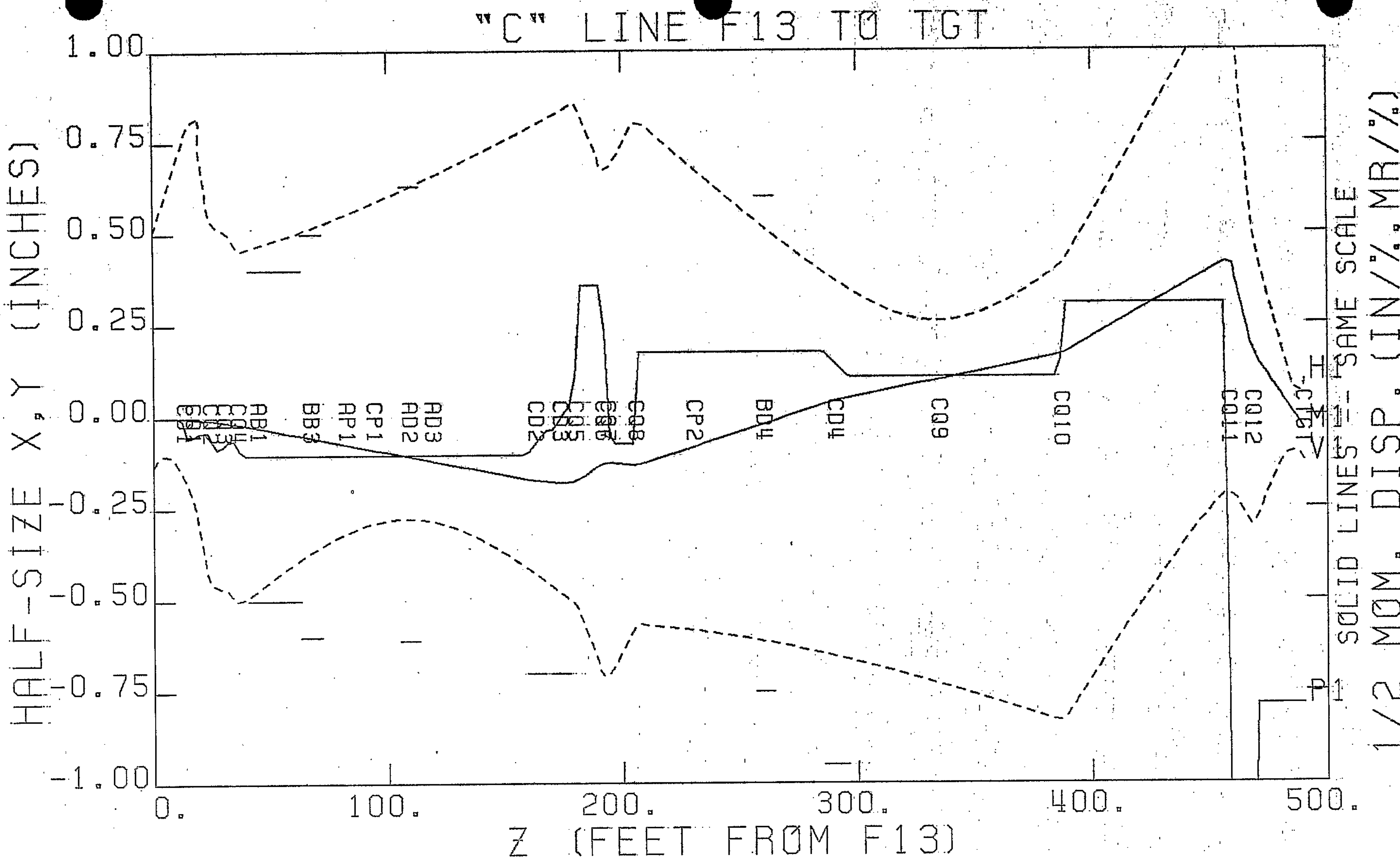

"C" LINE F13 TO TGT
HALF-SIZE X,Y (INCHES)
1.00
0.75
0.50
0.25
0.00
-0.25
-0.50
-0.75
-1.00
1/2 MOM. DISP. (IN/%,MR/%)
SOLID LINES -- SAME SCALE
H
V
P
1
AB1
BB3
AP1
CP1
AD2
AD3
CD2
CQ3
CQ5
CQ8
CP2
BD4
CD4
CQ9
CQ10
CQ11
CQ12
0.
100.
200.
300.
400.
500.
Z (FEET FROM F13)

