SSC-N-202

Tracking Study of Momentum Aperture of the SSC CDR Clustered Lattice at a Fixed Betatron Amplitude

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7/3/86

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TRACKING STUDY OF MOMENTUM APERTURE OF THE SSC CDR CLUSTERED LATTICE AT A FIXED BETATRON AMPLITUDE.

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A MOMENTUM SCAN AT A FIXED INITIAL AMPLITUDE - EQUAL TO APPROXIMATEY HALF THE DYNAMIC APERTURE AT $\Delta p/p = 0.0\%$ - HAS BEEN MADE FOR THE SSC CLUSTERED LATTICE HAVING TWO $\beta^* = 0.5$ m AND TWO $\beta^* = 10$ m INSERTIONS. THE AVERAGE TUNE OF BETATRON OSCILLATION AS WELL AS THE SMEAR HAS BEEN DETERMINED IN STEPS OF $\Delta p/p = 0.02\%$ IN THE INTERVAL $-0.12 \leq \Delta p/p \leq +0.12$

MAGNET MULTIPOLES:

1. NO SYSTEMATICS
2. $(\sigma a_n, \sigma b_n) \neq 0$ $2 \leq n \leq 5$ QUADS
3. $(\sigma a_n, \sigma b_n) \neq 0$ $2 \leq n \leq 10$ DIPOLES
4. ASSUMED 90% CORRECTION OF MULTIPOLES IN TRIPLETS Q1-Q

CONDITIONS:

1. CHROMATICITY = 0 IN BOTH PLANE
2. DYNAMIC APERTURE
3. RANDOM SEED #1
4. $\epsilon_x = \epsilon_y$, $(X_i, Y_i) \neq 0$

IN FIG 1 THE SMEAR AS DEFINED BY D. EDWARDS[1] AS WELL AS THE LINEAR TUNES AND THE TUNES DERIVED FROM BETATRON MOTION ARE DISPLAYED AS A FUNCTION OF MOMENTUM $\Delta P/p$.

1.) THE CRITERION OF LINEAR APERTURE BEING DEFINED BY A TUNE SHIFT OF LESS THAN 0.005 IS FULLFILLED IN THE X PLANE FOR $-0.1 \leq \Delta P/p \leq 0.1\%$ AND IS FULLFILLED IN THE INTERVAL $-0.08 \leq \Delta P/p \leq 0.06\%$. IN THE Y PLANE. INTRODUCTION OF A SLIGHT POSITIVE CHROMATICITY IN BOTH PLANES WOULD INCREASE THE MOMENTUM APERTURE SLIGHTLY.

2). THE DETERMINATION OF THE LINEAR APERTURE BY A SMEAR OF ≤ 0.1 GIVES A MOMENTUM APERTURE OF $-0.12 \leq A_{LIN} \leq 0.06\%$. THE SMEAR DUE TO NONLINEAR COUPLING IS INCLUDED IN THE SMEAR CALCULATION. COMPARISON OF THE PHASE PLOTS AT $+0.12$ AND -0.12% IN FIGS 2 AND 3, RESPECTIVELY SHOWS GREATER COUPLING FOR $\Delta P/p > 0$. THIS COUPLING LIMITS THE LINEAR APERTURE.

3). THERE IS VERTICAL DISPERSION IN THE LATTICE THAT DISPLACES THE Y PHASE PLOTS BOTH HORIZONTALLY (Y) AND VERTICALLY. THIS DISPLACEMENT IS SEEN IN FIGS. 2 AND 3. AT $\Delta P/p = 0.0\%$ $\eta_y(QD) = 1.11$ m AND $\eta_y(QF) = 0.50$ m.

REFERENCES

1. D. EDWARDS - FNAL THE FORULATION IS GIVEN BELOW.

a). DETERMINE THE COORDINATES OF THE CLOSED ORBIT X, X', Y, AND Y' FROM THE TRACKING DATA.

$$\bar{Z} = \sum_{i=1}^{TURNS} Z_i / TURNS \qquad \bar{Z}' = \sum_{i=1}^{TURNS} Z_i' / TURNS \quad \text{FOR } Z = X \text{ AND } Y$$

b). DETERMINE THE BETATRON AMPLITUDES ΔX_i, $\Delta X_i'$, ΔY_i, AND $\Delta Y_i'$ RELATIVE TO THE CLOSED ORBIT.

