AGS BOOSTER LATTICE
with
THICK LENS SEXTUPOLE

AD

Booster Technical Note
No. 101

Zohreh Parsa
December 11, 1987

ACCELERATOR DEVELOPMENT DEPARTMENT
Brookhaven National Laboratory
Upton, N.Y. 11973

AGS BOOSTER LATTICE
with
THICK LENS SEXTUPOLES

Zohreh Parsa

Accelerator Development Department

Brookhaven National Laboratory

upton, New York 11973

ABSTRACT

This note include some of the results and parameters obtained for the AGS Booster Lattice with eddy current and thick lens chromaticity correction sextupole configuration selected for the Booster. Lattice parameters and the amplitude dependence of tunes are calculated and tabulated. Comparison of Natural chromaticity for the Booster obtained from several Accelerator Physics codes are discussed. Results obtained from Synchrotron Design Program SYNCH and a schematic layout of the lattice are also included. This updates the information in the Booster lattice section of the Design Manual.

I. INTRODUCTION

This note describes the new parameters calculated for the AGS Booster lattice with eddy current and chromaticity correction sextupole configuration 1,2,4,7 selected for the Booster [1]. An over view of the Booster Lattice and its Superperiod structure etc. are given in Ref. [1, 2]; the Booster Geometry and coordinates in Reference [3]; magnet missalignment errors and closed orbit corrections are given in subsequent notes.

Figures 1 and 2 showing the layout of the Booster; and the Booster lattice and components of a superperiod are included For conveniece and clarity. We have used our previous Notation i.e; (ds/s)/(dp/p) is the momentum compaction factor (Alpha); $d\nu/(dp/p)$ is the chromaticity and η is the dispersion. Where the natural chromaticity (no eddy current and no correction sextupoles) for the Booster (obtained from several accelerator codes) is given in the next section.

II. Natural chromaticity

We have calculated the natural chromaticity and the strength for the chromaticity correction sextupoles for the AGS-Booster with several accelerator physics codes including MAD, HARMON, SYNCH, etc. Some of the results presented in this section.

With program MAD (e.g. MAD6 [7]) the chromaticity can be calculated in 3 ways (2 ways with HARMON commands and the third method with MAD itself).

The natural chromaticity (C_x, C_y) calculated for the Booster with (HCHROM) HARMON results in the following values:

