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The Heavy Ion Injection Line for the AGS Booster

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Technical Note

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February 12, 1986

THE HEAVY ION INJECTION LINE FOR THE AGS BOOSTER

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This note describes the preliminary design of the heavy ion beam transport line to the AGS Booster and injection into the Booster. The transport line described in this note starts from the 69° bend point around the end of the present Heavy Ion Transport Line (HITL) in the old South West Experimental Area and matches the phase space ellipses of the HITL to the lattice functions of the booster.

The geometry of the injection line is shown in the figure 1. The optical matching of the beam starts from the quadrupole doublet upstream of the 69° bend (AGS cordinates N6025.28, E4543.8). A 9°1' bend at this point will direct the beam into the AGS tunnel through an existing hole in the AGS wall in the old B10 external beam area. A series of 6 quadrupoles are used in this portion of the line.

The above line conitues to one foot inside the AGS tunnel. At this point (N8525.053, E3104.603, sea level 76.18 feet) a bend of 6.18° towards the outside wall of the AGS tunnel will direct beam into the next transport section. An intermediate matching of beta functions is done at the end of a pair of quadrupole following this bend. The dispersion function, however, is not completly matched here.

The next section consists of four FODO cell with a 5° bend at each bend point and a phase advance of 90° per cell. This section of the transport line can be represented by a unit matrix and by definition this section will transfer the identical beam properties to the next section.

The next section of the line goes into the old 50 Mev Linac building through the AGS L20 conjunction area. The line will go into the building far enough to clear off the staging area for that section of the Booster tunnel. A bend of almost 180^0 by two sector magnet will guide the beam to the A3 straigth section. The quadrupoles in this section together with trim magnets matches the lattice and dispersion functions of the beam to that at the injection point in the Booster.

We propose the aperture of the quadrupole in this transport to be 4 inches and also the length be 4 inches (with air cooled coils). This size is choosen in order to have a pole tip field of reasonable value (1 to 1.5 kiloguass).

To design the injection line, we first used the thin lens approximation to match the lattice functions. The final matching and design is done with the computer code MAD where the actual length of the quadrupoles is used and the edge focusing of the dipoles is included. The quadrupole strength and positions are optimized so that the horizontal and vertical beta functions remain below 80 meters, and maximum dispersion around 8 meters.

The MAD input of this beam line is given in table 1.

The emmitance of the beam, in both planes, is assumed to be 1 pi mm-mrad and the momentum spread .1 percent. The width of the heavy ion beam having the above emmitance and momentum spread is shown in figure 2. Please note that the complete beam line inside the AGS tunnel is not given in this figure. Instead, we have shown only one of the four identical units - each madeup of four FODO cells. Each unit has a unitary transfer matrix and thererfore the beam width and the lattice functions in the rest of the three units would be same as that in the one plotted in Fig 2.

The vertical bends are ignored in this calculation. They will be included in the final calculations after a detailed design of the geometry of injection and extraction area of the Booster is made.

The beam will be stacked into the Booster in the horizontal betatron space. We use an electrostatic inflector and three fast orbit bumps located at F8, A5 and upstream end of A3. The experience at AGS for this kind of injection scheme was very successful.

The SURVEY command in the program MAD is used to examine that the geometry is right and fits with the existing buildings and the site plans. A few minor changes may, however, be required and they will be incorporated when the details of the design are finalized.

