BNL-105064-2014-TECH

Booster Technical Note No. 17;BNL-105064-2014-IR

Chromaticity Correction for the AGS Booster with 1,2,4,7 Sextupole Configuration

E. Courant

March 1986

Collider Accelerator Department

Brookhaven National Laboratory

U.S. Department of Energy

USDOE Office of Science (SC)

DISCLAIMER

CHROMATICITY CORRECTION
for the
AGS BOOSTER
with
1,2,4,7 SEXTUPOLE CONFIGURATION

Booster Technical Note
No. 17

E. Courant and Z. Parsa
March 5, 1986

HIGH ENERGY FACILITIES
Brookhaven National Laboratory
Upton, N.Y. 11973

ABSTRACT

THIS NOTE DESCRIBES THE EFFECT OF THE CHROMATICITY CORRECTION SEXTUPOLES 1,2,4,7 CONFIGURATION SELECTED FOR THE AGS - BOOSTER. RESULTS OBTAINED FROM SYNCHROTRON DESIGN PROGRAM SYNCH AND A SCHEMATIC LAYOUT OF THE LATTICE ARE ALSO INCLUDED.

INTRODUCTION:

We have studied the implications of various chromaticity sextupole correction configurations for the AGS - Booster. In section II we present our results for the 1,2,4,7 configuration which was selected for the Booster. Amplitude (BETAX, BETAY) and dispersion functions for the Booster are shown in Figure 1.

The AGS Booster is designed to be an intermediate synchrotron injector for the AGS, capable of accelerating protons from 200 MeV, the Linac operating energy to 1 GeV, (with the possibility of an upgrade to 2.5 GeV), at 10 Hz repetition rate and Heavy Ions to magnetic rigidity equal to 16.7 Tesla-Meter at a 1 Hz repetition rate.

As presently designed, the Booster will have [ref1]: i) a circumference equal to one quarter that of AGS; ii) it will have a FODO lattice with bending magnets missing in some cells inorder to accomodate the space needed for RF acceleration, injection, ejection and abort system without otherwise interupting the periodicity; and iii) this specific lattice structure consists of six identical superperiods [ref.1]. Booster coordinates and parameter list are given in references 2 and 3.

References:

1. The Booster Lattice, Booster Tech. Note No. 1, E. Courant, Z. Parsa, January 15, 1986.

2. Booster Coordinates, Booster Tech. Note No. 6, Z. Parsa, January 28,1986.

3. Booster Parameter List, Booster Tech. Note No. 10, Z. Parsa, February 12, 1986.

4. usig BNLDAG::DUA0:[PARSA1.BOOSTER]SYNBOOST17.DAT as input. We obtained similar results using program MAD403 with [PARSA1.BOOSTER]MADBOOST.DAT as input).

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

6. See subsequent BST/TN on chromaticity correcting sextupoles and other correcting devices.

SECTION II

In this section we show the effect of the chromaticity correcting sextupoles 1,2,4,7 configuration for the AGS-Booster.
We have selected two families of sextupoles, located at 1,7 (SF), 2,4 (SD) per superperiod. Therefore the total number of sextupoles for the AGS-Booster is 24 (12 SF + 12 SD); each of 10 cm length; with aperture of 16.52 cm. We note that, at 1 GeV with integrated strength of 1.761 [T/m]; the injection pole tip fields for protons (including Polarized protons) is 0.45761 [KG], and for Heavy Ions is 0.03065 A/Q . Whereas, the ejection pole tip field for protons (including Polarized protons) is 1.2015 [KG], and for Heavy Ions is 3.5504 [KG] respectively.

Following tables give the summary of the parameters obtained for the AGS - Booster from program "SYNCH" [Ref. 4] with proton injection at 200 MeV, (BRHO= 2.14962 T-M and B = .156325 T), betatron tune QX = 4.82, QY = 4.83, and the Booster Circumference = 201.78 m . Tables I, II, and III shows the betatron functions and the amplitude dependence of tunes for linear lattice, eddy current sextupoles and correction sextupole configuration 1,2,4,7 [for DP/P = -0.002, 0, +0.002] respectively.

We note that; Eddy Current sextupole strengths are taken to be 0.12 Tesla per meter square [Ref. 5]; and in case III, chromaticity correction sextupoles are added (to Eddy Current sextupoles) to make the overall chromaticity zero. Alternate sextupole configurations was studied but the 1,2,4,7 configurations was selected since it exhibits reasonably small amplitude dependence of tunes, and sextupole strength; also accommodates the space required for the injection and ejection; (although we will continue with our studies of other sextupole configurations which may become more suitable for the Booster) [Ref. 6].