$$C_x = -5.36876 \qquad (1)$$
$$C_y = -5.44737$$

Using the 2nd method available in HARMON (HFUNCT) we obtain

$$C_x = -5.09315 \qquad (2)$$
$$C_y = -5.44730$$

The same natural chromaticity values given

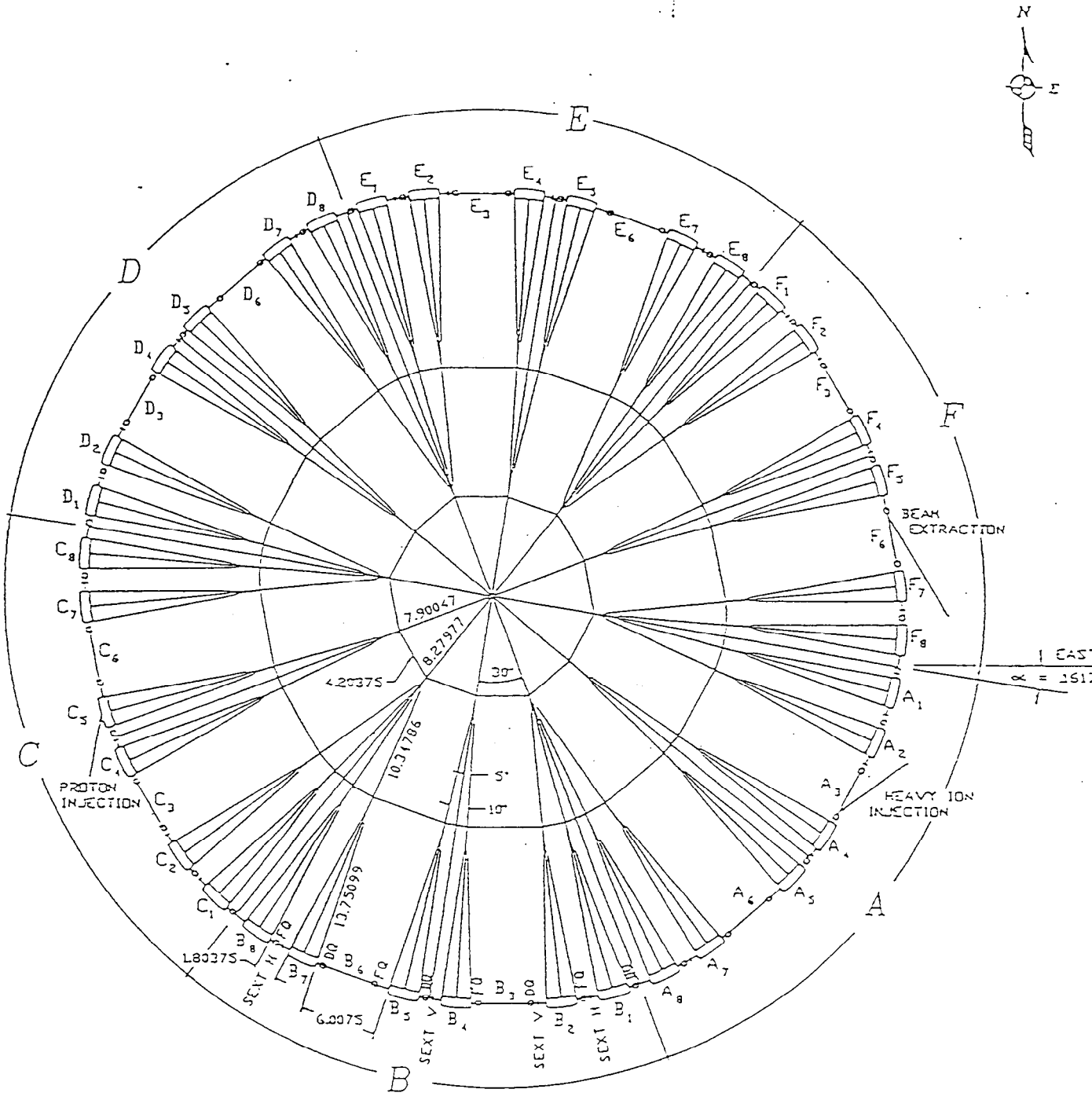

Figure 1. The layout of the Booster.

0 5
METERS
NOTE: ALL DIMENSIONS ARE IN METERS

in Eq. (2) were produced with program PATRICIA [8].

Additionally, with this method we can obtain nonlinear off momentum terms e.g. a_1, a_2, $a_3 \cdots$ and b_1, b_2, $b_3 \cdots$ in eq (3) and (4):

$$\nu_x = \nu_x^0 + a_1\delta + a_2\delta^2 + a_3\delta^3 + \cdots \quad (3)$$

where $a_1 \equiv C_x = -5.09315$

$a_2 = 1.95775$ (sum of two terms)

and $a_3 = 26.2204$ (sum of three terms)

similarly,

$$\nu_y = \nu_y^0 + b_1\delta + a_2\delta^2 + a_3\delta^3 + \cdots \quad (4)$$

Where $b_1 = -5.44730$

$b_2 = 1.33038$ (sum of two terms)

and $b_3 = 34.18545$ (sum of three terms)

where ν_x^0 and ν_y^0 are the initial values and ν_x and ν_y are the tunes at a given δ value.

We can also find the strength of the chromaticity correction sextupole (with HTUNE);

$$S_F = 0.6682058$$
$$S_F = -0.5111498 \qquad (5)$$

The values in Eq. (5) reduces the chromaticity obtained with (HCHROM) HARMON (given in Eq. (1)) to zero, but not the chromaticity values obtained (via 2nd method in HARMON or those obtained) via the third method in MAD, which become

$$C_x = 0.439 \qquad (6)$$

and

$$C_y = 0.18249$$

The differences in the 3 methods of chromaticity calculation used in Program MAD as well as other Programs depends on the methods of integration used to evaluate the integrals across the elements and how the edge effect and fring fields are treated.

