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Transfer Line Between the Booster and the AGS

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Collider Accelerator Department

Brookhaven National Laboratory

U.S. Department of Energy

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March 5, 1986

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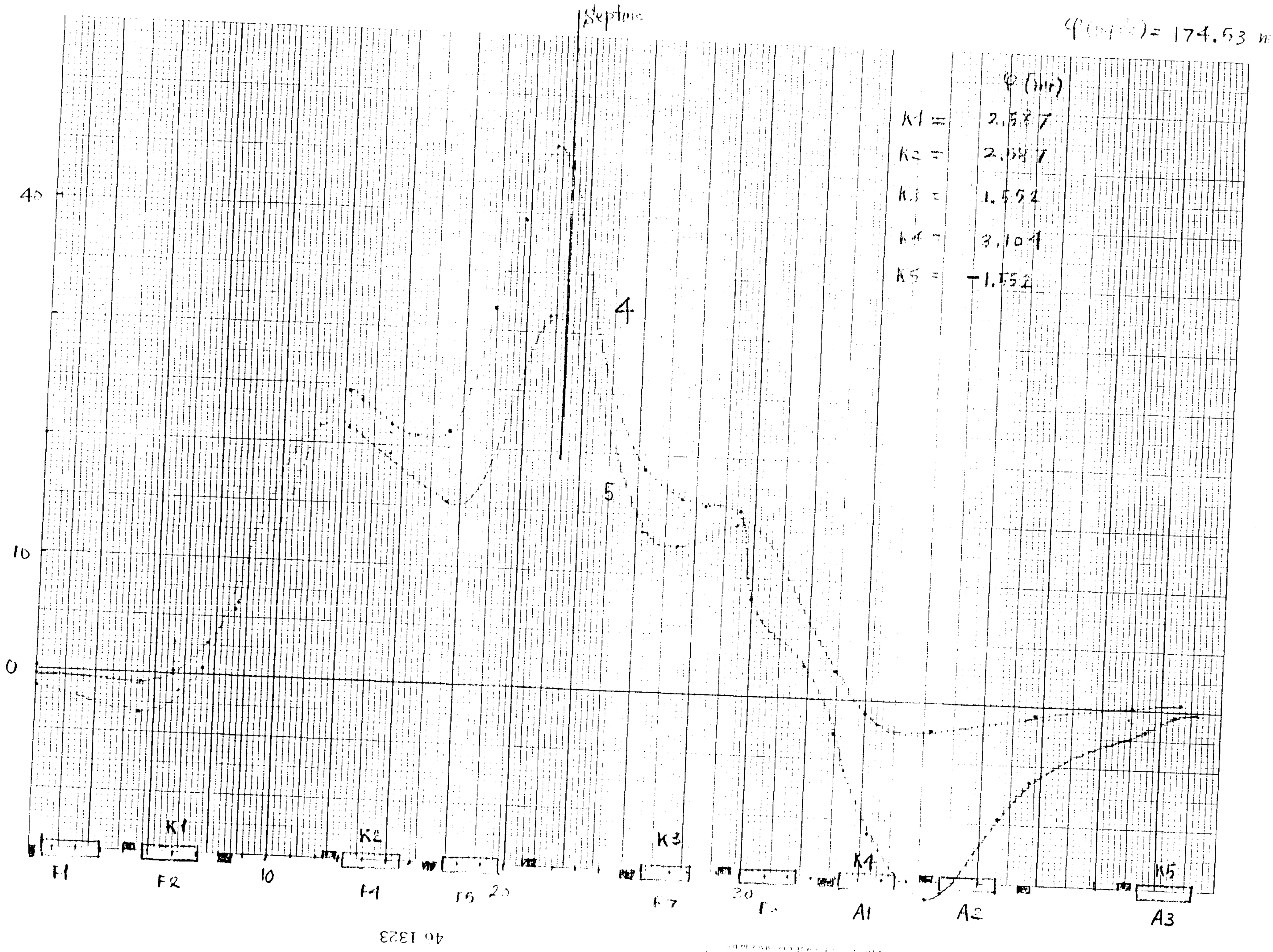
ABSTRACT