Figure 7

```
                        15-Jul-82 13:59
ORMS PARAMETERS:
 ALPHA, BETA, EPSILON (H,V) AT F13: -6.3388  1.9952  0.0140  0.8708  0.1279  0.0150

 CD1  (-2243) CQ1  (-1898) CQ2  ( 1073) CQ3  ( -303) CQ4  (  687) CD283( 3269) CD283( 3269) CQ588(-1105) CQ687( 1000) CQ687( 1000) C
Q588(-1105) CD4  (-2681) CQ9  (    1) CQ10 ( 2658) CQ11 (-3502) CQ12 ( 2390) CD3T (    0)
  CM%HZ     CM%HX     CM%VZ     CM%VX     CA%HI     CA%HO     CA%VI     CA%VO     CT%HZ     CT%HX     CT%VZ     CT%VX
  -199.77    403.98   1296.98    277.03  -1858.70   2977.50  -1533.36   -162.67    -33.40     62.45    -56.59     95.35
  BT%HZ     BT%HX     BT%VZ     BT%VX     AT%HZ     AT%HX     AT%VZ     AT%VX     BMDIV     TG%CH     TG%CV
    -1.00     62.00      3.00     32.00    854.00    224.00  -1592.00    127.00     86.52     93.04    125.76


                        15-Jul-82 14:03
ORMS PARAMETERS:
 ALPHA, BETA, EPSILON (H,V) AT F13: -6.3388  1.9952  0.0140  0.8708  0.1279  0.0150

 CD1  (-2243) CQ1  (-1898) CQ2  ( 1073) CQ3  ( -303) CQ4  (  687) CD283( 3269) CD283( 3269) CQ588(-1105) CQ687( 1000) CQ687( 1000) C
Q588(-1105) CD4  (-2681) CQ9  (    1) CQ10 ( 2658) CQ11 (-3502) CQ12 ( 2390) CD3T (    0)
  CM%HZ     CM%HX     CM%VZ     CM%VX     CA%HI     CA%HO     CA%VI     CA%VO     CT%HZ     CT%HX     CT%VZ     CT%VX
  -199.77    403.98   1296.98    277.03  -1858.70   2977.50  -1533.36   -162.67    -33.40     62.45    -56.59     95.35
  BT%HZ     BT%HX     BT%VZ     BT%VX     AT%HZ     AT%HX     AT%VZ     AT%VX     BMDIV     TG%CH     TG%CV
    -1.00     62.00      3.00     32.00    854.00    224.00  -1592.00    127.00     86.52     93.04    125.76
```