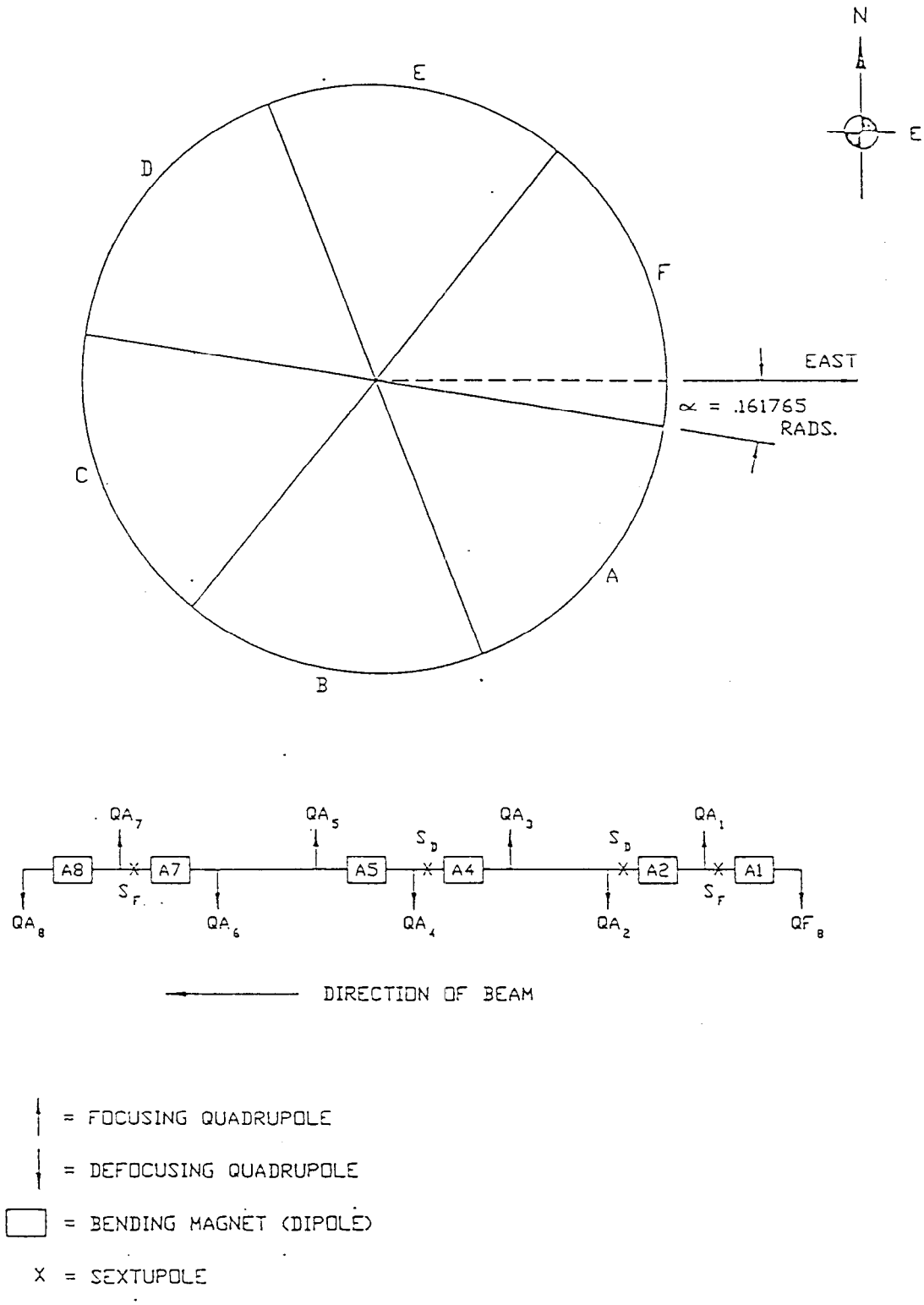

Figure 2. The booster lattice and components of a superperiod.

For example HARMON uses exact integration method across the quadrupole length, other methods may use numerical integration, etc.

Table I, will give the natural chromaticity values obtained from programs MAD (HARMON), PATRICIA and SYNCH.

The chromaticity calculated from these (different) programs may differ due to the differences in the algorithm used in each program.

TABLE I

Natural Chromaticity for the AGS Booster

	C_x	C_y
SYNCH	-4.9297	-5.26488
MAD	-4.929702	-5.264883
HARMON (HCHROM)	-5.36876	-5.44737
HARMON (HFUNC)	-5.09315	-5.44730
PATRICIA	-5.093	-5.447

III. Chromaticity Correction:

In this section we present some of the results obtained with program SYNCH [4]. Betatron functions and the amplitude dependence of tunes for the lattice with eddy current and chromaticity correction sextupole scheme 1, 2, 4, 7 (selected for the Booster) for $dp/p = -.01$ to $+.01$ in increments of $.002$ is given in the Appendix.

Following Parameters are used throughout our calculations; nominal Tunes of $\nu_x = 4.82$ and $\nu_y = 4.83$; eddy current sextupole strengths of 0.12 Tesla (T) per meter (m) square [5]; with $BR = 2.14962$ Tesla meters (for proton at injection energy of 200 MeV). Thus $B''l/BR2$ (called SV in SYNCH) becomes $0.133977168\ m^{-2}$ (with the dipole length $l = 2.4$ m).

We first calculated the natural chromaticity, where there are no eddy current or correcting sextupoles

present (section II). Next we calculate the parameters for the Booster lattice with eddy current sextupole (but no chromaticity correction sextupole), resulting in the chromaticity of

$$C_x = 3.97111$$

$$C_y = -13.09569;$$

momentum compaction factor

$$\alpha = .041970$$

and transition γ value equal to 4.88124. With sextupole correction strength of

$$SF = 0.072967 \ m^{-2}$$

and $$SD = -0.807939 \ m^{-2}.$$

with the amplitude dependence of tunes due to sextupoles as

$$\nu_x = 4.820 - 10.8\,\epsilon_x - 0.291\,\epsilon_y$$

$$\nu_y = 4.830 - 0.291\,\epsilon_x - 87.0\,\epsilon_y$$

(additional parameters are given in the Appendix). These parameters reflect the effect of the eddy current sextupole on the Booster lattice.

Table II(a,b) shows the horizontal and vertical chromaticity C_x and C_y; momentum compaction factor α; horizontal and vertical tunes ν_x and ν_y and γ_t, the transition γ; for the Booster lattice with eddy current and chromaticity correction sextupole 1, 2, 4, 7 configuration (for $\Delta P/P$ of $-.01$ to $+.01$ in 0.002 increments).

Additionally, Tables 1-4, showing the betatron functions and the amplitude dependence of tunes for eddy current sextupoles and the chromaticity correction sextupole schem for $\Delta P/P = -.002, 0, +.002$ (respectively), is included in Appendix A to facilitate the updating of the Booster Design Manual, (where we used our previous conventions for labling these Tables).

Table II (a)

AGS Booster lattice with eddy current and chromaticity correction sextupoles

$\frac{\Delta P}{P}$	C_x	C_y	α
-.010	-.58683	0.37871	0.0399677
-.008	-.46491	0.31062	0.0403852
-.006	-.34530	0.23860	0.0407942
-.004	-.22795	0.16276	0.0411947
-.002	-.11286	0.08318	0.0415867
.000	0.0000	0.0000	0.0419701
.002	0.11065	-0.08668	0.042345
.004	0.21910	-0.17672	0.042713
.006	0.32538	-0.26999	0.043069
.008	0.42948	-0.36635	0.043418
.010	0.53142	-0.46566	0.043758

TABLE II (b)

AGS Booster lattice with eddy current and chromaticity correction sextupoles

$\frac{\Delta P}{P}$	ν_x	ν_z	γ_{tr}
-.010	4.82286	4.82798	5.00202
-.008	4.82182	4.82869	4.97610
-.006	4.82101	4.82925	4.95109
-.004	4.82045	4.82966	4.92696
-.002	4.82011	4.82991	4.90369
.000	4.82000	4.83000	4.88124
.002	4.82011	4.82991	4.85958
.004	4.82043	4.82965	4.83870
.006	4.82096	4.82921	4.81856
.008	4.82170	4.82857	4.79915
.010	4.82263	4.82775	4.78045

REFERENCES

1. Z. Parsa, AGS Booster Geometry and Coordinates; AD-Booster Technical Note No. 100, (November 1987); and Booster Survey and Linear Lattice Parameters with Program MAD; AD-Booster Technical Note No. 99, (November 1987).

