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The Booster Lattice

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THE BOOSTER LATTICE

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ABSTRACT

THIS NOTE DESCRIBES THE AGS-BOOSTER LATTICE, ITS SUPERPERIODS AND THEIR COMPONENTS. RESULTS OBTAINED FROM THE SYNCHROTRON DESIGN PROGRAM SYNCH ARE ALSO INCLUDED.

INTRODUCTION:

The AGS Booster is designed to be an intermediate synchrotron injector for the AGS, capable of accelerating Protons and Heavy Ions.

Specifications call for the Booster to accelerate protons from 200 MeV, the Linac operating energy to 1 GeV, (with the possibility of an upgrade to 2.5 GeV).

As presently designed, the Booster will have a circumference equal to one quarter that of AGS [ref1]. It will be capable of accelerating protons to 1 GeV at 10 Hz repetition rate and Heavy Ions to magnetic rigidity equal to 16.7 Tesla-Meter at a 1 Hz repetition rate.

The Booster will have a FODO lattice with bending magnets missing in some cells. The dipoles of the proposed lattice have an aperture of 3.25" x 10" and injection field of about 1.6 KG (.7 KG for Heavy Ions). Magnetic field cycle requirements are 4 KG at 10 Hz rate for 1 GeV protons and 12 KG at 1 Hz rate for Heavy Ions. Amplitude (BETAX, BETAY) and Dispersion functions of the lattice obtained from our SYNCH run are shown in Figure 3.

In total, the Booster will have 36 dipoles, each of 2.4 meter magnetic length, and 48 quadrupoles each of 0.50375 meter magnetic length. For maximum tuning versatility the dipoles and the quadrupoles will be independently powered.

The space needed for RF acceleration, injection, ejection and abort system is provided by omitting some bending magnets from the FODO structure focusing without otherwise interupting the periodicity. We have chosen a "seperated function" structure with quadrupoles and zero-gradiant dipoles.

This specific lattice structure consists of six identical superperiods, designated A to F, with each superperiod containing:

two full cells with bending magnets;
one empty half cell [bending magnet omitted];
two full cells;
one empty half cell;
two full cells;

as shown in Figure 2.

There is also a one meter free space on one side of each quadrupole which can be utilized for chromoticity - correcting sextupoles and other correcting and monitoring devices. The choice of sextupole and corrector layouts will be discussed in a subsequent report.

I. SUPERPERIOD STRUCTURE

The AGS-Booster lattice has six superperiods, with the structure formula written symbolically for a complete superperiod as

S = D b F b D n F b D b F n D b F b

where the components of the superperiod are the following:

D - Defocusing quadrupoles (0.50375 meters)

F - Focuing quadrupoles (0.50375 meters)

0 - Drift space (1 meter)

o - Drift space (.3 meters)

N - Drift space (2.4 meters), [section with no magnet]

B - Dipole (bending) magnet (2.4 meters)

b - oB0

n - oN0 Drift space (3.7 meters)

Booster coordinates and parameter list are given in references 2 and 3. Here we show the geometrical layout, global labeling and the lattice functions.

Figure 1, shows the overall layout of the Booster ring including the locations and directions of proton (p) injection (at C6), Heavy Ion (H.I.) injection (at A3) and beam extraction (at F6). In addition, we have shown the global labeling of the lattice divided into six super- periods (with the clockwise Beam direction) starting from the AF junction which is located 0.161764 Radians South of East with respect to the center of the Booster.

A schematic diagram of the lattice and components of the superperiod are illustrated in Figure 2. There the Focusing Quadrupoles (↑), Defocusing Quadrupoles (↓), Bending Magnets (Dipoles □), and two families of sextupoles (X) SF (Focusing) and SD (Defocusing) are shown. In this scheme we have included four sextupoles for illustration purposes only, (the actual number of sextupoles is still under study).

References:

1. The proposed parameters were all obtained from Y.Y. Lee, private Communications; AGS Booster Conceptual Design Report, Vol. I, (April 1984).