Figure 8

NAME(??%??)AREA( )COMP( )DEVTP( )ADDR( ) WHO( )WHR( )14-Jul-82

	EQUIP	AREA	DEVICE TYPE	DEFINITION
1	AT%HX	SEB	(REFERENCE)	(HALF WIDTH(MILS) OF HORIZ. BEAM AT WAIST NEAR'A' TGT (QTUNE PGM.)
2	AT%HZ	SEB	(REFERENCE)	(Z POS. OF 'A' TGT HORZ. WAIST,INCH; 0='A' TGT;-50=50 IN.UPSTM 'A')
3	AT%VX	SEB	(REFERENCE)	(HALF WIDTH(MILS) OF VERT. BEAM AT WAIST NEAR'A' TGT. (QTUNE PGM.)
4	AT%VZ	SEB	(REFERENCE)	(Z POS. OF 'A' TGT.VERT. WAIST,INCH; 0='A' TGT;-50=50 IN.UPSTRM 'A' T)
5	BT%HX	SEB	(REFERENCE)	(HALF WIDTH(MILS) OF HORIZ. BEAM AT WAIST NEAR 'B' TGT. (QTUNE PGM.)
6	BT%HZ	SEB	(REFERENCE)	(Z POS. OF 'B' TGT HORZ.WAIST,INCH; 0= 'B' TGT;-50=50 IN.UPSTM 'B')
7	BT%VX	SEB	(REFERENCE)	(HALF WIDTH(MILS) OF VERT. BEAM AT WAIST NEAR 'B' TGT. (QTUNE PGM.)
8	BT%VZ	SEB	(REFERENCE)	(Z POS. OF 'B' TGT VERT.WAIST,INCH; 0= 'B' TGT;-50=50 IN. UPSTRM 'B'T)
9	CA%HI	SEB	(REFERENCE)	(1000 TIMES BEAM HORIZ. EMITTANCE ALPHA AT CQ5 UPSTREAM (Q TUNE USES)
10	CA%HO	SEB	(REFERENCE)	(1000 TIMES BEAM HORIZ. EMITTANCE ALPHA AT CQ8 DOWNSTREAM (Q TUNE USE)
11	CA%VI	SEB	(REFERENCE)	(1000 TIMES BEAM VERTICAL EMITTANCE ALPHA AT CQ5 UPSTREAM (Q TUNE USE)
12	CA%VO	SEB	(REFERENCE)	(1000 TIMES BEAM VERTICAL EMITTANCE ALPHA AT CQ8 DNSTREAM (Q TUNE USE)
13	CM%HX	SEB	(REFERENCE)	(HALF-WIDTH(MILS) OF HORIZ BEAM AT WAIST MID 'C' LINE(Q TUNE PGM)
14	CM%HZ	SEB	(REFERENCE)	(Z POS. MIDDLE C LINE(INCH FROM F13)OF HORZ. WAIST(Q TUNE PGM USES)
15	CM%VX	SEB	(REFERENCE)	(HALF-WIDTH(MILS) OF VERT. BEAM AT WAIST MID C LINE (Q TUNE PGM.)
16	CM%VZ	SEB	(REFERENCE)	(Z POS. MIDDLE C LINE (INCH FROM F13)VERT. WAIST (Q TUNE PGM USES)