2. Z. Parsa, Booster Parameter List, Booster Tech. Note No. 60 and BNL Informal Report BNL-39311; Booster Design Manual;

   Z. Parsa and Eugene Raka, Acceleration Parameters for the AGS Booster; AD-Booster Technical Note 91, (September 17, 1987).

   Y. Y. Lee, BNL Informal Report BNL-34989R, 1985.

3. E. Courant and Z. Parsa, Chromaticity Correction for the AGS Booster with 1,2,4,7 Sextupole Configuration; AD-Booster Tech. Note No. 17, (March 5, 1986).

4. program SYNCH available in BNLDAG::DUA0:[PARSA1.SYNCH]; A.Garren, Principal author, SSC Central Design Group, Berkeley California.

5. G. Morgan and S. Kahn, Booster Technical Note No. 4.

6. M. Donald, D. Schofield, A Users Guide to the HARMON program, Lep Note 420 (1982); M. Donald private communication.

7. F. C. Iselin, Principal author

8. H. Wiedemann, User's Guide for Patricia, PEP Technical Memo PTM-230 (1981); F. Dell, private communication.

* We would like to thank E. Courant and S. Tepikian for discussions and information.

A P P E N D I X A

Some Results obtained from Program SYNCH

For the Booster with $\Delta P/P = -.02, 0, +.02$

TABLE 1 Betatron function and tune amplitude dependence.

No Chromaticity Sextupole

(Eddy current sextupoles: + 0.12 T/m^2 at proton injection.)

circumference =	201.7	m	ν_x =	4.82000
radius =	32.1143	m	ν_y =	4.83000
$d\nu_x/(dp/p)$ =	3.97111		(ds/s)/(dp/p) =	0.041970
$d\nu_y/(dp/p)$ =	-13.09569		trans. γ =	(4.88124, 0.000)

maxima

β_x =	13.86571	β_y =	13.64403
η_{eq} =	2.95145	y_{eq} =	0.00000

minima

β_x =	3.57537	β_y =	3.70334
η_{eq} =	0.54003	y_{eq} =	0.00000

sextupole corrections

$\int k_f \, ds$ = 0.072967 m^{-2}

$\int k_d \, ds$ = -0.807939 m^{-2}

Amplitude dependence of tunes due to sextupoles:

$\nu_x = 4.820 - 10.8\,\epsilon_x - 0.291\,\epsilon_y$ $\qquad d\nu_x/(dp/p) = 0.000$

$\nu_y = 4.830 - 0.291\,\epsilon_x - 87.0\,\epsilon_y$ $\qquad d\nu_y/(dp/p) = 0.000$

TABLE 2 Betatron function and tune amplitude dependence.

Chromaticity Sextupoles at 1,2,4,7 for dp/p = −0.002			
circumference =	201.7631 m	ν_x =	4.82011
radius =	32.1116 m	ν_y =	4.829 91
$d\nu_x/(dp/p)$ =	− 0.11286	(ds/s)/(dp/p) =	0.0415867
$d\nu_y/(dp/p)$ =	0.08318	trans. γ =	4.9036 9
maxima			
β_x =	13.79068	β_y =	13.72901
η_{eq} =	2.95878	y_{eq} =	0.00000
minima			
β_x =	3.56700	β_y =	3.64843
η_{eq} =	0.52348	y_{eq} =	0.00000

Amplitude dependence of tunes due to sextupoles:

$$\nu_x = 4.820111 + 11.1\,\epsilon_x - .0906\,\epsilon_y$$
$$\nu_y = 4.829915 - .0906\,\epsilon_x + 86.5\,\epsilon_y$$

TABLE 3 Betatron function and tune amplitude dependence.

Chromaticity Sextupoles at 1,2,4,7 for dp/p = 0.0000					
circumference =	201.7800	m	ν_x =	4.82000	
radius =	32.1143	m	ν_y =	4.83000	
$d\nu_x/(dp/p)$ =	0.00000		(ds/s)/(dp/p) =	0.0419701	
$d\nu_y/(dp/p)$ =	0.00000		trans. γ =	(4.88124, 0.000)	
maxima					
β_x =	13.86571		β_y =	13.64403	
η_{eq} =	2.95145		y_{eq} =	0.00000	
minima					
β_x =	3.57537		β_y =	3.70334	
η_{eq} =	0.54003		y_{eq} =	0.00000	

Amplitude dependence of tunes due to sextupoles:

$$\nu_x = 4.820 + 10.8\,\epsilon_x - 0.291\,\epsilon_y$$
$$\nu_y = 4.830 - 0.291\,\epsilon_x + 87.0\,\epsilon_y$$

TABLE Betatron function and tune amplitude dependence.