2. Booster Coordinates, Booster Tech. Note No. 3 Z. Parsa , G.F. Dell (January 1986)

3. Booster Parameter List, Booster Tech. Note No.2, Z. Parsa, (January 1986).

4. Calculation of Eddy Currents, Booster Tech. Note No. 4, G. Morgan and S. Kahn, (January 1986).

SECTION II

In this section we give a summary of the parameters obtained from program SYNCH using:

DUA0:[PARSA1.BOOSTER]SYNBOOST.DAT

as input.

In addition we have included a copy of our result in the Appendix.

Tables I, II, and III shows the Betatron functions and the Amplitude dependence of tunes for linear lattice, Eddy Current sextupoles and correction sextupoles 1,2,4,7 (illustrated in Figure 2) respectively.

We note that; Eddy Current sextupole strengths are taken to be 0.12 Tesla per meter square [4], at 200 MeV Proton injection energy (in all dipoles); and in case III, correction sextupoles are added (to Eddy Current sextupoles) to make the overall chromaticity zero. Alternate sextupole configurations will be discussed in subsequent notes.

TABLE I

1BETATRON FUNCTIONS OF BSP (Linear lattice)

CIRCUMFERENCE = 201.7800 M
RADIUS = 32.1143 M

THETX =	6.28318532 RAD	NUX =	4.75000
THETY =	0.00000000 RAD	NUY =	4.75000
DNUX/(DP/P) =	-4.80824	(DS/S)/(DP/P) =	.0434943
DNUY/(DP/P) =	-5.13813	TGAM =	(4.79495, 0.00000)

MAXIMA --- BETX(13) =	13.87963	BETY(36) =	13.67106
MINIMA --- BETX(10) =	3.66905	BETY(23) =	3.80459

XEQ(23) =	2.93871	YEQ(36) =	0.00000
XEQ(1) =	.60721	YEQ(36) =	0.00000

TABLE II

1BETATRON FUNCTIONS OF BS2 (No chromaticity sextupoles)

CIRCUMFERENCE = 201.7800 M
RADIUS = 32.1143 M

THETX = 6.28318532 RAD NUX = 4.75000
THETY = 0.00000000 RAD NUY = 4.75000

DNUX/(DP/P) = 4.54397 (DS/S)/(DP/P) = .0434943
DNUY/(DP/P) = -13.39855 TGAM = (4.79495, 0.00000)

MAXIMA --- BETX(17) = 13.87963 BETY(52) = 13.67106
MINIMA --- BETX(14) = 3.66905 BETY(35) = 3.80459

XEQ(35) = 2.93871 YEQ(52) = 0.00000
XEQ(1) = .60721 YEQ(52) = 0.00000

AMPLITUDE DEPENDENCE OF TUNES DUE TO SEXTUPOLES

NU-X = 4.750000 - .236E+02EX + .112E+02EY
NU-Y = 4.750000 + .112E+02EX - .200E+02EY

TABLE III

1BETATRON FUNCTIONS OF B4C (Chrom. sext. at 1,2,4,7)

CIRCUMFERENCE = 201.7800 M
RADIUS = 32.1143 M

THETX = 6.28318532 RAD NUX = 4.75000
THETY = 0.00000000 RAD NUY = 4.75000

DNUX/(DP/P) = -.00000 (DS/S)/(DP/P) = .0434943
DNUY/(DP/P) = .00000 TGAM = (4.79495, 0.00000)

MAXIMA --- BETX(21) = 13.87963 BETY(56) = 13.67106
MINIMA --- BETX(18) = 3.66905 BETY(9) = 3.80459

XEQ(37) = 2.93871 YEQ(56) = 0.00000
XEQ(1) = .60721 YEQ(56) = 0.00000

SEXTUPOLE CORRECTIONS

KSF = .35878577E-01 KSD = -.80131487E+00

AMPLITUDE DEPENDENCE OF TUNES DUE TO SEXTUPOLES

NU-X = 4.750000 + .883E+01EX + .651E+00EY
NU-Y = 4.750000 + .651E+00EX + .808E+02EY

Acknowledgements:

We wish to thank members of the Booster Lattice Design Study Group: A. Antillon, D. Barton, J. Claus, G. Danby, G. Dell, E. Forsyth, R. Gupta, J. Kats, S. Y. Lee, Y. Y. Lee G. Morgan, G. Parzen, E. C. Raka, R. Rau, S. Tepikian, X. Zhao and Ms. K. Brown for our drawings.