$$\Delta Z_i = Z_i - \bar{Z} \qquad \Delta Z_i' = Z_i' - \bar{Z}' \quad \text{FOR } Z = X \text{ AND } Y.$$

c). DETERMINE THE COURANT-SNYDER INVARIANT W_{Z_i} FOR EACH TURN.

$$W_{Z_i} = \left[\Delta Z_i^2 + (\alpha_Z \Delta Z_i + \beta_Z \Delta Z_i')^2 \right] / \beta_Z \quad \text{FOR } Z = X \text{ AND } Y.$$

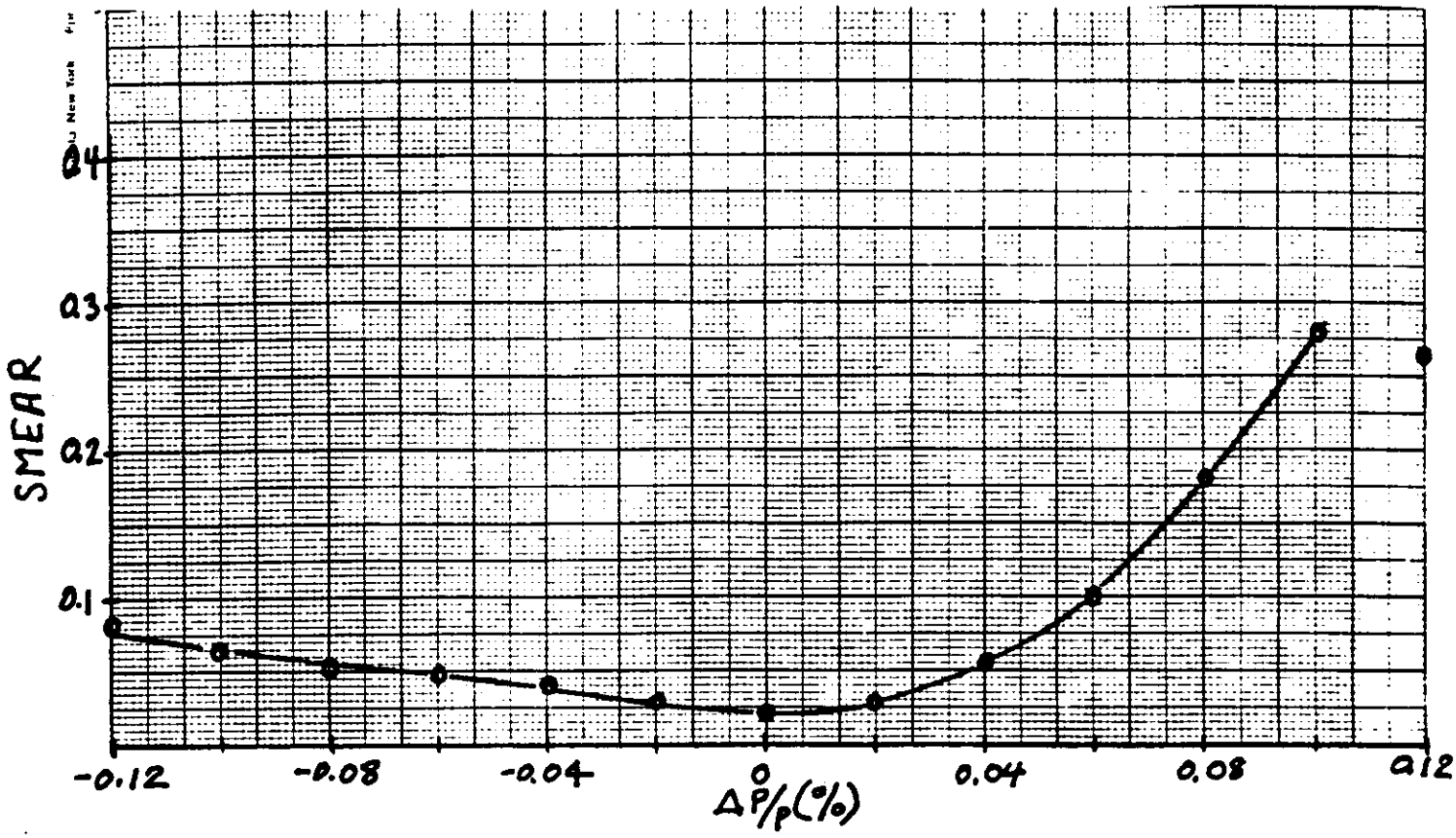
d). DEFINE $P_{Z_i} = W_{Z_i}^{1/2}$, COMPUTE $\bar{P}_Z$, AND DETERMINE $\Delta P_{Z_i} = P_{Z_i} - \bar{P}_Z$ FOR EACH TURN.