Chromaticity Sextupoles at 1,2,4,7 for dp/p = 0.002				
circumference =	201.70	m	ν_x =	4.82011
radius =	32.1170	m	ν_y =	4.82991
$d\nu_x/(dp/p)$ =	0.11065			
$d\nu_y/(dp/p)$ =	−0.08668			
(ds/s)/(dp/p) =	0.0423450		trans. γ =	(4.85958, 0.000)
maxima				
β_x =	13.94143		β_y =	13.73051
η_{eq} =	2.94398		y_{eq} =	0.00000
minima				
β_x =	3.58368		β_y =	3.64959
η_{eq} =	0.55645		y_{eq} =	0.00000

Amplitude dependence of tunes due to sextupoles:

$$\nu_x = 4.820109 + 10.5\,\epsilon_x - 0.613\,\epsilon_y$$
$$\nu_y = 4.829913 - 0.613\,\epsilon_x + 87.5\,\epsilon_y$$

A P P E N D I X B

Some Results obtained from Program SYNCH

For the Booster with $\Delta P/P = -.01$ to $+ .01$

in .002 increments.

CURRENT VALUES

$\Delta P/P$ = -0.01000

```
_$2$DUA7:[ZOHREH.BOOSTER.COORDS.GEOM.BST.BSTNOV]BSTEND.SYNOUT;2                    1-DEC-1987 13:20

BETATRON FUNCTIONS OF  BSP
POS          S      QX     QY     BX       BY      AX      AY     EX        EXP     EY      EYP        XCO      DXCO     YCO      DYCO
            (M)                   (M)      (M)                    (M)                (M)                (MM)     (MR)     (MM)     (MR)

 CIRCUMFERENCE =    201.6970 M          THETX =   6.28318534 RAD      NUX =    4.82286      DNUX/(DP/P) =   -0.58683
        RADIUS =    32.1011 M          THETY =   0.00000000 RAD      NUY =    4.82798      DNUY/(DP/P) =    0.37871
 (DS/S)/(DP/P)=  0.0399677              TGAM=(   5.00202,   0.00000)

 MAXIMA    --- BETX(   59) =    13.73175    BETY(   22) =    14.09446    XEQ(   45) =    2.98708    YEQ(   68) =    0.00000
 MINIMA    --- BETX(   22) =     3.53280    BETY(   59) =     3.42982    XEQ(    1) =    0.45590    YEQ(   68) =    0.00000
MAXIMA      XCO(   68)=  -4.95567     YCO(   68)=   0.00000
MINIMA      XCO(   45)= -29.56335     YCO(   68)=   0.00000

AMPLITUDE DEPENDENCE OF TUNES DUE TO SEXTUPOLES
NU-X =   4.822861 + 0.125E+02EX  - 0.220E+01EY     DNUX/(DPP/P) =   -0.58683
NU-Y =   4.827977 - 0.220E+01EX  + 0.852E+02EY     DNUY/(DPP/P) =    0.37871
```

CURRENT VALUES

$\Delta P/P$ = -0.00800

```
_$2$DUA7:[ZOHREH.BOOSTER.COORDS.GEOM.BST.BSTNOV]BSTEND.SYNOUT;2                    1-DEC-1987 13:20

BETATRON FUNCTIONS OF  BSP
POS          S      QX     QY     BX       BY      AX      AY     EX        EXP     EY      EYP        XCO      DXCO     YCO      DYCO
            (M)                   (M)      (M)                    (M)                (M)                (MM)     (MR)     (MM)     (MR)

 CIRCUMFERENCE =    201.7133 M          THETX =   6.28318534 RAD      NUX =    4.82182      DNUX/(DP/P) =   -0.46491
        RADIUS =    32.1037 M          THETY =   0.00000000 RAD      NUY =    4.82869      DNUY/(DP/P) =    0.31062
 (DS/S)/(DP/P)=  0.0403852              TGAM=(   4.97610,   0.00000)

 MAXIMA    --- BETX(   59) =    13.68226    BETY(   22) =    13.99963    XEQ(   45) =    2.98012    YEQ(   68) =    0.00000
 MINIMA    --- BETX(   22) =     3.54147    BETY(   59) =     3.48422    XEQ(    1) =    0.47302    YEQ(   68) =    0.00000
MAXIMA      XCO(   68)=  -4.03645     YCO(   68)=   0.00000
MINIMA      XCO(   45)= -23.64345     YCO(   68)=   0.00000

AMPLITUDE DEPENDENCE OF TUNES DUE TO SEXTUPOLES
NU-X =   4.821816 + 0.121E+02EX  - 0.159E+01EY     DNUX/(DPP/P) =   -0.46491
NU-Y =   4.828689 - 0.159E+01EX  + 0.854E+02EY     DNUY/(DPP/P) =    0.31062
```

