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

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DISCLAIMER

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

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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::DUAO:[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
```

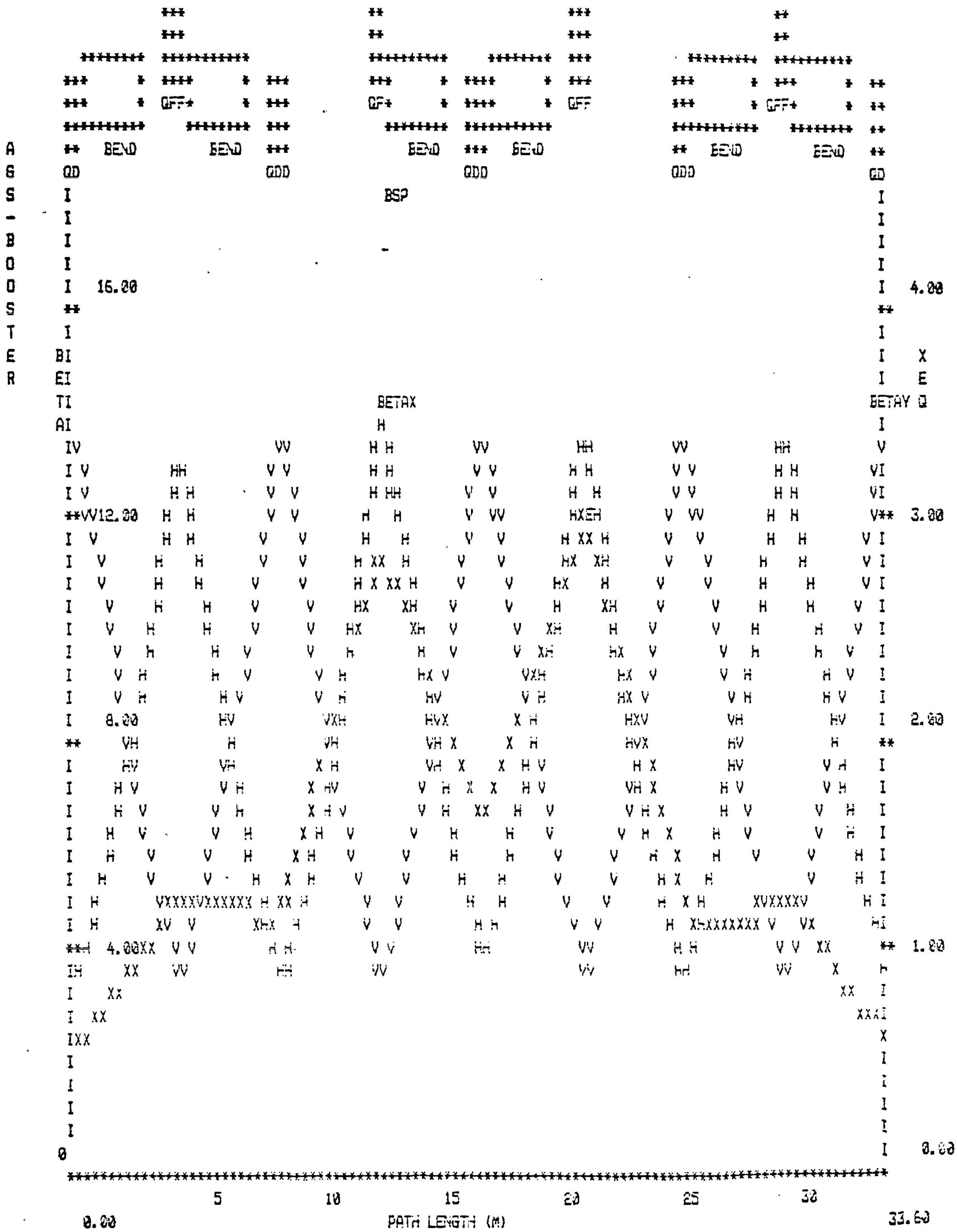

FIG. 1 The Amplitude and Dispersion Functions of the Booster Lattice.