TABLE I

BETATRON FUNCTIONS [LINEAR LATTICE]

CIRCUMFERENCE = 201.7800 M
RADIUS = 32.1143 M

THETX = 6.28319424 RAD NUX = 4.82000
THETY = 0.00000000 RAD NUY = 4.83000

DNUX/(DP/P) = -4.92970 DS/S)/(DP/P) = .0419702

DNUY/(DP/P) = -5.26488 TGAM = (4.88123, 0.00000)

MAXIMA

BETX(13) =	13.86571	BETY(36) =	13.64403
XEQ(23) =	2.95145	YEQ(36) =	0.00000

MINIMA

BETX(10) =	3.57537	BETY(23) =	3.70334
XEQ(1) =	.54003	YEQ(36) =	0.00000

TABLE II

NO CHROMATICITY SEXTUPOLE
[EDDY CURRENT SEXTUPOLES +.12 TM-2 @ PROTON INJECTION]

CIRCUMFERENCE = 201.7800 M THETX = 6.28319424 RAD
RADIUS = 32.1143 M THETY = 0.00000000 RAD

NUX = 4.82000 DNUX/(DP/P) = 4.03907
NUY = 4.83000 DNUY/(DP/P) = -13.15549

(DS/S)/(DP/P)=.0419702 TGAM=(4.88123,0.00000)

MAXIMA

BETX(21) = 13.86571 BETY(56) = 13.64403
XEQ(37) = 2.95145 YEQ(56) = 0.00000

MINIMA

BETX(18) = 3.57537 BETY(37) = 3.70334
XEQ(1) = .54003 YEQ(56) = 0.00000

SEXTUPOLE CORRECTIONS

DKSF = .68771833E-01 DKSD = -.81038396E+00
KSF = .68771833E-01 KSD = -.81038396E+00

AMPLITUDE DEPENDENCE OF TUNES DUE TO SEXTUPOLES

NU-X = 4.820000 - .223E+02EX + .110E+02EY
NU-Y = 4.830000 + .110E+02EX - .188E+02EY

TABLE III A

CHROMATICITY SEXTUPOLES at 1,2,4,7 for DP/P = -0.002

CIRCUMFERENCE = 201.7631 M THETX = 6.29578581 RAD
RADIUS = 32.1116 M THETY = 0.00000000 RAD

NUX = 4.82120 DNUX/(DP/P) = -.09800
NUY = 4.82989 DNUY/(DP/P) = .15190

(DS/S)/(DP/P)=.0417355 TGAM=(4.89494,0.00000)

MAXIMA

BETX(21) = 13.78978 BETY(18) = 13.72915
XEQ(37) = 2.96406 YEQ(56) = 0.00000

MINIMA

BETX(18) = 3.56555 BETY(49) = 3.64829
XEQ(1) = .52395 YEQ(56) = 0.00000

MAXIMA XCO(56)= -1.06329 YCO(56)= 0.00000
MINIMA XCO(37)= -5.91570 YCO(56)= 0.00000

AMPLITUDE DEPENDENCE OF TUNES DUE TO SEXTUPOLES

NU-X = 4.821203 + .121E+02EX - .972E+00EY
NU-Y = 4.829891 - .972E+00EX + .866E+02EY

TABLE III B

CHROMATICITY SEXTUPOLES at 1,2,4,7 for DP/P = 0.000

CIRCUMFERENCE = 201.7800 M THETX = 6.28319424 RAD
RADIUS = 32.1143 M THETY = 0.00000000 RAD

NUX = 4.82000 DNUX/(DP/P) = .00000
NUY = 4.83000 DNUY/(DP/P) =-.00000

(DS/S)/(DP/P)= .0419702 TGAM=(4.88123,0.00000)