Table 1.

```
TITLE!
 HEAVY ION INJECTION LINE FOR BOOSTER
!
!  5-FEB-1986 13:49:14
!
D01:       DRIFT,L=0.152400000000
D02:       DRIFT,L=0.789400000000
D03:       DRIFT,L=8.00000000000
D11:       DRIFT,L=6.10500000000
D12:       DRIFT,L=12.0000000000
D21:       DRIFT,L=5.99998108165
D22:       DRIFT,L=9.29367088212
D23:       DRIFT,L=7.06000000000+2.00000000000*8.40000000000+&
           4.00000000000-D21[L]-2.00000000000*D22[L]
D24:       DRIFT,L=1.18668312610
D25:       DRIFT,L=4.05000000000+1.29000000000-D24[L]
QF01:      QUADRUPO,L=0.304800000000,K1=3.23385262041
QD01:      QUADRUPO,L=0.304800000000,K1=-2.82048964073
QF10:      QUADRUPO,L=0.100000000000,K1=1.56240089691
QD10:      QUADRUPO,L=0.100000000000,K1=-1.35414659787
QF11:      QUADRUPO,L=0.100000000000,K1=1.49868231045
QD11:      QUADRUPO,L=0.100000000000,K1=-0.856178220118
QF21:      QUADRUPO,L=0.100000000000,K1=0.843094095871
QD21:      QUADRUPO,L=0.100000000000,K1=-1.23109880698
QD22:      QUADRUPO,L=0.100000000000,K1=-2.34734545161
QF22:      QUADRUPO,L=0.100000000000,K1=-0.122523537282
BEND0:     SBEND,L=0.789400000000,ANGLE=0.213504480000
BEND1:     SBEND,L=0.150000000000,ANGLE=-0.107860000000
BEND2:     SBEND,L=0.150000000000,ANGLE=0.151494000000
D3:        DRIFT,L=5.59140000000
D41:       DRIFT,L=5.63600000000
D42:       DRIFT,L=5.32560000000
D43:       DRIFT,L=11.1110000000
D5:        DRIFT,L=0.350000000000
BEND3:     SBEND,L=0.150000000000,ANGLE=0.436330000000E-01
BEND4:     SBEND,L=0.150000000000,ANGLE=0.152890000000
BEND5:     SBEND,L=0.750000000000,ANGLE=0.692861000000
QF3:       QUADRUPO,L=0.500000000000E-01,K1=0.96402700000
QD3:       QUADRUPO,L=0.500000000000E-01,K1=-1.17528800000
```

```
QF40:      QUADRUPO,L=0.100000000000,K1=-0.359872201140E-01
QF41:      QUADRUPO,L=0.100000000000,K1=1.38155489446
QD41:      QUADRUPO,L=0.100000000000,K1=-1.26120608378
QD5:       QUADRUPO,L=0.150000000000,K1=-1.51270000000
LINE0:     LINE=(QF01,D01,QD01,2*D03,BEND0)
LINE0A:    LINE=(LINE0,D11,QF10)
LINE0B:    LINE=(LINE0A,D12,QD10)
LINE1B:    LINE=(2*(D12,QF11,D12,QD11),D11)
LINE1:     LINE=(D11,QF10,(D12,QD10,D12,QF11),(D12,QD11,D12,QF11),D12,&
           QD11,D11)
LINE01:    LINE=(LINE0,LINE1)
LINE2A:    LINE=(BEND1,D21,QF21,D22,QD21,D22,QF21,D23)
LINE2C:    LINE=(BEND2,D24,QD22,D25,QF22)
LINE2:     LINE=(LINE2A,LINE2C)
LINE12:    LINE=(LINE1,LINE2)
LINE012A:  LINE=(LINE01,LINE2A)
LINE012:   LINE=(LINE0,LINE12)
LH3:       LINE=(QF3,D3,2*BEND3,D3,QD3)
LF3:       LINE=(LH3,-LH3)
LINE3:     LINE=(4*LF3)
LINE4:     LINE=(QF40,D41,BEND4,D42,QD41,D43,QF41,D43,QD41,D43,QF41,D43)
LINE03:    LINE=(LINE012,LINE3)
LINE034:   LINE=(LINE03,LINE4)
LINE5:     LINE=(D5,2*QD5,D5,2*BEND5,2*QD5,D5,2*BEND5,2*QD5)
LINE0345:  LINE=(LINE034,LINE5)
USE,LINE0345
PRINT,#S/E
TWISS,BETX=226.5,BETY=156.6,ALFX=-62.39,ALFY=-28.67
STOP
```