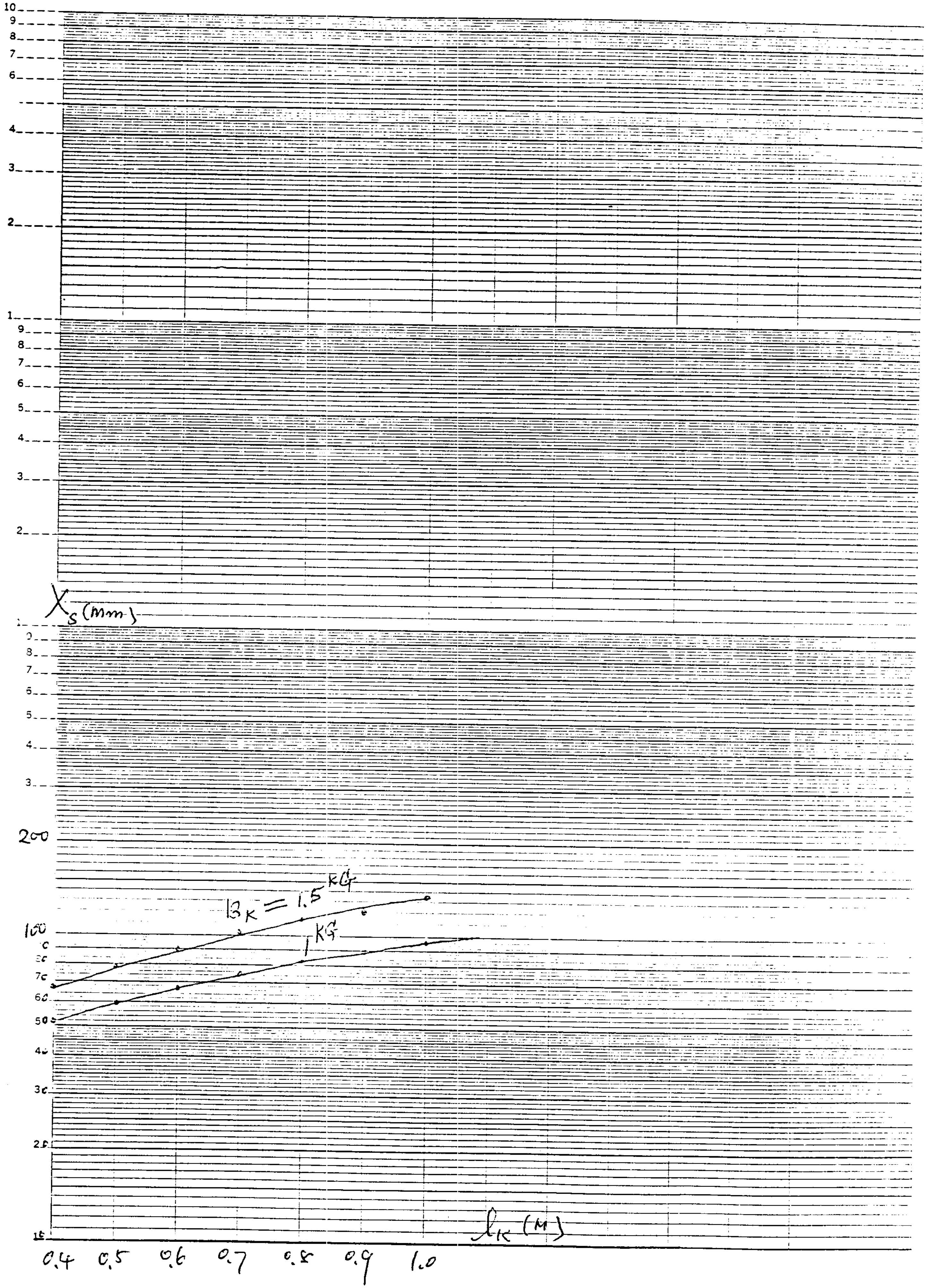
A beambump system in the booster and the transfer system has been worked out for the beam transfer between the booster and the AGS. The heavy ion beam is focused to the copper foil (70 mg/cm^2 thickness) with $\beta_x = \beta_y$ = 3 m . The beam is then transfered through some 14 quadrupoles with three dipoles to the AGS L20 straight section. The betafunctions in transfer line is maximum at 25m and 15m in most of the quadrupoles.