MAXIMA

BETX(21) = 13.86571 BETY(56) = 13.64403
XEQ(37) = 2.95145 YEQ(56) = 0.00000

MINIMA

BETX(18) = 3.57537 BETY(37) = 3.70334
XEQ(1) = .54003 YEQ(56) = 0.00000

MAXIMA XCO(56)= 0.00000 YCO(56)= 0.00000
MINIMA XCO(56)= 0.00000 YCO(56)= 0.00000

AMPLITUDE DEPENDENCE OF TUNES DUE TO SEXTUPOLES

NU-X = 4.820000 + .117E+02EX - .502E+00EY
NU-Y = 4.830000 - .502E+00EX + .870E+02EY

TABLE III C

CHROMATICITY SEXTUPOLES at 1,2,4,7 for DP/P = +0.002

CIRCUMFERENCE = 201.7969 M THETX = 6.27065293 RAD
RADIUS = 32.1170 M THETY = 0.00000000 RAD

NUX = 4.81900 DNUX/(DP/P) = .09520
NUY = 4.82989 DNUY/(DP/P) = -.15310

(DS/S)/(DP/P)= .0421948 TGAM=(4.86822,0.00000)

MAXIMA

BETX(21) = 13.94219 BETY(56) = 13.72988
XEQ(37) = 2.93877 YEQ(56) = 0.00000

MINIMA

BETX(18) = 3.58513 BETY(21) = 3.64963
XEQ(56) = .55591 YEQ(56) = 0.00000

MAXIMA XCO(37)= 5.89008 YCO(56)= 0.00000
MINIMA XCO(1)= 1.09668 YCO(56)= 0.00000

AMPLITUDE DEPENDENCE OF TUNES DUE TO SEXTUPOLES

NU-X = 4.818997 + .114E+02EX - .960E-01EY
NU-Y = 4.829890 - .960E-01EX + .874E+02EY

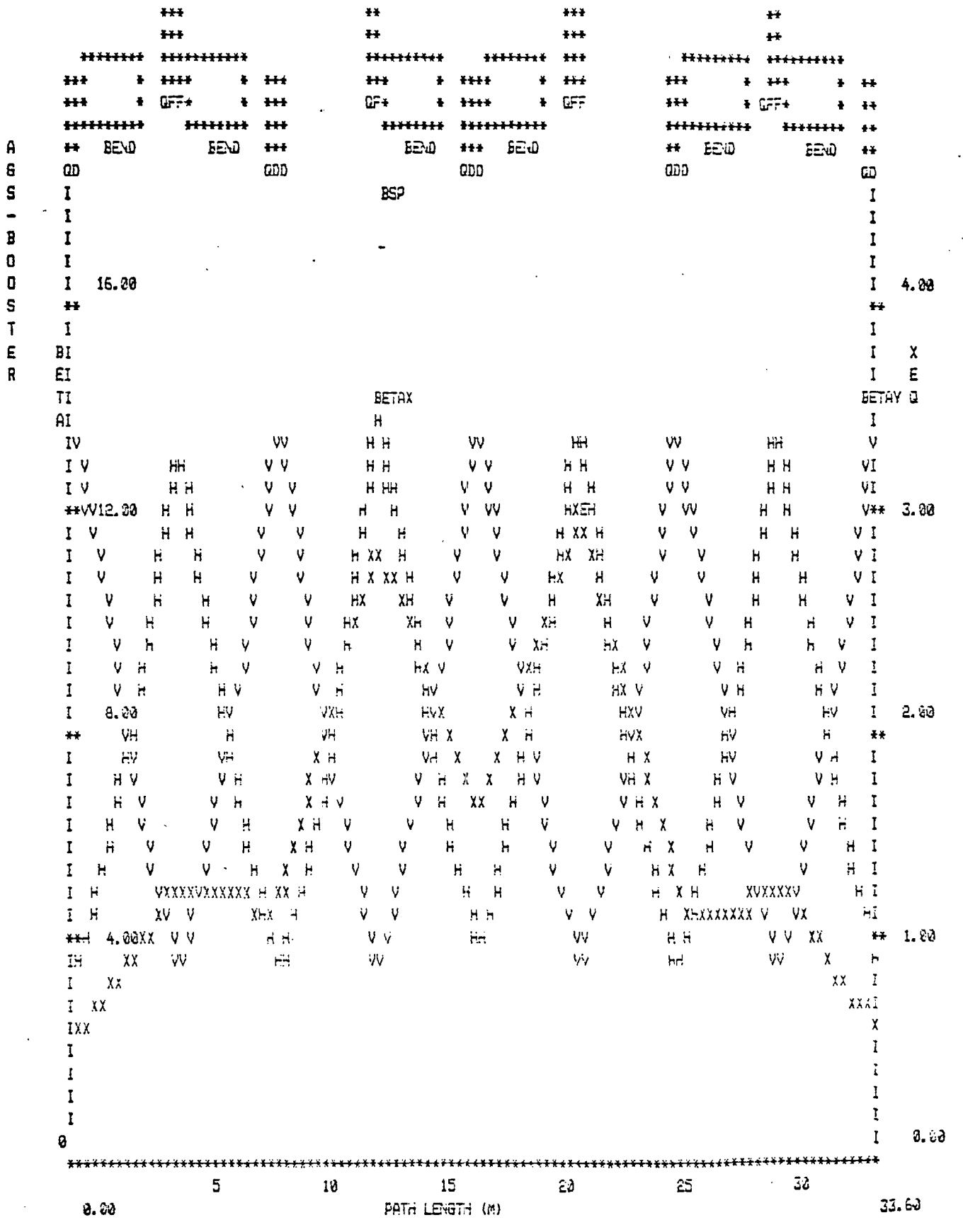


FIG. 1 The Amplitude and Dispersion Functions of the Booster Lattice.