17	CT%HX	SEB	(REFERENCE)	(HALF WIDTH(MILS) OF HORIZ.BEAM AT WAIST NEAR 'C' TGT.(QTUNE PGM USES)
18	CT%HZ	SEB	(REFERENCE)	(Z POS. OF 'C' TGT. HORZ.WAIST, INCH; 0= 'C' TGT;-50=50 IN. UPSTRM 'C)
19	CT%VX	SEB	(REFERENCE)	(HALF WIDTH(MILS) OF VERT. BEAM AT WAIST NEAR 'C' TGT.(QTUNE PGM USES)
20	CT%VZ	SEB	(REFERENCE)	(Z POS. OF 'C' TGT.VERT. WAIST,INCH; 0='C' TGT;-50=50 IN. UPSTRM 'C')
21	TG%AH	SEB	(REFERENCE)	(CALCULATED HORIZONTAL HALF WIDTH BEAM SIZE IN MILS AT "A" TARGET)
22	TG%AV	SEB	(REFERENCE)	(CALCULATED VERTICAL HALF WIDTH BEAM SIZE IN MILS AT "A" TARGET)
23	TG%BH	SEB	(REFERENCE)	(CALCULATED HORIZONTAL HALF WIDTH BEAM SIZE IN MILS AT "B" TARGET)
24	TG%BV	SEB	(REFERENCE)	(CALCULATED VERTICAL HALF WIDTH BEAM SIZE IN MILS AT "B" TARGET)
25	TG%CH	SEB	(REFERENCE)	(CALCULATED HORIZONTAL HALF WIDTH BEAM SIZE IN MILS AT "C" TARGET)
26	TG%CV	SEB	(REFERENCE)	(CALCULATED VERTICAL HALF WIDTH BEAM SIZE IN MILS AT "C" TARGET)
27	TG%UH	FEB	(REFERENCE)	(CALCULATED HORZ. HALF WIDTH BEAM SIZE IN MILS AT U TGT. - QTUNE PGM)
28	TG%UV	FEB	(REFERENCE)	(CALCULATED VERT. HALF WIDTH BEAM SIZE IN MILS AT U TGT. - QTUNE PGM)
29	U8%MD	FEB	(REFERENCE)	(1000 X CALC. MOMENTUM DISPERSION(INCH/RATIO) AT END OF 8 DEG. MAGNET)
30	U8%MP	FEB	(REFERENCE)	(1000 X CALC. MOMENTUM DISPERSION PRIME(MR/RATIO) AT END OF 8 DEG. MA)
31	UT%HX	FEB	(REFERENCE)	(HALF WIDTH(MILS) OF HORZ. BEAM AT WAIST NEAR TGT - QTUNE PGM. USES)
32	UT%HZ	FEB	(REFERENCE)	(Z POS. OF U TGT. HORZ. WAIST, INCH; 0=U TGT.; -50=50 IN. UPSTRM U TG)
33	UT%VX	FEB	(REFERENCE)	(HALF WIDTH(MILS) OF VERT. BEAM AT WAIST NEAR TGT - QTUNE PGM. USES)
34	UT%VZ	FEB	(REFERENCE)	(Z POS. OF U TGT. VERT. WAIST, INCH; 0=U TGT.; -50=50 IN. UPSTRM U TG)