Heavy Ion Injection line for Booster

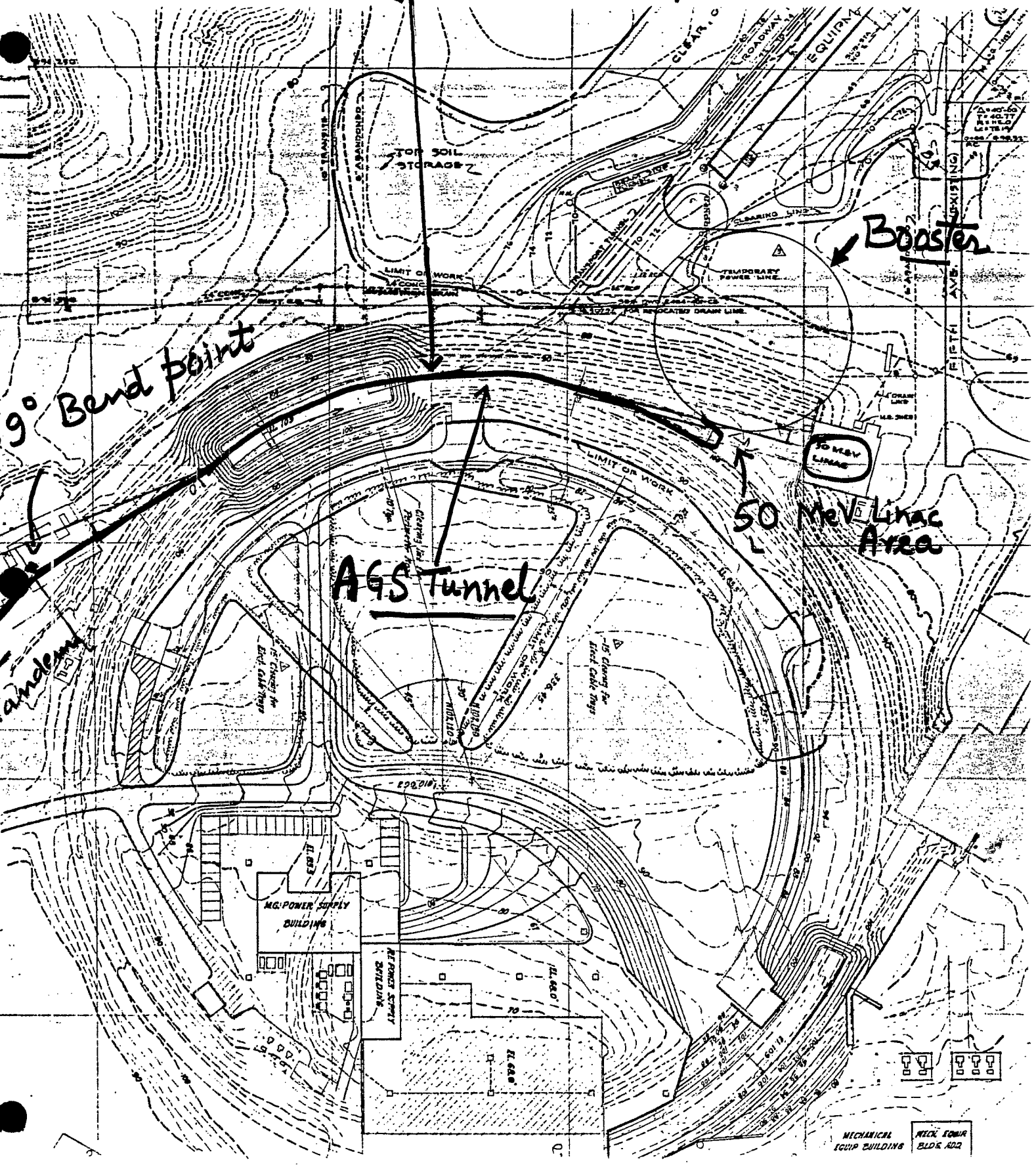

FIG 1. SITE PLAN

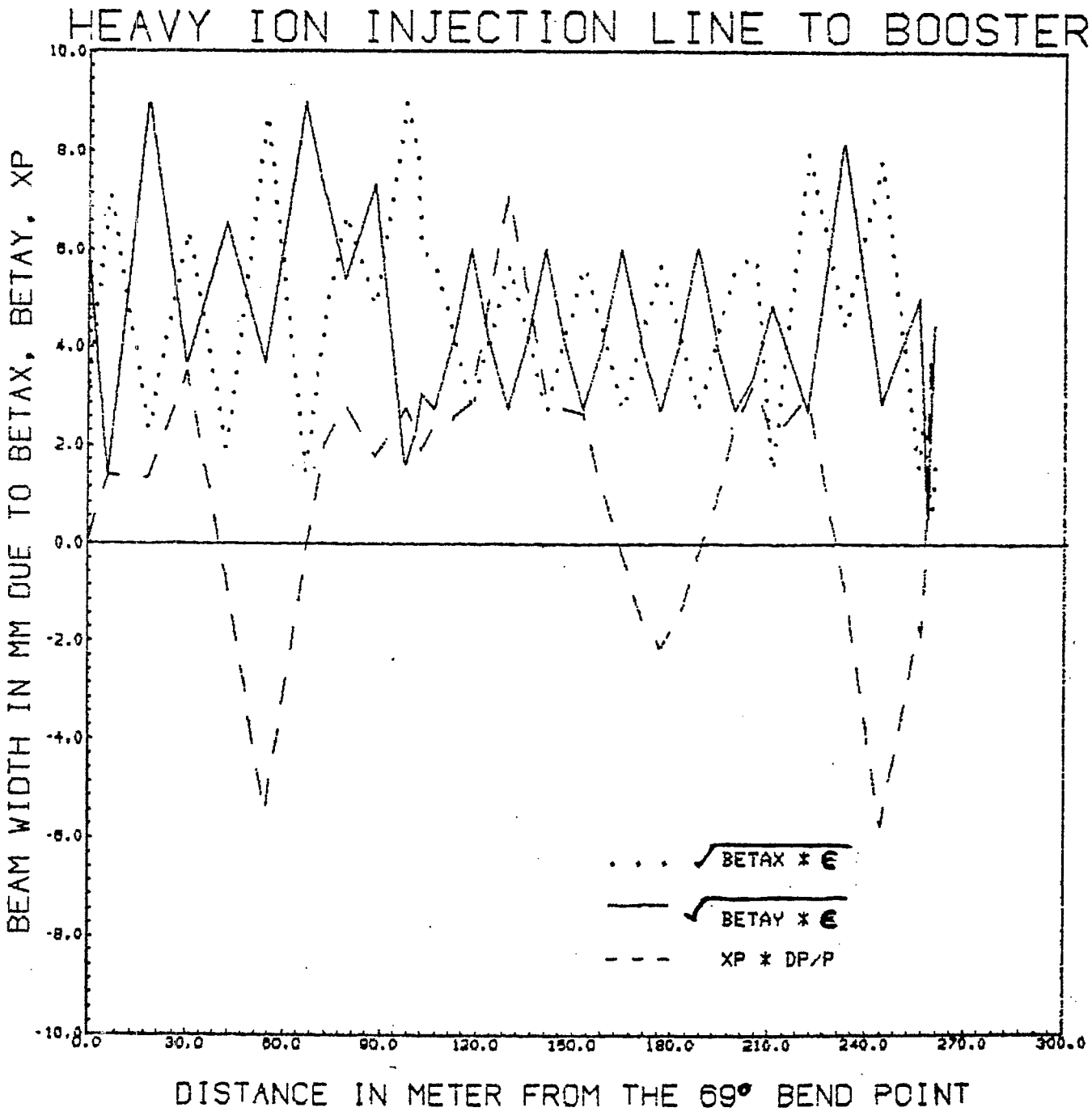
HEAVY ION INJECTION LINE TO BOOSTER
BEAM WIDTH IN MM DUE TO BETAX, BETAY, XP
10.0
8.0
6.0
4.0
2.0
0.0
-2.0
-4.0
-6.0
-8.0
-10.0
0.0
30.0
60.0
90.0
120.0
150.0
180.0
210.0
240.0
270.0
300.0
√BETAX * ε
√BETAY * ε
XP * DP/P
DISTANCE IN METER FROM THE 69° BEND POINT

FIG 2