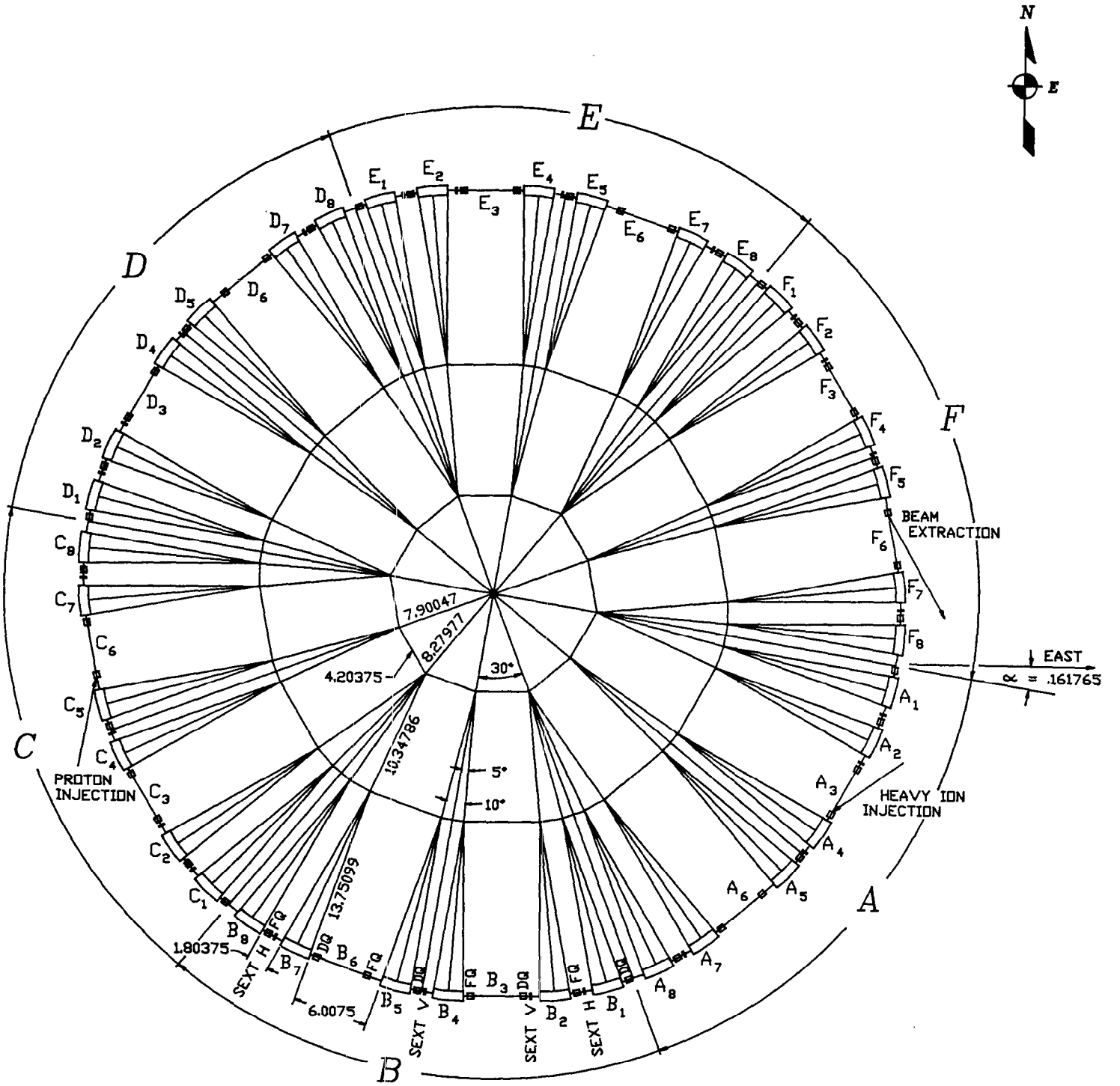
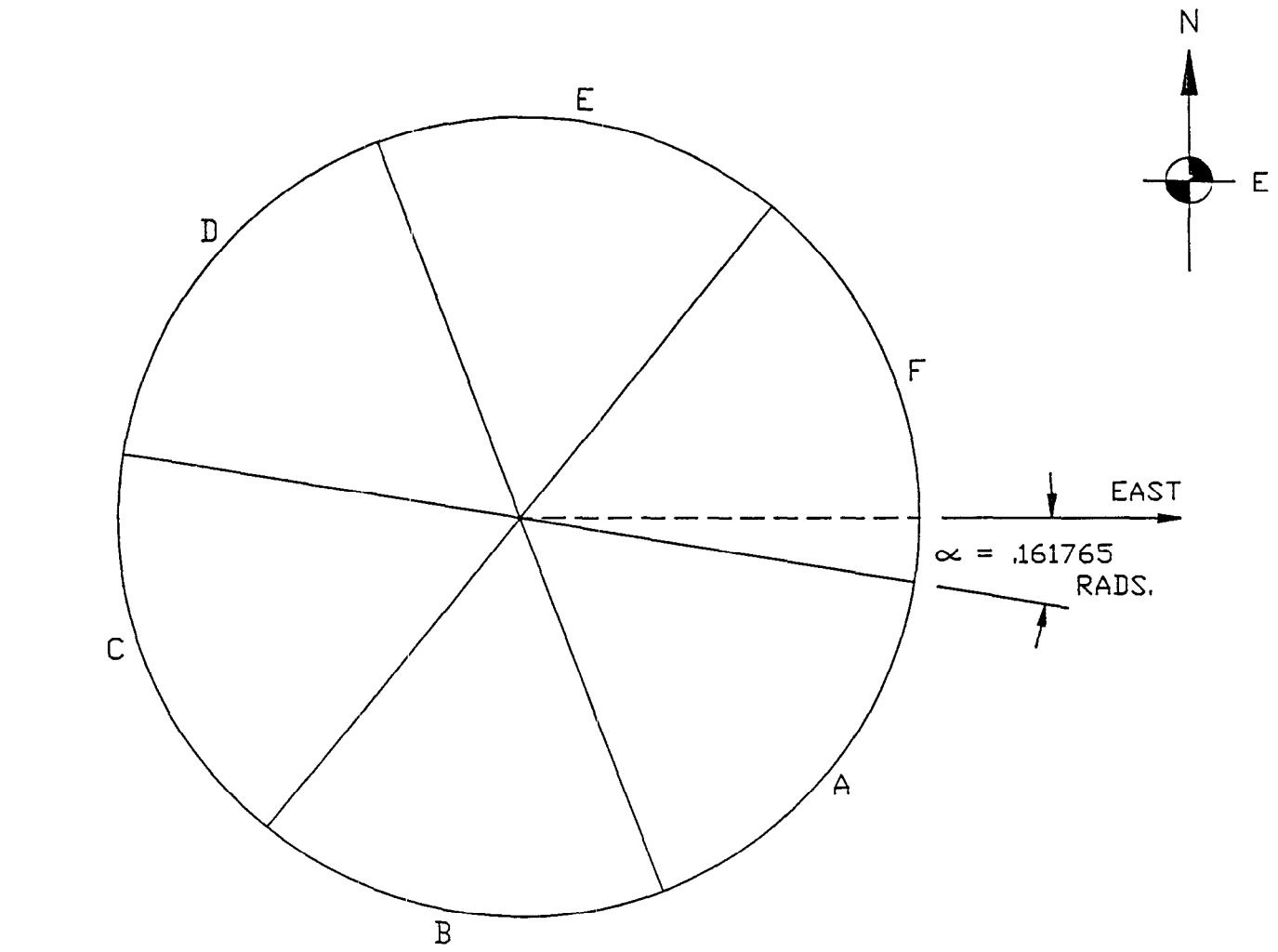
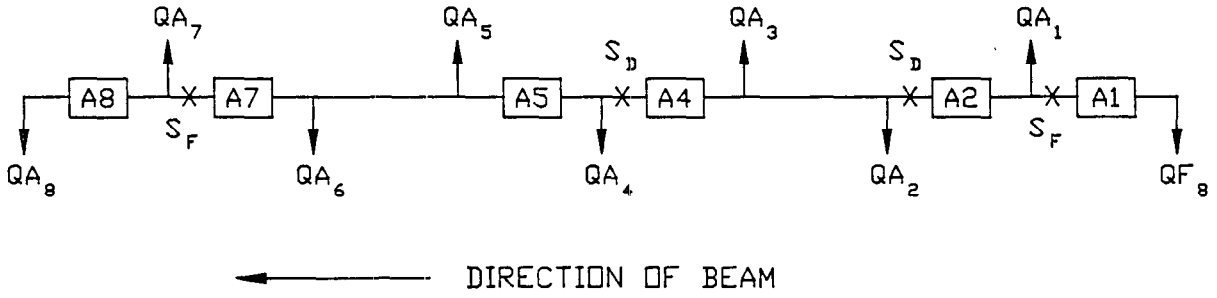