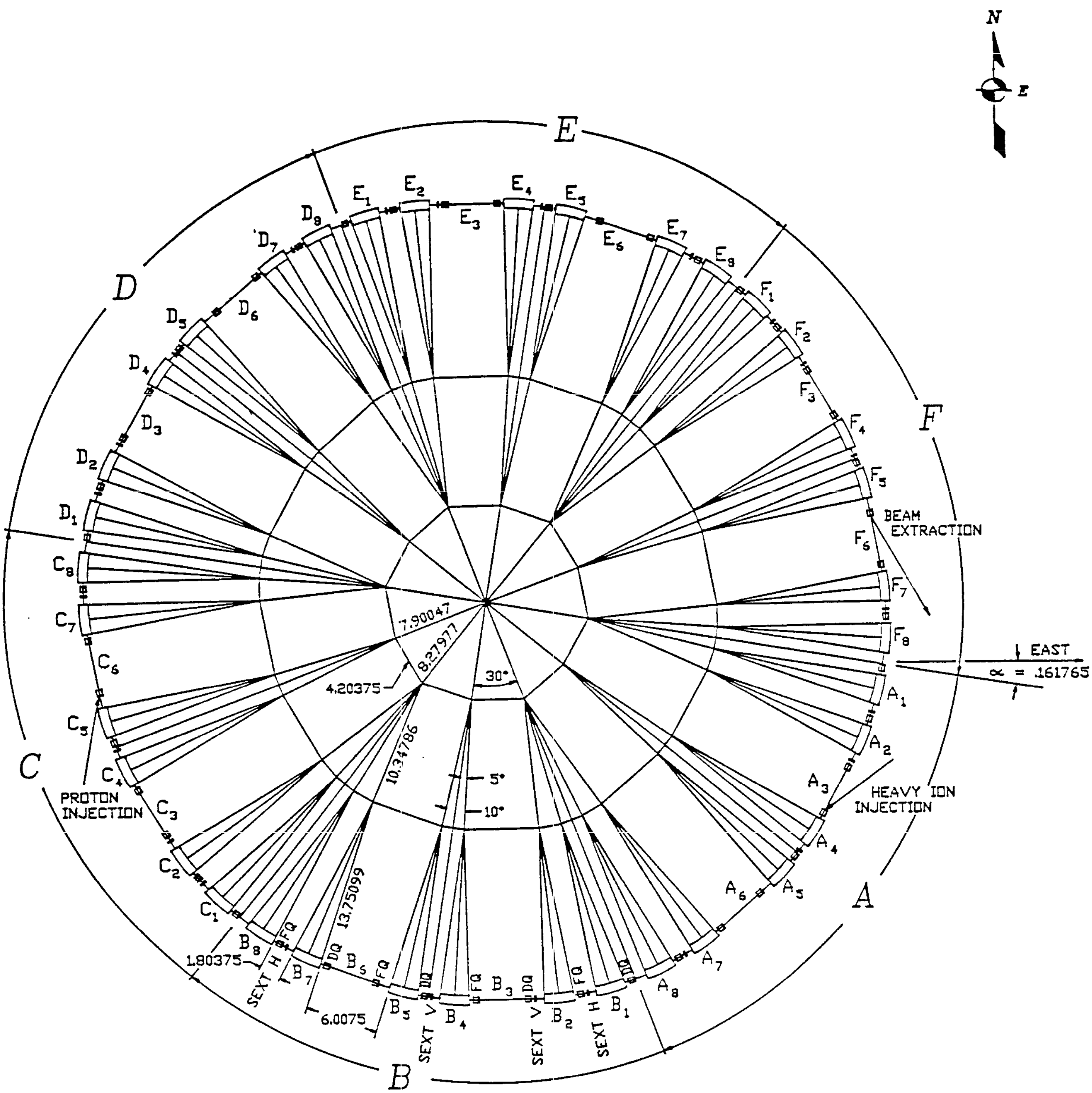

Fig. 3 Overall Layout of the Booster [Ref. 1]

0 5
METERS
NOTE: ALL DIMENSIONS ARE IN METERS