The beam extraction from the booster is best facilitated by a set of slow beam bumps to excite the closed orbit locally and the kicker is then excited with rise time of 190 nsec to kick the beam 66 mm(for proton @Brho=5.677) or 50 mm(for heavy ions with Brho=16.7 Tm).The total kick angle is about 8.5 mrad. At the F6 location, septum of 10 mm thickness at 50.8 mm away from the central orbit is used to deflect the extracted beam at the exit of the septum is 110 mrad and away from the corresponding quadrupole at Q6D is 35 cm.

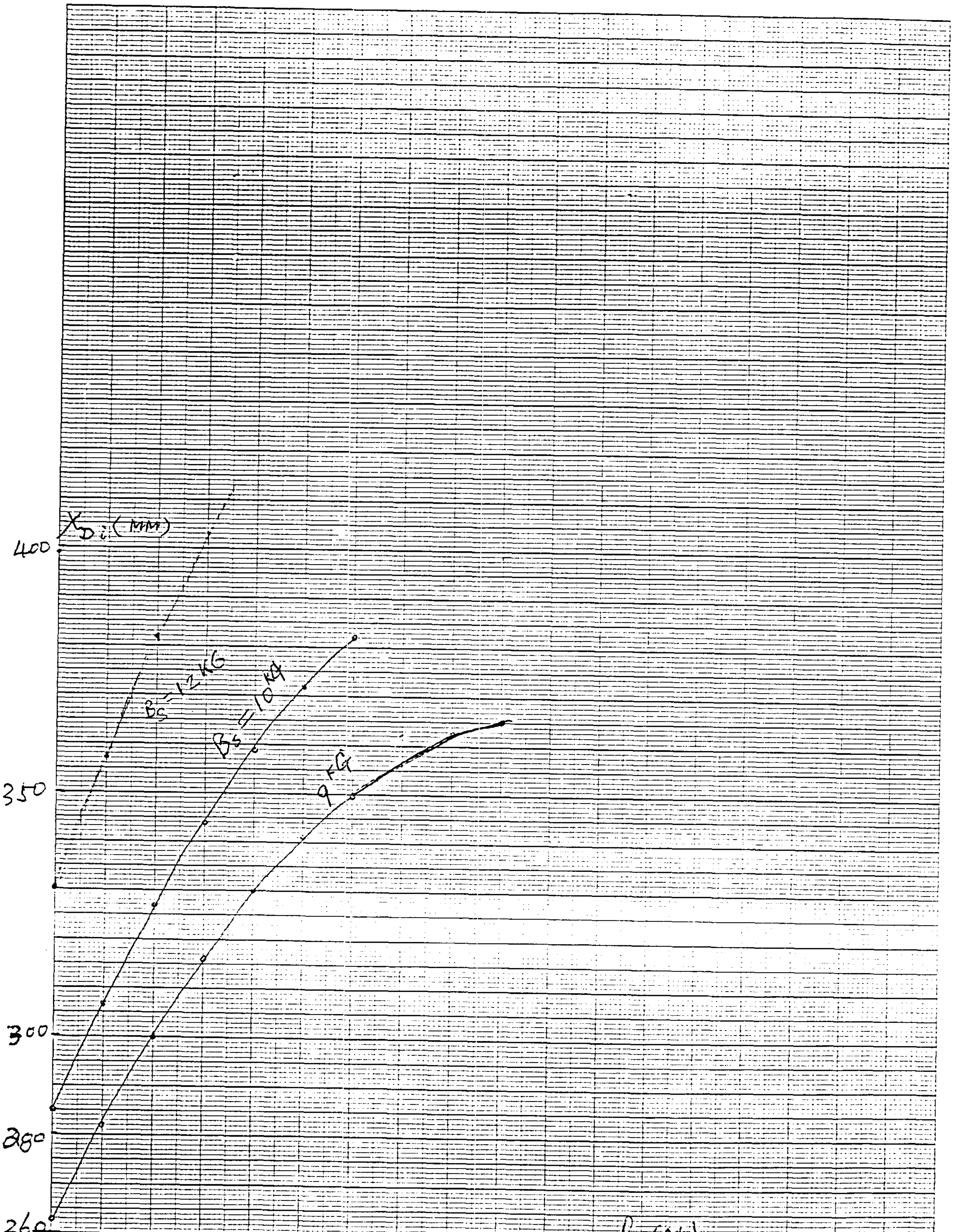
Fig.1 shows the closed orbit near the beam bump region, where the beam size at the injection and the beam size at the extraction for the proton and heavy ion is also shown for comparison. Figs. 2 shows the corresponding kickers needed for displacing the beam into the septum, which located at 50.8mm from the central orbit. With the beam size, the total beam displacement will be about 90 mm including the beam bump. Fig.3 shows the corresponding septum magnet consideration for the beam to clear the quadrupole Q6D 35 cm. These consideration will be discussed further by G. Cottingham.