Figure 9

15-Jul-82 14:05

"C" LINE MAGNETS FROM F13 TO C TARGET

---ELEMENT---		---MAGNET---				Z(U/S)	LENGTH	XAPER	YAPER	POWER SUPPLY INFORMATION --PRIMARY--		--MAX--	--SECONDARY--	
#	NAME	LABEL	KIND	GROUP	#	INCH	INCH	INCH	INCH	DDF	AMPS/DCN	KAMPS	DDF	AMPS/DCN
1			DRIFT		0	0.000	143.825	0.000	0.000					
2	CD1	CD1	RDPOL	15C30	-7	143.825	34.350	1.440	1.440	CD1	0.6250	2.100		
3			DRIFT		0	178.175	8.075	0.000	0.000					
4	CQ1	CQ1	QUAD	N3Q36	1	186.250	37.500	1.440	1.440	CQ1	0.7500	2.400		
5			DRIFT		0	223.750	46.500	0.000	0.000					
6	CQ2	CQ2	QUAD	N3Q48	2	270.250	49.500	1.360	1.360	CQ2	1.0000	2.400		
7			DRIFT		0	319.750	20.500	0.000	0.000					
8	CQ3	CQ3	QUAD	N3Q48	2	340.250	49.500	1.380	1.380	CQ3	1.0000	2.400		
9			DRIFT		0	389.750	26.500	0.000	0.000					
10	CQ4	CQ4	QUAD	N3Q36	1	416.250	37.500	1.440	1.440	CQ4	0.7500	2.400		
11			DRIFT		0	453.750	33.125	0.000	0.000					
12		AB1	DRIFT		0	486.875	106.250	0.400	0.500					
13			DRIFT		0	593.125	163.750	0.400	0.500					
14		BB3	DRIFT		0	756.875	106.250	0.500	0.600					
15			DRIFT		0	863.125	68.750	0.000	0.000					
16		AP1	DRIFT		0	931.875	122.500	0.000	0.000					
17			DRIFT		0	1054.375	15.500	0.000	0.000					
18		CP1	DRIFT		0	1069.875	122.500	0.000	0.000					
19			DRIFT		0	1192.375	70.024	0.000	0.000					
20		AD2	DRIFT		0	1262.399	96.000	0.630	0.610					
21			DRIFT		0	1358.399	22.191	0.000	0.000					
22		AD3	DRIFT		0	1380.590	96.000	0.000	0.000					
23			DRIFT		0	1476.590	434.038	0.000	0.000					
24	CD2	CD2	RDPOL	5C90T	8	1910.628	91.500	0.000	0.700	CD283	0.3750	1.400		
25			DRIFT		0	2002.128	34.501	0.000	0.000					
26	CD3	CD3	RDPOL	5C90T	8	2036.629	91.500	0.000	0.700	CD283	0.3750	1.400	CD3T	0.1250
27			DRIFT		0	2128.129	24.650	0.000	0.000					
28	CQ5	CQ5	QUAD	4Q16	3	2152.779	17.200	1.690	1.690	CQ588	0.2500	0.406		
29			DRIFT		0	2169.979	124.800	0.000	0.000					
30	CQ6	CQ6	QUAD	4Q16	3	2294.779	17.200	1.690	1.690	CQ687	0.2500	0.406		
31			DRIFT		0	2311.979	6.800	0.000	0.000					
32	CQ7	CQ7	QUAD	4Q16	3	2318.779	17.200	1.690	1.690	CQ687	0.2500	0.406		
33			DRIFT		0	2335.979	124.800	0.000	0.000					
34	CQ8	CQ8	QUAD	4Q16	3	2460.779	17.200	1.690	1.690	CQ588	0.2500	0.406		
35			DRIFT		0	2477.979	229.150	0.000	0.000					
36		CP2	DRIFT		0	2707.129	122.500	0.000	0.000					
37			DRIFT		0	2829.629	248.897	0.000	0.000					
38		BD4	DRIFT		0	3078.526	92.500	0.600	0.750					
39			DRIFT		0	3171.026	256.120	0.000	0.000					
40	CD4	CD4	RDPOL	D121	9	3427.146	123.500	1.000	0.950	CD4	0.3750	1.200		
41			DRIFT		0	3550.646	461.013	0.000	0.000					
42	CQ9	CQ9	QUAD	4Q16	3	4011.659	17.200	1.690	1.690	CQ9	0.0625	0.200		
43			DRIFT		0	4028.859	601.900	0.000	0.000					
44	CQ10	CQ10	QUAD	8Q32	4	4630.759	36.000	0.000	0.000	CQ10	0.3750	1.050		
45			DRIFT		0	4666.759	813.570	0.000	0.000					
46	CQ11	CQ11	QUAD	N3Q36	1	5480.329	37.500	1.440	1.440	CQ11	0.3750	1.425		
47			DRIFT		0	5517.829	84.542	0.000	0.000					
48	CQ12	CQ12	QUAD	N3Q36	1	5602.371	37.500	1.440	1.440	CQ12	0.7500	2.100		
49			DRIFT		0	5639.871	240.155	0.000	0.000					
50		CTGT	DRIFT		0	5880.026	0.000	0.000	0.000					