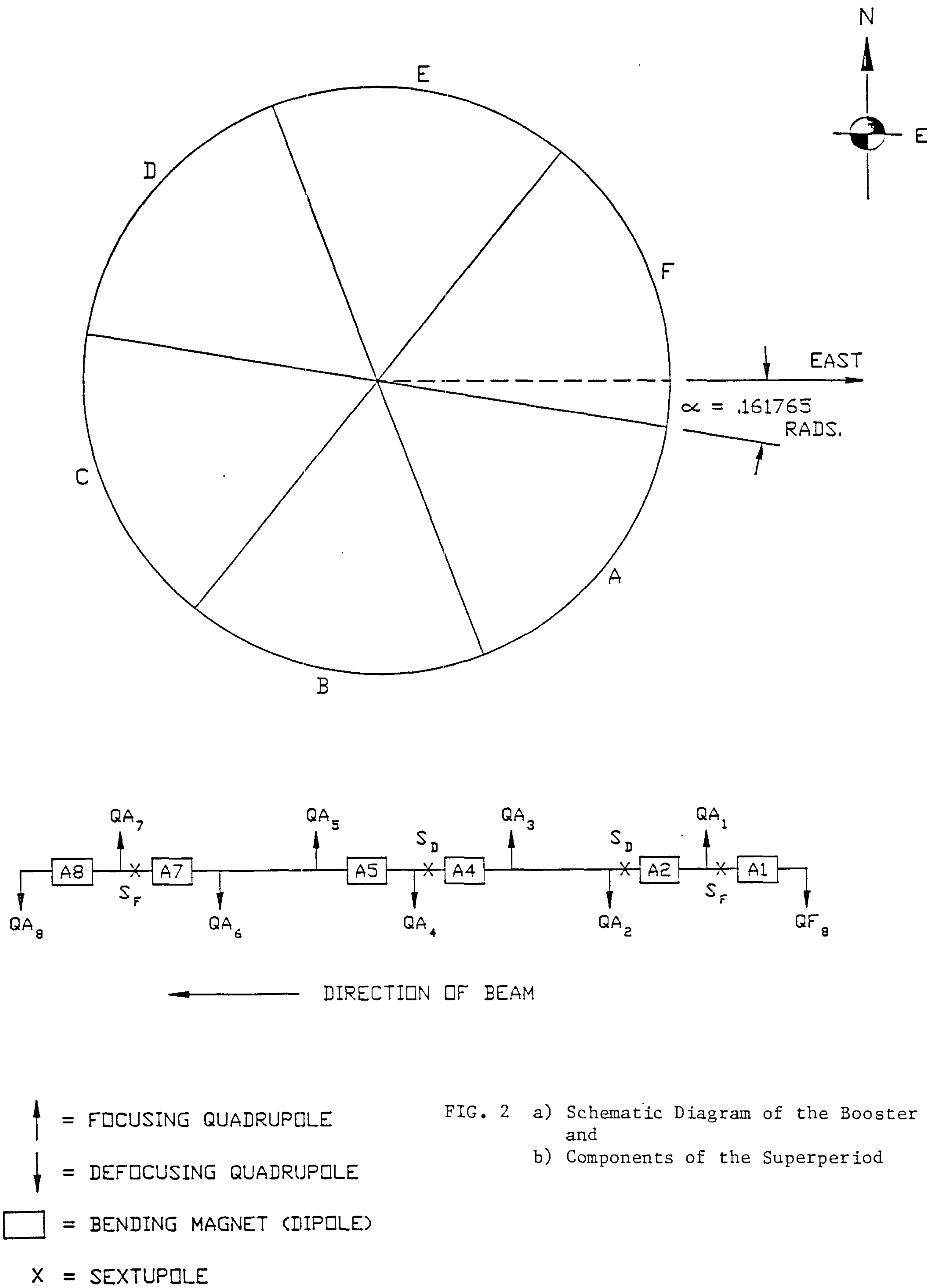

FIG. 2 a) Schematic Diagram of the Booster and
b) Components of the Superperiod