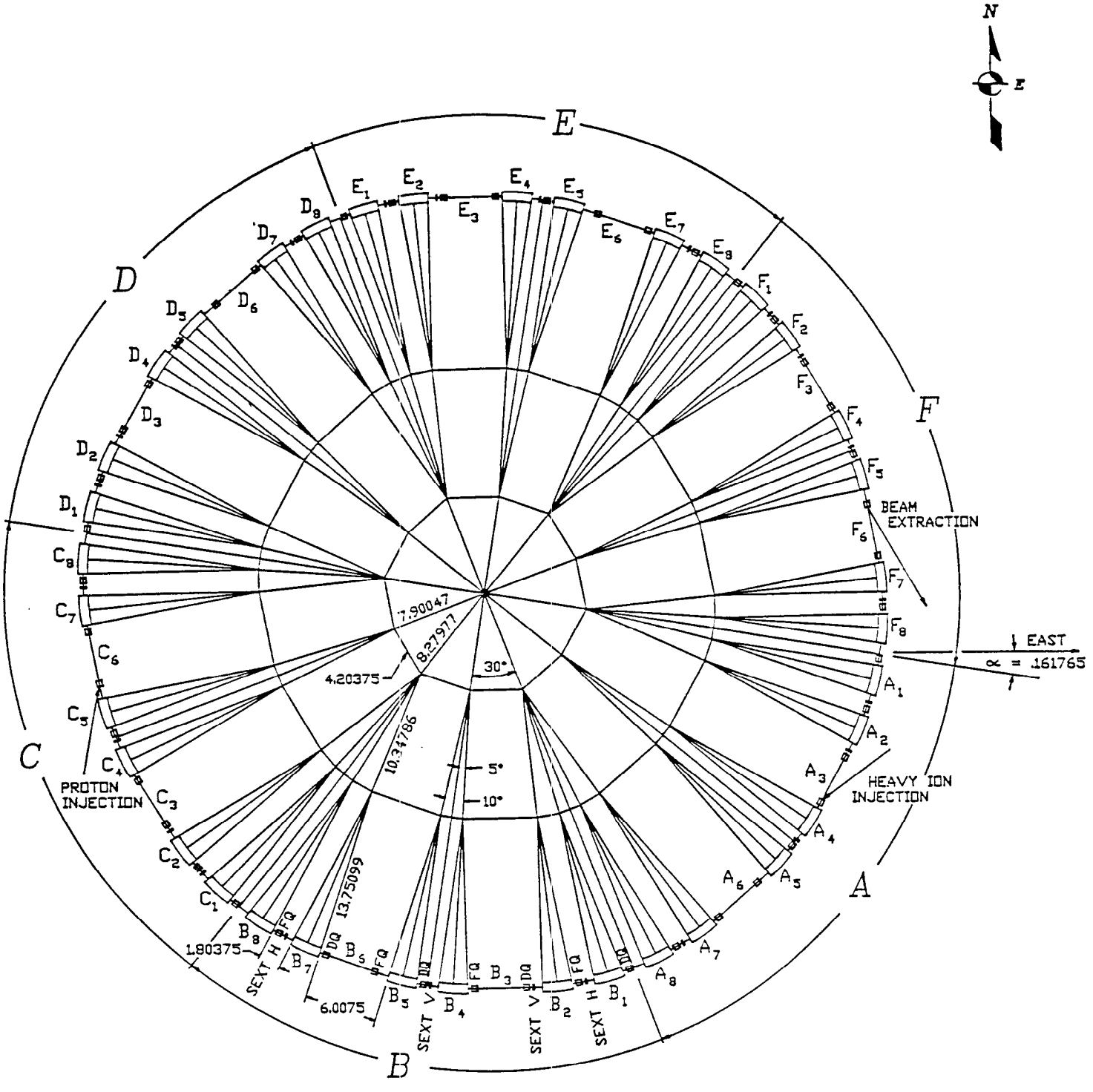
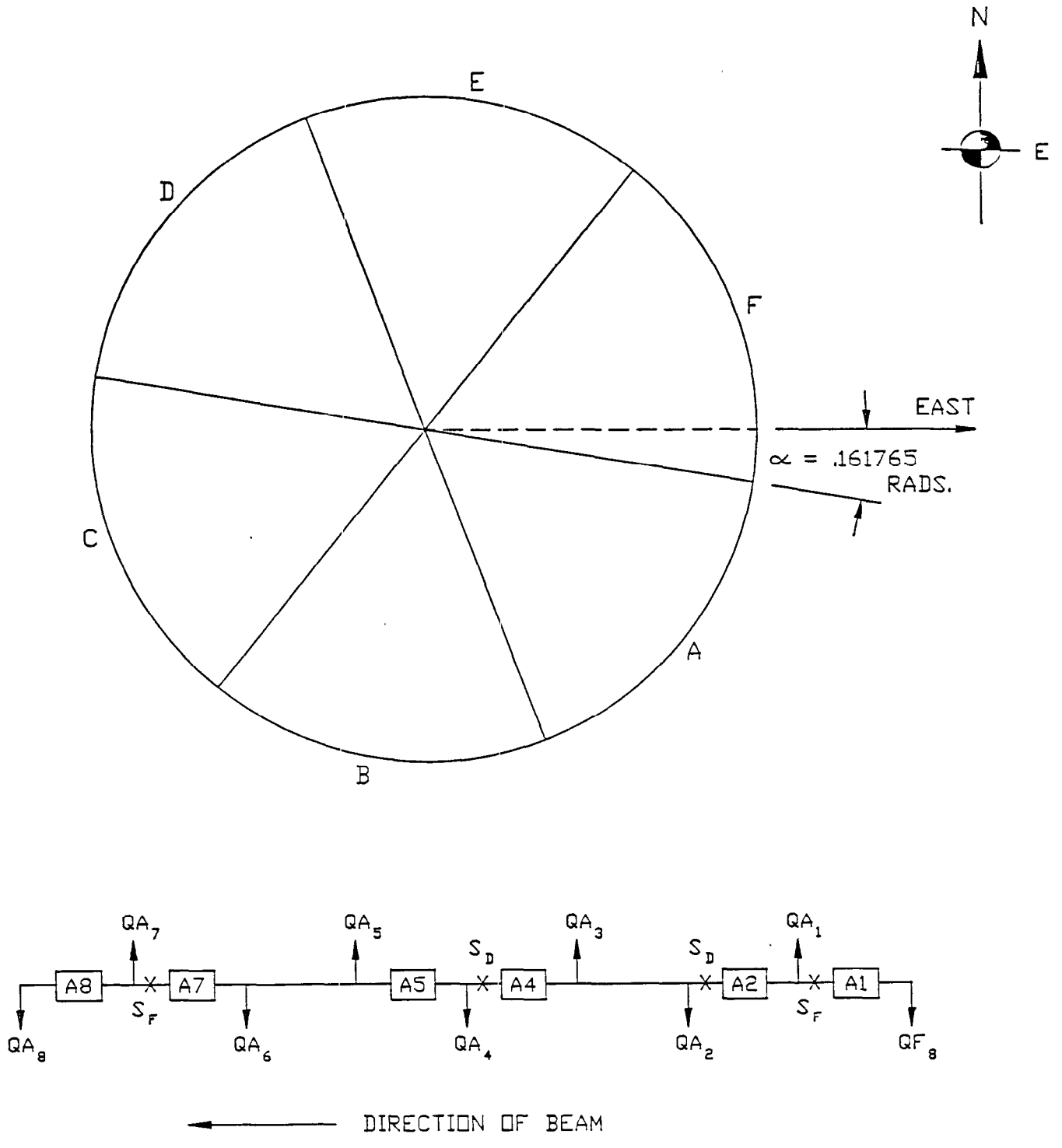


Fig. 3 Overall Layout of the Booster [Ref. 1]



↑ = FOCUSING QUADRUPOLE

↓ = DEFOCUSING QUADRUPOLE

▭ = BENDING MAGNET (DIPOLE)

X = SEXTUPOLE

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