Figure 10

15-Jul-82 14:06

"C" LINE MAGNETS FROM F13 TO C TARGET

#	ELEMENT NAME	ELEMENT LABEL	MAGNET KIND	MAGNET GROUP	#	EFF.LEN INCH	KG/IN OR KG-IN POWER SERIES COEFFICIENTS FOR I IN KILOAMPS A0	A1	A2	A3	A4	MAX.MAGNET KAMPS
1			DRIFT		0	143.825						
2	CD1	CD1	RDPOL	15C30	-7	34.350	1.6358793E+00	3.0900087E+02	1.5332217E+01	-7.0501699E+00	0.0000000E+00	2.400
3			DRIFT		0	8.075						
4	CQ1	CQ1	QUAD	N3Q36	1	37.500	1.5201630E-02	4.4772430E+00	1.9792940E-01	4.7379500E-02	-9.1596540E-02	2.600
5			DRIFT		0	46.500						
6	CQ2	CQ2	QUAD	N3Q48	2	49.500	1.5201630E-02	4.4772430E+00	1.9792940E-01	4.7379500E-02	-9.1596540E-02	2.600
7			DRIFT		0	20.500						
8	CQ3	CQ3	QUAD	N3Q48	2	49.500	1.5201630E-02	4.4772430E+00	1.9792940E-01	4.7379500E-02	-9.1596540E-02	2.600
9			DRIFT		0	26.500						
10	CQ4	CQ4	QUAD	N3Q36	1	37.500	1.5201630E-02	4.4772430E+00	1.9792940E-01	4.7379500E-02	-9.1596540E-02	2.600
11			DRIFT		0	33.125						
12		AB1	DRIFT		0	106.250						
13			DRIFT		0	163.750						
14		BB3	DRIFT		0	106.250						
15			DRIFT		0	68.750						
16		AP1	DRIFT		0	122.500						
17			DRIFT		0	15.500						
18		CP1	DRIFT		0	122.500						
19			DRIFT		0	70.024						
20		AD2	DRIFT		0	96.000						
21			DRIFT		0	22.191						
22		AD3	DRIFT		0	96.000						
23			DRIFT		0	434.038						
24	CD2	CD2	RDPOL	5C90T	8	91.500	-9.8442070E-02	3.7920254E+02	5.6712130E+01	-2.1529586E+01	0.0000000E+00	3.500
25			DRIFT		0	34.501						
26	CD3	CD3	RDPOL	5C90T	8	91.500	-9.8442070E-02	3.7920254E+02	5.6712130E+01	-2.1529586E+01	0.0000000E+00	3.500
27			DRIFT		0	24.650						
28	CQ5	CQ5	QUAD	4Q16	3	17.200	1.1668710E-02	1.4303190E+01	1.9918540E+01	-8.3568380E+01	6.3286540E+01	0.500
29			DRIFT		0	124.800						
30	CQ6	CQ6	QUAD	4Q16	3	17.200	1.1668710E-02	1.4303190E+01	1.9918540E+01	-8.3568380E+01	6.3286540E+01	0.500
31			DRIFT		0	6.800						
32	CQ7	CQ7	QUAD	4Q16	3	17.200	1.1668710E-02	1.4303190E+01	1.9918540E+01	-8.3568380E+01	6.3286540E+01	0.500
33			DRIFT		0	124.800						
34	CQ8	CQ8	QUAD	4Q16	3	17.200	1.1668710E-02	1.4303190E+01	1.9918540E+01	-8.3568380E+01	6.3286540E+01	0.500
35			DRIFT		0	229.150						
36		CP2	DRIFT		0	122.500						
37			DRIFT		0	248.897						
38		BD4	DRIFT		0	92.500						
39			DRIFT		0	256.120						
40	CD4	CD4	RDPOL	D121	9	123.500	4.3116340E+00	7.3160340E+02	-7.2491390E+02	8.0547750E+02	-3.0467400E+02	1.300
41			DRIFT		0	461.013						
42	CQ9	CQ9	QUAD	4Q16	3	17.200	1.1668710E-02	1.4303190E+01	1.9918540E+01	-8.3568380E+01	6.3286540E+01	0.500
43			DRIFT		0	601.900						
44	CQ10	CQ10	QUAD	8Q32	4	36.000	1.0087900E-03	1.2879310E+00	-4.5792080E-02	3.6950680E-02	-1.1821350E-02	3.300
45			DRIFT		0	813.570						
46	CQ11	CQ11	QUAD	N3Q36	1	37.500	1.5201630E-02	4.4772430E+00	1.9792940E-01	4.7379500E-02	-9.1596540E-02	2.600
47			DRIFT		0	84.542						
48	CQ12	CQ12	QUAD	N3Q36	1	37.500	1.5201630E-02	4.4772430E+00	1.9792940E-01	4.7379500E-02	-9.1596540E-02	2.600
49			DRIFT		0	240.155						
50		CTGT	DRIFT		0	0.000						

Figure 11

```
           *** HELP INFO. FOR TUNING QUADS ***
WHEN REQUESTED  GIVE 0,1,2,3,4,5,6, OR E ;PLOT MADE IF TUNING OK;ALL
         DEVICES ASSUMED CONSTANT EXCEPT THE QUADS.
0 --TYPE 0 AFTER VARYING QUADS--NEW WAIST PARAMETERS WILL BE FOUND
         AFTER READING ALL DEVICES.
E --TYPE E TO LEAVE TUNING MODE.
1 --TYPE 1 -PGM READS "CM%??" WAIST PARAM. & FINDS NEW VALUES OF CQ1-4.
2 --PGM VARYS CQ5&8 AND CQ6&7 TO MAKE CA%HO=-CA%HI AND CA%VO =-CA%VI
3 --PGM READS ALL "CT%??" AND TUNES CQ9-12.
4 --PGM READS ALL "BT%??" AND TUNES BQ9-13.
5 --PGM READS "AT%?Z" AND TUNES AQ7&8 AND AQ9.
6 --PGM READS "UT%??" AND TUNES UQ11-14.

 ***NOTE: IF TUNING OK BUT POW. SUPPLY SATURATED, PLOT MADE BUT VALUES
         TYPED & NOT SENT TO AGAST: *2551* = SATUR. TO TUNE, MAKE
         SMALL CHANGES (LESS THAN  20).
TYPE <CR> TO CONTINUE
```

Figure 12