Fig. 1 Overall Layout of the Booster

0 5
METERS
NOTE: ALL DIMENSIONS ARE IN METERS





= FOCUSING QUADRUPOLE

= DEFOCUSING QUADRUPOLE

= BENDING MAGNET (DIPOLE)

X = SEXTUPOLE

FIG. 2 a) Schematic Diagram of the Booster and
b) Components of the Superperiod

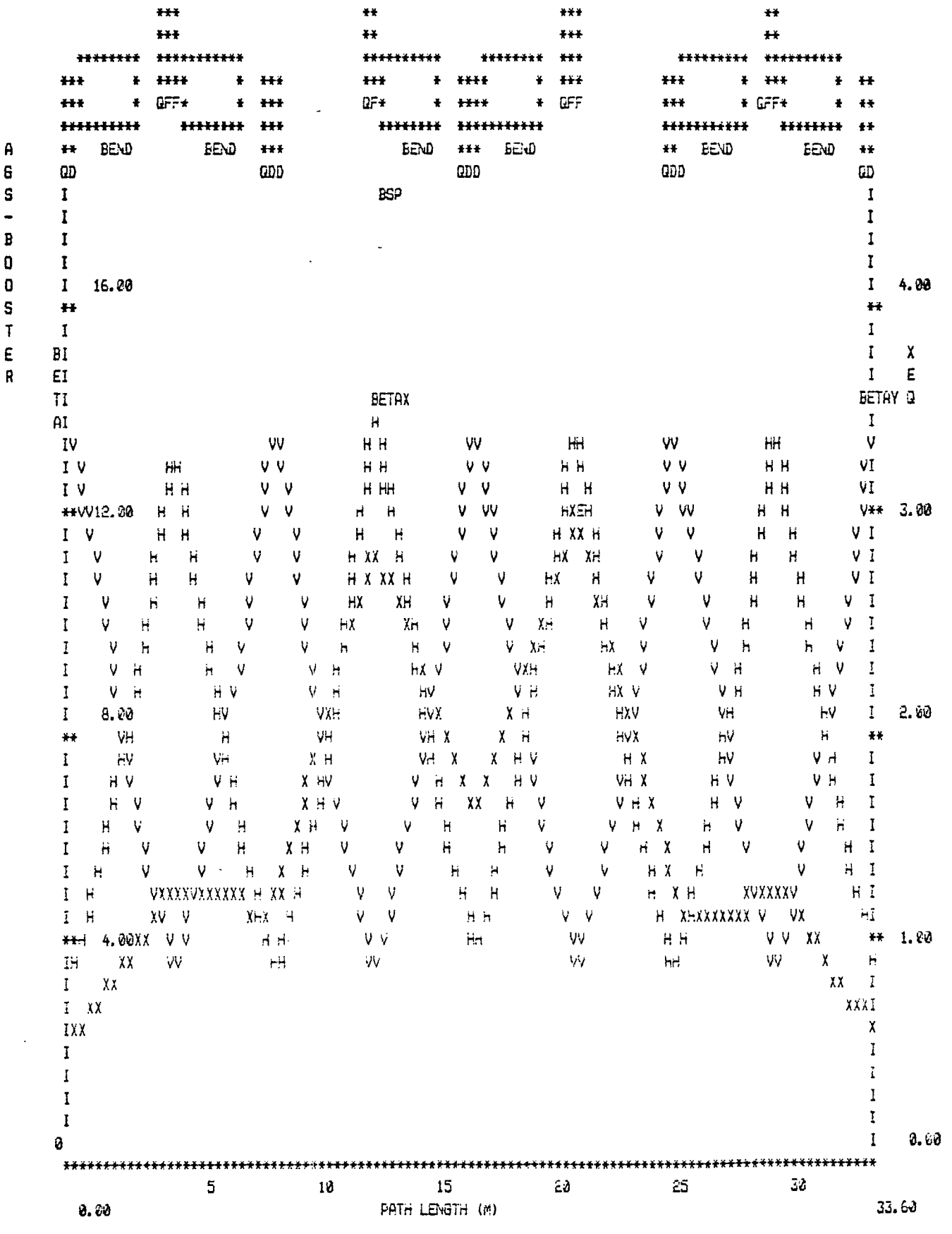


FIG. 3 The Amplitude and Dispersion Functions of the Booster Lattice.

BETATRON FUNCTIONS OF BSP (Linear Lattice)