φ(...) = 174.53 m
φ (mV)
K1 = 2.527
K2 = 2.587
K3 = 1.552
K4 = 3.101
K5 = -1.552
Septum
4
5
40
10
0
F1
F2
K1
10
K2
F4
F6
20
K3
F7
30
K4
A1
A2
K5
A3
40 1323



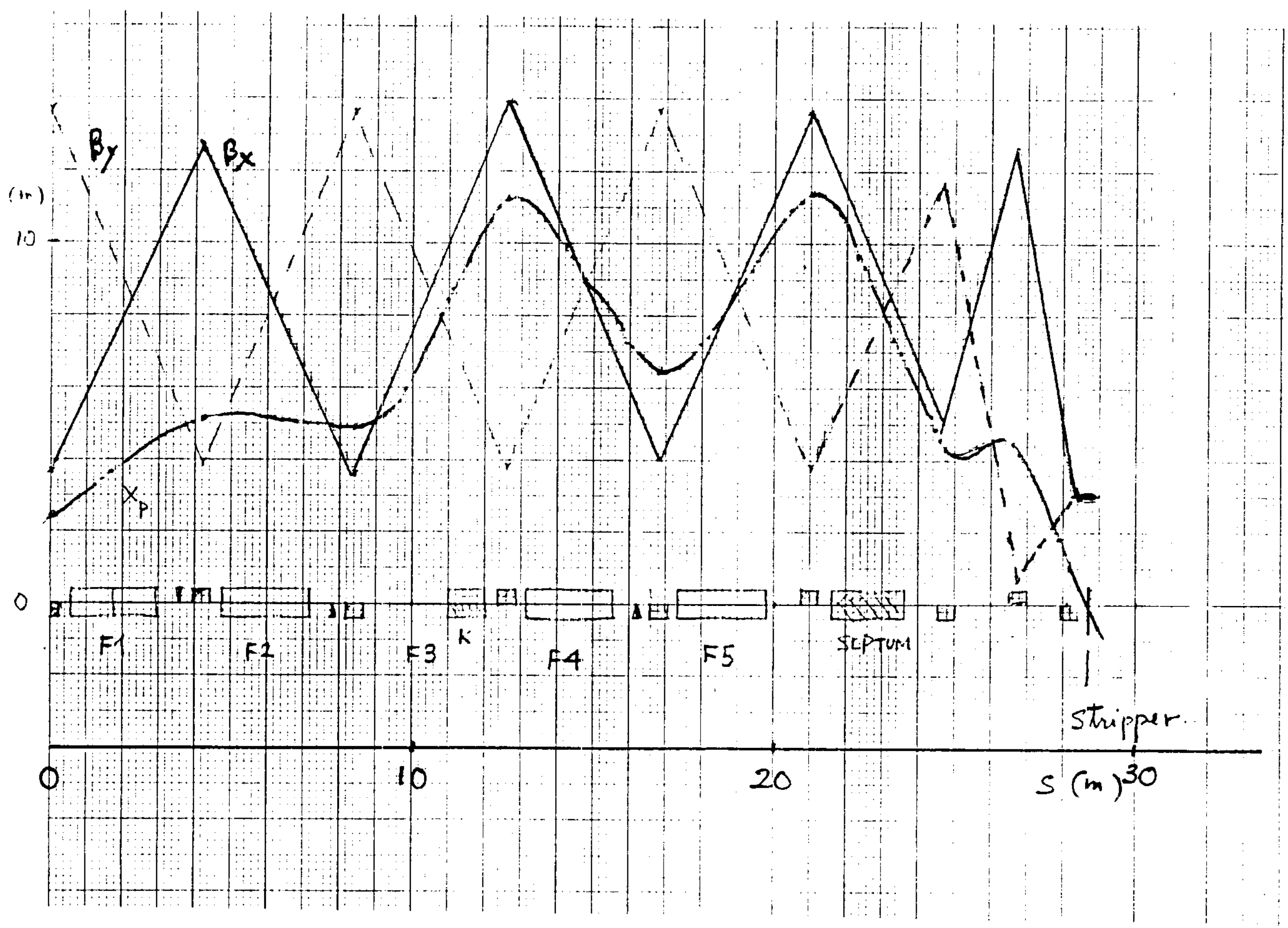
Xs (mm)
200
100
Bk = 1.5 KG
1 KG
lk (M)
0.4
0.5
0.6
0.7
0.8
0.9
1.0