e). DETERMINE THE RMS DEVIATION OF THE ΔP_{Z_i}'s

$$\sigma P_Z = \left[\sum_{i=1}^{TURNS} \Delta P_{Z_i}^2 / TURNS \right]^{1/2}$$

f). DETERMINE THE SMEAR DEFINED AS:

$$SMEAR = \left[\frac{\sigma P_x^2 + \sigma P_y^2}{\bar{P}_x^2 + \bar{P}_y^2} \right]^{1/2}$$


SMEAR
0.4
0.3
0.2
0.1
-0.12
-0.08
-0.04
0
0.04
0.08
0.12
ΔP/P(%)

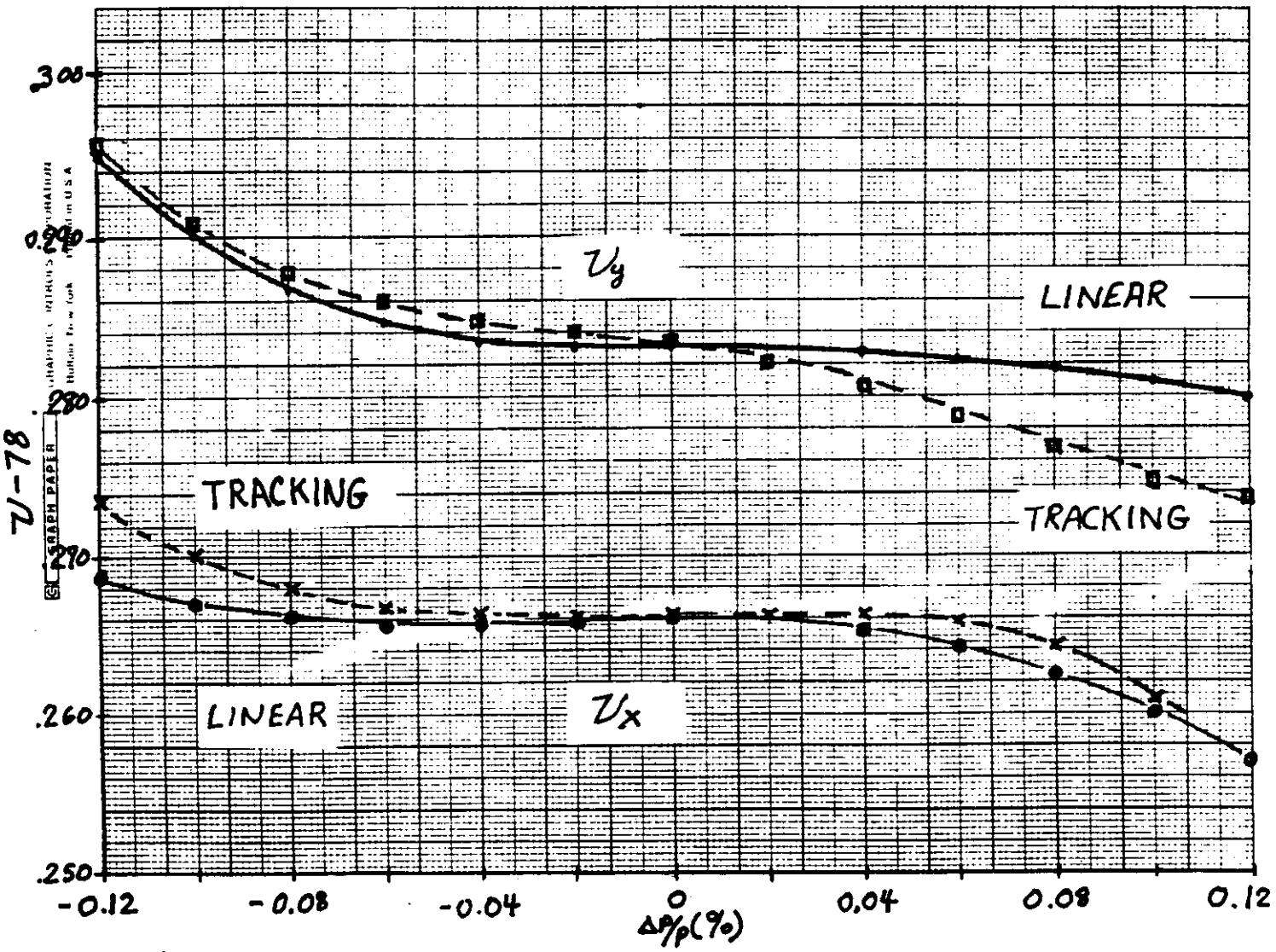
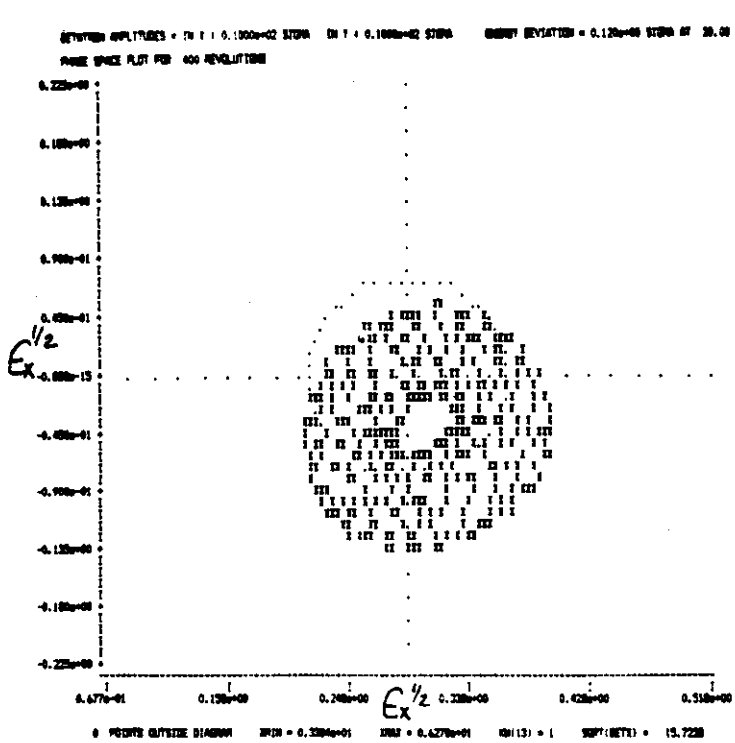
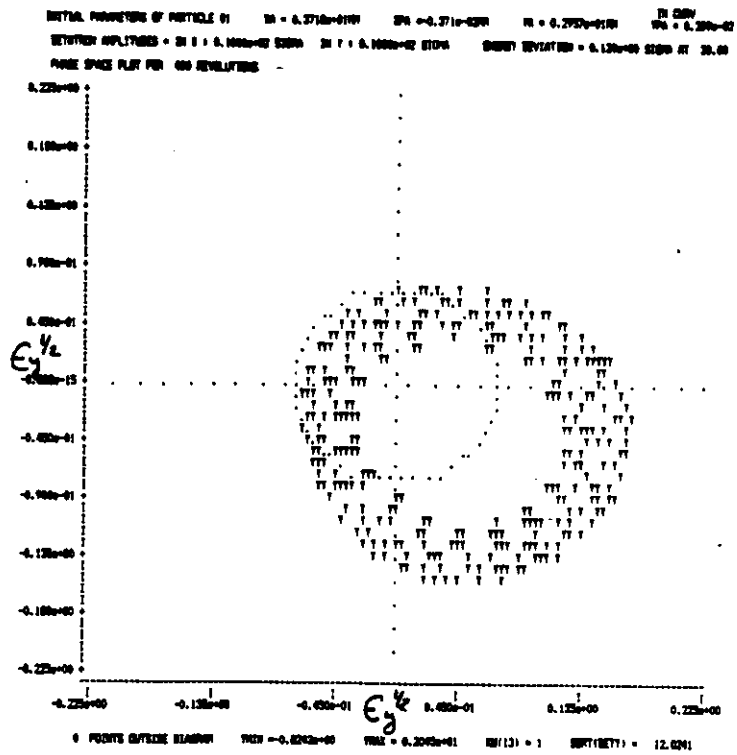

ν-78
.300
.290
.280
.270
.260
.250
ν_y
LINEAR
TRACKING
TRACKING
LINEAR
ν_x
-0.12
-0.08
-0.04
0
0.04
0.08
0.12
ΔP/P(%)