CURRENT VALUES

$\Delta P/P$ = -0.00600

```
_$2$DUA7:[ZOHREH.BOOSTER.COORDS.GEOM.BST.BSTNOV]BSTEND.SYNOUT;2                    1-DEC-1987 13:20

BETATRON FUNCTIONS OF  BSP
POS          S      QX     QY     BX       BY       AX      AY     EX        EXP     EY      EYP        XCO      DXCO     YCO      DYCO
            (M)                   (M)      (M)                     (M)               (M)                (MM)     (MR)     (MM)     (MR)

 CIRCUMFERENCE =    201.7298 M          THETX =   6.28318534 RAD      NUX =    4.82101      DNUX/(DP/P) =   -0.34530
        RADIUS =    32.1063 M          THETY =   0.00000000 RAD      NUY =    4.82925      DNUY/(DP/P) =    0.23860
 (DS/S)/(DP/P)=  0.0407942              TGAM=(   4.95109,   0.00000)

 MAXIMA     --- BETX(   25) =    13.64283    BETY(   22) =    13.90699    XEQ(   45) =    2.97310    YEQ(   68) =    0.00000
 MINIMA     --- BETX(   22) =     3.55006    BETY(   59) =     3.53882    XEQ(    1) =    0.48998    YEQ(   68) =    0.00000
MAXIMA       XCO(   68)=  -3.08097     YCO(   68)=   0.00000
MINIMA       XCO(   45)= -17.72698     YCO(   68)=   0.00000

AMPLITUDE DEPENDENCE OF TUNES DUE TO SEXTUPOLES
NU-X =   4.821013 + 0.118E+02EX  - 0.103E+01EY     DNUX/(DPP/P) =   -0.34530
NU-Y =   4.829254 - 0.103E+01EX  + 0.857E+02EY     DNUY/(DPP/P) =    0.23860
```

CURRENT VALUES

$\Delta P/P$ = -0.00400

```
_$2$DUA7:[ZOHREH.BOOSTER.COORDS.GEOM.BST.BSTNOV]BSTEND.SYNOUT;2                    1-DEC-1987 13:20

BETATRON FUNCTIONS OF  BSP
POS          S      QX     QY     BX       BY       AX      AY     EX        EXP     EY      EYP        XCO      DXCO     YCO      DYCO
            (M)                   (M)      (M)                     (M)               (M)                (MM)     (MR)     (MM)     (MR)

 CIRCUMFERENCE =    201.7464 M          THETX =   6.28318534 RAD      NUX =    4.82045      DNUX/(DP/P) =   -0.22795
        RADIUS =    32.1089 M          THETY =   0.00000000 RAD      NUY =    4.82966      DNUY/(DP/P) =    0.16276
 (DS/S)/(DP/P)=  0.0411947              TGAM=(   4.92696,   0.00000)

 MAXIMA     --- BETX(   25) =    13.71637    BETY(   22) =    13.81673    XEQ(   45) =    2.96599    YEQ(   68) =    0.00000
 MINIMA     --- BETX(   22) =     3.55857    BETY(   59) =     3.59357    XEQ(    1) =    0.50680    YEQ(   68) =    0.00000
MAXIMA       XCO(   68)=  -2.08955     YCO(   68)=   0.00000
MINIMA       XCO(   45)= -11.81409     YCO(   68)=   0.00000

AMPLITUDE DEPENDENCE OF TUNES DUE TO SEXTUPOLES
NU-X =   4.820447 + 0.115E+02EX  - 0.531E+00EY     DNUX/(DPP/P) =   -0.22795
NU-Y =   4.829664 - 0.531E+00EX  + 0.861E+02EY     DNUY/(DPP/P) =    0.16276
```

CURRENT VALUES

ΔP/P = -0.00200

```
_$2$DUA7:[ZOHREH.BOOSTER.COORDS.GEOM.BST.BSTNOV]BSTEND.SYNOUT;2                    1-DEC-1987 13:20

BETATRON FUNCTIONS OF  BSP
POS          S      QX     QY     BX       BY      AX     AY     EX       EXP    EY     EYP       XCO     DXCO     YCO     DYCO
            (M)                  (M)      (M)                    (M)              (M)              (MM)    (MR)     (MM)    (MR)

 CIRCUMFERENCE =    201.7631 M          THETX =   6.28318534 RAD      NUX =    4.82011      DNUX/(DP/P) =   -0.11286
        RADIUS =    32.1116 M          THETY =   0.00000000 RAD      NUY =    4.82991      DNUY/(DP/P) =    0.08318
 (DS/S)/(DP/P)=  0.0415867              TGAM=(   4.90369,   0.00000)

 MAXIMA    --- BETX(   25) =    13.79068    BETY(   22) =    13.72901    XEQ(   45) =    2.95878    YEQ(   68) =    0.00000
 MINIMA    --- BETX(   22) =     3.56700    BETY(   59) =     3.64843    XEQ(    1) =    0.52348    YEQ(   68) =    0.00000
MAXIMA      XCO(   68)=  -1.06246     YCO(   68)=   0.00000
MINIMA      XCO(   45)=  -5.90502     YCO(   68)=   0.00000

AMPLITUDE DEPENDENCE OF TUNES DUE TO SEXTUPOLES
NU-X =   4.820111 + 0.111E+02EX  - 0.906E-01EY     DNUX/(DPP/P) =   -0.11286
NU-Y =   4.829915 - 0.906E-01EX  + 0.865E+02EY     DNUY/(DPP/P) =    0.08318
```