POS		S(M)	NUX	NUY	BETAX(M)	BETAY(M)	XEQ(M)	YEQ(M)	ZEQ (M)	ALPHAX	ALPHAY	DXEQ	DYEQ
0		0.000	0.0000	0.0000	3.72324	13.67106	.60721	0.00000	0.00000	.00813	-.00000	-.01414	0.00000
1	QD	.252	.0106	.0030	3.87185	13.18971	.61458	0.00000	0.00000	-.60519	1.88810	.07285	0.00000
2	S30	.552	.0224	.0067	4.26672	12.08800	.63644	0.00000	0.00000	-.71105	1.78427	.07285	0.00000
3	BEND	2.952	.0836	.0542	9.49416	5.51703	1.00964	0.00000	.13790	-1.44489	.95364	.23736	0.00000
4	S100	3.952	.0981	.0886	12.70917	3.95585	1.24700	0.00000	.13790	-1.77012	.60754	.23736	0.00000
5	QF	4.204	.1012	.0990	13.16202	3.80459	1.28473	0.00000	.13790	-.00683	-.00000	.06136	0.00000
6	QF	4.456	.1043	.1094	12.71589	3.95585	1.27773	0.00000	.13790	1.75739	-.60754	-.11677	0.00000
7	S30	4.756	.1082	.1209	11.69040	4.35153	1.24270	0.00000	.13790	1.66094	-.71137	-.11677	0.00000
8	BEND	7.156	.1570	.1809	5.35955	9.75962	1.15390	0.00000	.34147	.95008	-1.54200	.04296	0.00000
9	S100	8.156	.1924	.1949	3.81440	13.18971	1.19685	0.00000	.34147	.59508	-1.88810	.04296	0.00000
10	QD	8.408	.2032	.1979	3.66905	13.67106	1.22933	0.00000	.34147	-.01112	-.00000	.21570	0.00000
11	QD	8.659	.2140	.2009	3.82587	13.18971	1.30617	0.00000	.34147	-.61894	1.88810	.39623	0.00000
12	S370	12.359	.3006	.2865	13.35506	3.95585	2.77220	0.00000	.34147	-1.95652	.60754	.39623	0.00000
13	QF	12.611	.3035	.2969	13.87963	3.80459	2.82317	0.00000	.34147	-.10183	-.00000	.00726	0.00000
14	QF	12.863	.3064	.3073	13.45529	3.95585	2.77584	0.00000	.34147	1.76692	-.60754	-.38197	0.00000
15	S30	13.163	.3101	.3188	12.42271	4.35153	2.66125	0.00000	.34147	1.67501	-.71137	-.38197	0.00000
16	BEND	15.563	.3551	.3788	5.91706	9.75962	1.91765	0.00000	.73596	1.00809	-1.54200	-.23612	0.00000
17	S100	16.563	.3870	.3929	4.24162	13.18971	1.68153	0.00000	.73596	.66734	-1.88810	-.23612	0.00000
18	QD	16.815	.3967	.3958	4.07363	13.67106	1.65204	0.00000	.73596	.00759	.00000	.00123	0.00000