FIG. 1



X PLANE



Y PLANE

$\nu_x = 78.265$, $\nu_y = 78.283$

$(\sigma a_n, \sigma b_n) \neq 0 \quad 2 \leq n \leq 5$ QUADS

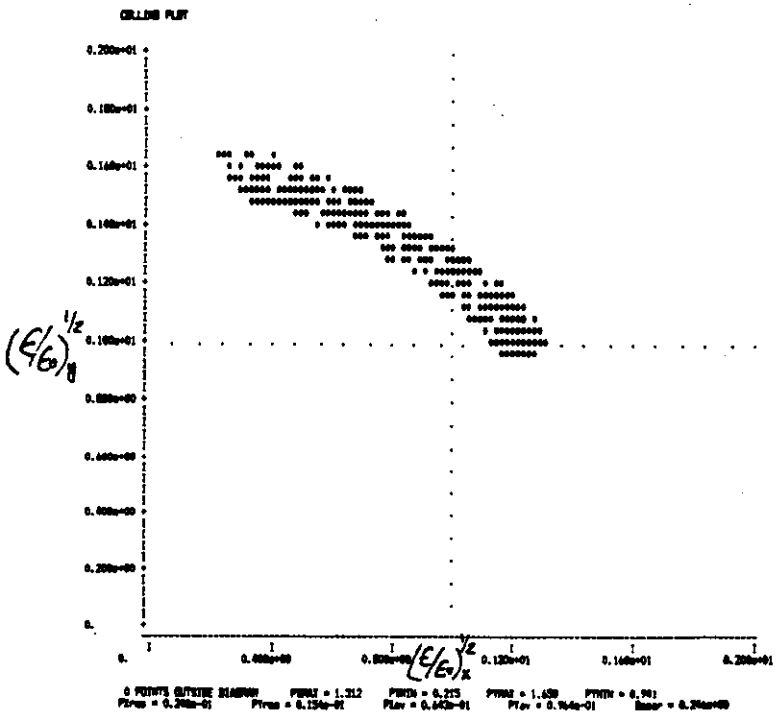
$(\sigma a_n, \sigma b_n) \neq 0 \quad 2 \leq n \leq 10$ DIPOLES.

INITIAL CONDITIONS:

$(X, Y) \neq 0$

$X_i^{QF} = 1.36$ mm , $Y_i^{QF} = 0.787$ mm

400 TURNS $\Delta p/p = 0.12\%$

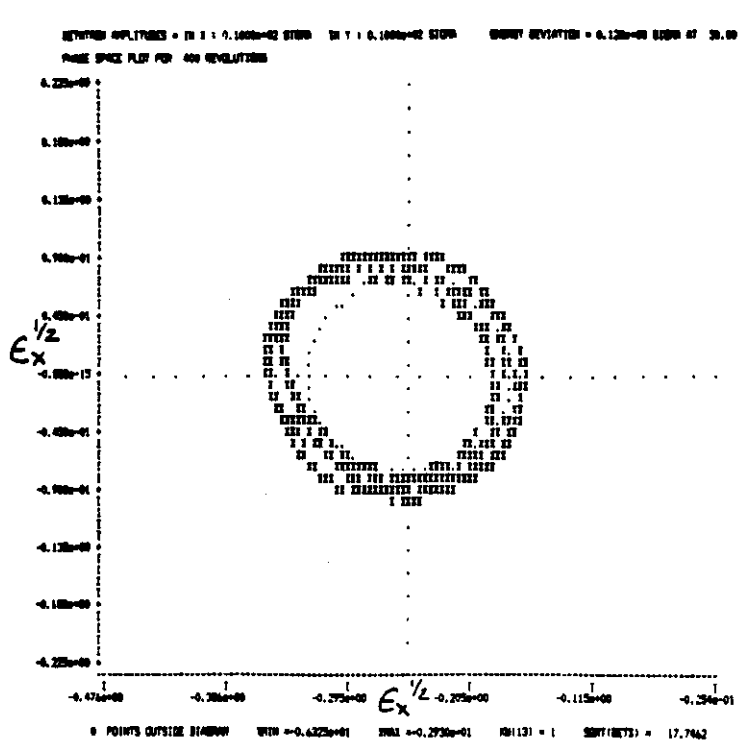


$3.384 \leq X(mm) \leq 6.278$

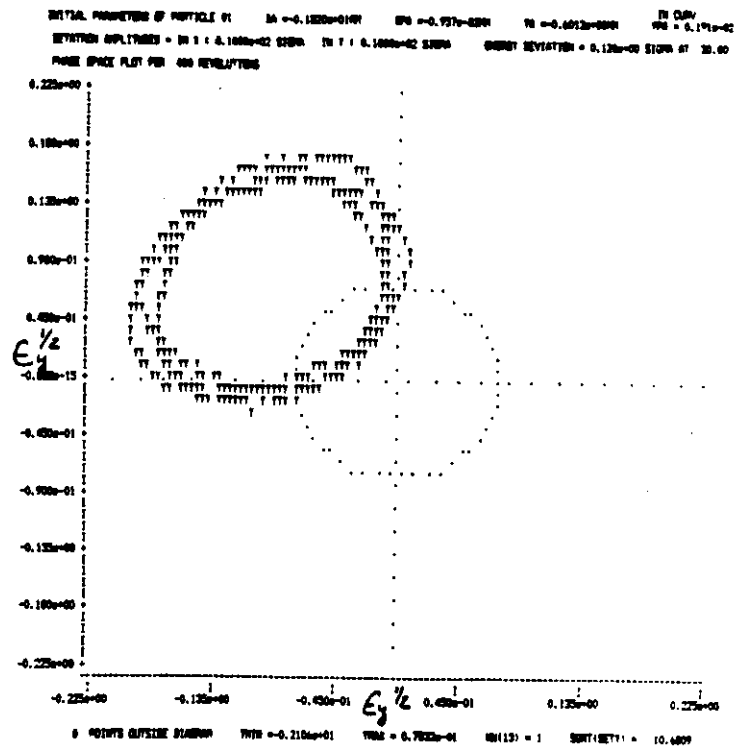
$-0.824 \leq Y(mm) \leq 2.045$

SMEAR = 0.246

FIG. 2



X PLANE



Y PLANE

$\nu_x = 78.265$, $\nu_y = 78.283$

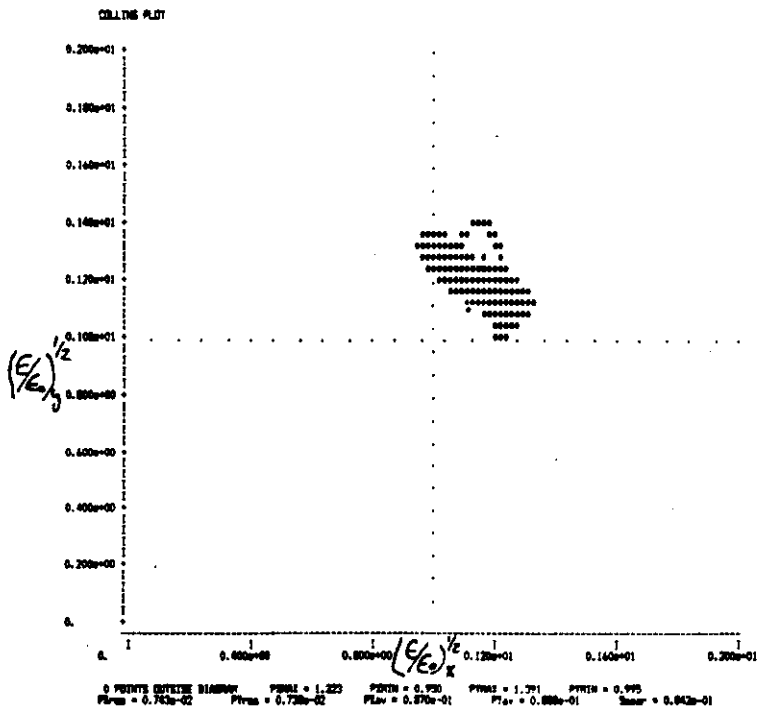
$(\sigma a_n, \sigma b_n) \neq 0 \quad 2 \leq n \leq 5$ QUADS

$(\sigma a_n, \sigma b_n) \neq 0 \quad 2 \leq n \leq 10$ DIPOLES

INITIAL CONDITIONS: $(X,Y) \neq 0$

$X_c^{QF} = 1.36$ mm $\quad Y_c^{QF} = 0.787$ mm

400 TURNS $\Delta p/p = -0.12\%$



$-6.325 \leq X(mm) \leq -2.930$

$-2.106 \leq Y(mm) \leq 0.078$

SMEAR $= 8.4 \cdot 10^{-2}$

FIG. 3