CURRENT VALUES

ΔP/P = 0.00000

```
_$2$DUA7:[ZOHREH.BOOSTER.COORDS.GEOM.BST.BSTNOV]BSTEND.SYNOUT;2                    1-DEC-1987 13:20

BETATRON FUNCTIONS OF  BSP
POS          S      QX     QY     BX       BY      AX     AY     EX       EXP    EY     EYP       XCO     DXCO     YCO     DYCO
            (M)                  (M)      (M)                    (M)              (M)              (MM)    (MR)     (MM)    (MR)

 CIRCUMFERENCE =    201.7800 M          THETX =   6.28318534 RAD      NUX =    4.82000      DNUX/(DP/P) =    0.00000
        RADIUS =    32.1143 M          THETY =   0.00000000 RAD      NUY =    4.83000      DNUY/(DP/P) =    0.00000
 (DS/S)/(DP/P)=  0.0419701              TGAM=(   4.88124,   0.00000)

 MAXIMA    --- BETX(   25) =    13.86571    BETY(   68) =    13.64403    XEQ(   45) =    2.95145    YEQ(   68) =    0.00000
 MINIMA    --- BETX(   22) =     3.57537    BETY(   45) =     3.70334    XEQ(   68) =    0.54003    YEQ(   68) =    0.00000
MAXIMA      XCO(    1)=   0.00000     YCO(   68)=   0.00000
MINIMA      XCO(   45)=   0.00000     YCO(   68)=   0.00000

AMPLITUDE DEPENDENCE OF TUNES DUE TO SEXTUPOLES
NU-X =   4.820000 + 0.108E+02EX  + 0.291E+00EY     DNUX/(DPP/P) =    0.00000
NU-Y =   4.829999 + 0.291E+00EX  + 0.870E+02EY     DNUY/(DPP/P) =    0.00000
```

```
CURRENT VALUES
      ΔP/P        =    0.00200
.......................................................................................................................

_$2$DUA7:[ZOHREH.BOOSTER.COORDS.GEOM.BST.BSTNOV]BSTEND.SYNOUT;2                    1-DEC-1987 13:20

BETATRON FUNCTIONS OF  BSP
POS          S      QX     QY     BX       BY       AX      AY     EX        EXP     EY      EYP        XCO      DXCO     YCO      DYCO
            (M)                   (M)      (M)                     (M)               (M)                (MM)     (MR)     (MM)     (MR)

 CIRCUMFERENCE =    201.7970 M          THETX =   6.28318534 RAD      NUX =    4.82011      DNUX/(DP/P) =    0.11065
        RADIUS =    32.1170 M          THETY =   0.00000000 RAD      NUY =    4.82991      DNUY/(DP/P) =   -0.08668
 (DS/S)/(DP/P)=  0.0423450              TGAM=(   4.85958,   0.00000)

 MAXIMA    --- BETX(   25) =    13.94143    BETY(   68) =    13.73051    XEQ(   45) =    2.94398    YEQ(   68) =    0.00000
 MINIMA    --- BETX(   22) =     3.58368    BETY(   25) =     3.64959    XEQ(   68) =    0.55645    YEQ(   68) =    0.00000
MAXIMA      XCO(   45)=   5.90067     YCO(   68)=   0.00000
MINIMA      XCO(    1)=   1.09757     YCO(   68)=   0.00000

AMPLITUDE DEPENDENCE OF TUNES DUE TO SEXTUPOLES
NU-X =   4.820109 + 0.105E+02EX  + 0.613E+00EY     DNUX/(DPP/P) =    0.11065
NU-Y =   4.829913 + 0.613E+00EX  + 0.875E+02EY     DNUY/(DPP/P) =   -0.08668
.......................................................................................................................

CURRENT VALUES
      ΔP/P        =    0.00400
.......................................................................................................................

_$2$DUA7:[ZOHREH.BOOSTER.COORDS.GEOM.BST.BSTNOV]BSTEND.SYNOUT;2                    1-DEC-1987 13:20

BETATRON FUNCTIONS OF  BSP
POS          S      QX     QY     BX       BY       AX      AY     EX        EXP     EY      EYP        XCO      DXCO     YCO      DYCO
            (M)                   (M)      (M)                     (M)               (M)                (MM)     (MR)     (MM)     (MR)

 CIRCUMFERENCE =    201.8141 M          THETX =   6.28318534 RAD      NUX =    4.82043      DNUX/(DP/P) =    0.21910
        RADIUS =    32.1197 M          THETY =   0.00000000 RAD      NUY =    4.82965      DNUY/(DP/P) =   -0.17672
 (DS/S)/(DP/P)=  0.0427113              TGAM=(   4.83870,   0.00000)

 MAXIMA    --- BETX(   25) =    14.01782    BETY(   68) =    13.81937    XEQ(   45) =    2.93635    YEQ(   68) =    0.00000
 MINIMA    --- BETX(   22) =     3.59194    BETY(   25) =     3.59552    XEQ(   68) =    0.57275    YEQ(   68) =    0.00000
MAXIMA      XCO(   45)=  11.79668     YCO(   68)=   0.00000
MINIMA      XCO(    1)=   2.23000     YCO(   68)=   0.00000

AMPLITUDE DEPENDENCE OF TUNES DUE TO SEXTUPOLES
NU-X =   4.820432 + 0.102E+02EX  + 0.876E+00EY     DNUX/(DPP/P) =    0.21910
NU-Y =   4.829650 + 0.876E+00EX  + 0.881E+02EY     DNUY/(DPP/P) =   -0.17672
.......................................................................................................................
```

```
CURRENT VALUES
        ΔP/P     =     0.00600
.......................................................................................................................

_$2$DUA7:[ZOHREH.BOOSTER.COORDS.GEOM.BST.BSTNOV]BSTEND.SYNOUT;2                    1-DEC-1987 13:20

BETATRON FUNCTIONS OF  BSP