19	QD	17.067	.4065	.3988	4.23379	13.18971	1.68215	0.00000	.73596	-.65106	1.88810	.23862	0.00000
20	S30	17.367	.4172	.4026	4.65469	12.08800	1.75374	0.00000	.73596	-.75195	1.78427	.23862	0.00000
21	BEND	19.767	.4742	.4501	9.96843	5.51703	2.50578	0.00000	1.10251	-1.43958	.95364	.38649	0.00000
22	S100	20.767	.4881	.4844	13.15579	3.95585	2.89228	0.00000	1.10251	-1.74779	.60754	.38649	0.00000
23	QF	21.019	.4911	.4948	13.58117	3.80459	2.93871	0.00000	1.10251	.07862	.00000	-.01886	0.00000
24	QF	21.271	.4941	.5052	13.07841	3.95585	2.88283	0.00000	1.10251	1.89418	-.60754	-.42355	0.00000
25	S370	24.971	.5812	.5908	3.86395	13.18971	1.31570	0.00000	1.10251	.59622	-1.88810	-.42355	0.00000
26	QD	25.223	.5919	.5938	3.71955	13.67106	1.23212	0.00000	1.10251	-.01606	-.00000	-.24214	0.00000
27	QD	25.474	.6025	.5967	3.88052	13.18971	1.19299	0.00000	1.10251	-.63068	1.88810	-.06948	0.00000
28	S30	25.774	.6142	.6005	4.29135	12.08800	1.17215	0.00000	1.10251	-.73874	1.78427	-.06948	0.00000
29	BEND	28.174	.6746	.6480	9.69009	5.51703	1.19735	0.00000	1.30370	-1.48785	.95364	.09042	0.00000
30	S100	29.174	.6888	.6823	12.99744	3.95585	1.28777	0.00000	1.30370	-1.81950	.60754	.09042	0.00000
31	QF	29.426	.6918	.6927	13.46504	3.80459	1.28799	0.00000	1.30370	-.01535	-.00000	-.08863	0.00000
32	QF	29.678	.6948	.7031	13.01254	3.95585	1.24338	0.00000	1.30370	1.79092	-.60754	-.26461	0.00000
33	S30	29.978	.6986	.7146	11.96709	4.35153	1.16400	0.00000	1.30370	1.69392	-.71137	-.26461	0.00000
34	BEND	32.378	.7463	.7747	5.48311	9.75962	.72338	0.00000	1.46271	.98025	-1.54200	-.10164	0.00000
35	S100	33.378	.7810	.7887	3.88023	13.18971	.62175	0.00000	1.46271	.62263	-1.88810	-.10164	0.00000
36	QD	33.630	.7917	.7917	3.72324	13.67106	.60721	0.00000	1.46271	.00813	-.00000	-.01414	0.00000

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