POS          S      QX     QY     BX       BY      AX      AY     EX        EXP     EY      EYP          XCO      DXCO     YCO      DYCO
            (M)                   (M)      (M)                    (M)               (M)                  (MM)     (MR)     (MM)     (MR)

 CIRCUMFERENCE =     201.8314 M          THETX =   6.28318534 RAD      NUX =     4.82096      DNUX/(DP/P) =     0.32538
        RADIUS =     32.1225 M          THETY =   0.00000000 RAD      NUY =     4.82921      DNUY/(DP/P) =    -0.26999
 (DS/S)/(DP/P)=  0.0430690               TGAM=(   4.81856,   0.00000)

 MAXIMA     --- BETX(    25) =     14.09483    BETY(    68) =     13.91043     XEQ(    45) =     2.92855     YEQ(    68) =     0.00000
 MINIMA     --- BETX(    22) =      3.60017    BETY(    25) =      3.54120     XEQ(    68) =     0.58893     YEQ(    68) =     0.00000
MAXIMA       XCO(    45)=  17.68766     YCO(    68)=   0.00000
MINIMA       XCO(     1)=   3.39702     YCO(    68)=   0.00000

AMPLITUDE DEPENDENCE OF TUNES DUE TO SEXTUPOLES
NU-X =    4.820964 + 0.990E+01EX   + 0.108E+01EY     DNUX/(DPP/P) =     0.32538
NU-Y =    4.829205 + 0.108E+01EX   + 0.888E+02EY     DNUY/(DPP/P) =    -0.26999
.......................................................................................................................

CURRENT VALUES
        ΔP/P     =     0.00800
.......................................................................................................................

_$2$DUA7:[ZOHREH.BOOSTER.COORDS.GEOM.BST.BSTNOV]BSTEND.SYNOUT;2                    1-DEC-1987 13:20

BETATRON FUNCTIONS OF  BSP
POS          S      QX     QY     BX       BY      AX      AY     EX        EXP     EY      EYP          XCO      DXCO     YCO      DYCO
            (M)                   (M)      (M)                    (M)               (M)                  (MM)     (MR)     (MM)     (MR)

 CIRCUMFERENCE =     201.8487 M          THETX =   6.28318534 RAD      NUX =     4.82170      DNUX/(DP/P) =     0.42948
        RADIUS =     32.1252 M          THETY =   0.00000000 RAD      NUY =     4.82857      DNUY/(DP/P) =    -0.36635
 (DS/S)/(DP/P)=  0.0434181               TGAM=(   4.79915,   0.00000)

 MAXIMA     --- BETX(    25) =     14.17245    BETY(     1) =     14.00352     XEQ(    45) =     2.92056     YEQ(    68) =     0.00000
 MINIMA     --- BETX(    48) =      3.59259    BETY(    25) =      3.48665     XEQ(     1) =     0.60499     YEQ(    68) =     0.00000
MAXIMA       XCO(    45)=  23.57323     YCO(    68)=   0.00000
MINIMA       XCO(    68)=   4.59841     YCO(    68)=   0.00000

AMPLITUDE DEPENDENCE OF TUNES DUE TO SEXTUPOLES
NU-X =    4.821699 + 0.960E+01EX   + 0.122E+01EY     DNUX/(DPP/P) =     0.42948
NU-Y =    4.828574 + 0.122E+01EX   + 0.895E+02EY     DNUY/(DPP/P) =    -0.36635
.......................................................................................................................
```

```
CURRENT VALUES
        ΔP/P    =     Ø.Ø1ØØØ
.......................................................................................................................

_$2$DUA7:[ZOHREH.BOOSTER.COORDS.GEOM.BST.BSTNOV]BSTEND.SYNOUT;2                          1-DEC-1987 13:2Ø

BETATRON FUNCTIONS OF  BSP
POS          S      QX     QY      BX       BY       AX      AY     EX        EXP     EY      EYP          XCO      DXCO     YCO      DYCO
            (M)                   (M)      (M)                      (M)               (M)                  (MM)     (MR)     (MM)     (MR)

 CIRCUMFERENCE =     2Ø1.8662 M          THETX =    6.28318534 RAD      NUX =     4.82263      DNUX/(DP/P) =     Ø.53142
        RADIUS =     32.128Ø M          THETY =    Ø.ØØØØØØØØ RAD      NUY =     4.82775      DNUY/(DP/P) =    -Ø.46566
 (DS/S)/(DP/P)=  Ø.Ø437585               TGAM=(    4.78Ø45,    Ø.ØØØØØ)

 MAXIMA     --- BETX(    25) =     14.25Ø64    BETY(     1) =     14.Ø9846     XEQ(    45) =     2.91238     YEQ(    68) =     Ø.ØØØØØ
 MINIMA     --- BETX(    48) =      3.5838Ø    BETY(    25) =      3.43194     XEQ(     1) =     Ø.62Ø95     YEQ(    68) =     Ø.ØØØØØ
MAXIMA       XCO(    45)=  29.45296     YCO(    68)=   Ø.ØØØØØ
MINIMA       XCO(    68)=   5.83393     YCO(    68)=   Ø.ØØØØØ

AMPLITUDE DEPENDENCE OF TUNES DUE TO SEXTUPOLES
NU-X =    4.822632 + Ø.931E+Ø1EX   + Ø.131E+Ø1EY     DNUX/(DPP/P) =     Ø.53142
NU-Y =    4.827753 + Ø.131E+Ø1EX   + Ø.9Ø3E+Ø2EY     DNUY/(DPP/P) =    -Ø.46566
.......................................................................................................................
     ...,....1....,....2....,....3....,....4....,....5....,....6....,....7....,....8


=======================================================================================================================
END OF SYNCH RUN  BST
```

Page 27