X_Di (MM)
400
350
300
280
260
1.4
1.6
1.8
2.0
2.2
2.4
2.6
2.8
3.0
3.2
ℓs (M)
Bs = 12 KG
Bs = 10 KG
9 KG

2. Focusing at the stripper

The beam of heavy ion is then transported to the stripper of copper with 70 mg/cm^2. Three quadrupoles are used to tune the betatron amplotudes of 3x3 m and Xp=0 m. After the stripper the beam is expected to increase its emittance by an amount of 1 pi-mm-mrad. Fig. 4 show the betafunctions in this special focusing region.



3. Beam transport

The beam is then transported with three dipoles onto the beam line of the old 50 MEV injection line. At the present design these dipoles are combined functions. Because of the heavy ion has higher charge after the stripper, the magnet field required is smaller by a factor of .724, .547, .418 for Cu,I, and Au respectively. Minimum of 6 quadrupoles is needed to match the betatron functions of the AGS ring. More realistically, simple FODO quadrupoles with roughly the same geometrical distribution can be used in the beam transfer after the dipoles. That is quadrupoles will be placed every 3.5 m of distance. We shall come up appeoximately 12 quadrupoles of .5 m. The betatron function can be controlled to within 15 m in average.

Table 1 list all the relevant elements of the booster transfer line. Note that the heavy ion and proton beams have different magnet rigidity at the extraction. The kicker is more seriously constrained by the proton consideration than the heavy ion beam. At the septum, the heavy ion central orbit and the proton central orbit is displaced by a distance of 12 mm. This displacement will continue until the straight section of the transfer line, where the a small orbit corrector will be used to adjust these two beams.

The final matching of the betatron functions to the AGS will be worked out with the AGS beam line. We have not done do in the present preliminary study.

Booster extraction and AGS injection system

Beam bumps:	
F2B	-0.01119 of tha main dipoles
F4B	-0.01119
F7B	-0.01343
A1B	-0.01343
Kicker @F3	
L	
dx(proton)	66 mm@brho=5.677 or 11 for 2.5Gev
(heavy ion)	50 mm@brho=16.7
theta kick	8.383233 mrad
x@sept.(prot)	88 mm from central orbit
(h.i.)	77 mm
Septum@F6	
L	
theta sept.	125.7485 mrad
thickness	10 mm including vacuum chamber
Transfer line	field@brho=16.7
	all quads .5m
q1	-20 T/m
q2	23 T/m
q3	-24 T/m
strip foil	70 mg/cm^2
beta@foil	3 m x&y
Xp	0
E loss	5 Mev/amu
sig. E	0.5 Mev/amu
	brho=11 Tm is used in the following
B1T	1.58 m
	1.32 T/m
q4	-8.17 T/m
B2T	2.12 m
q5	9.88 T/m
B3T	1.58 m
	-3.29 T/m
q6	7.90 T/m
q7	-9.22 T/m
q8	8.10 T/m
q9	-7.44 T/m
q10	6.59 T/m
q11	-7.25 T/m
q12	9.88 T/m
q13	-7.25 T/m
q14	7.25 T/m
q15	-6.59 T/m
q16	7.90 T/m
q17	-9.88 T/m
AGS injection	

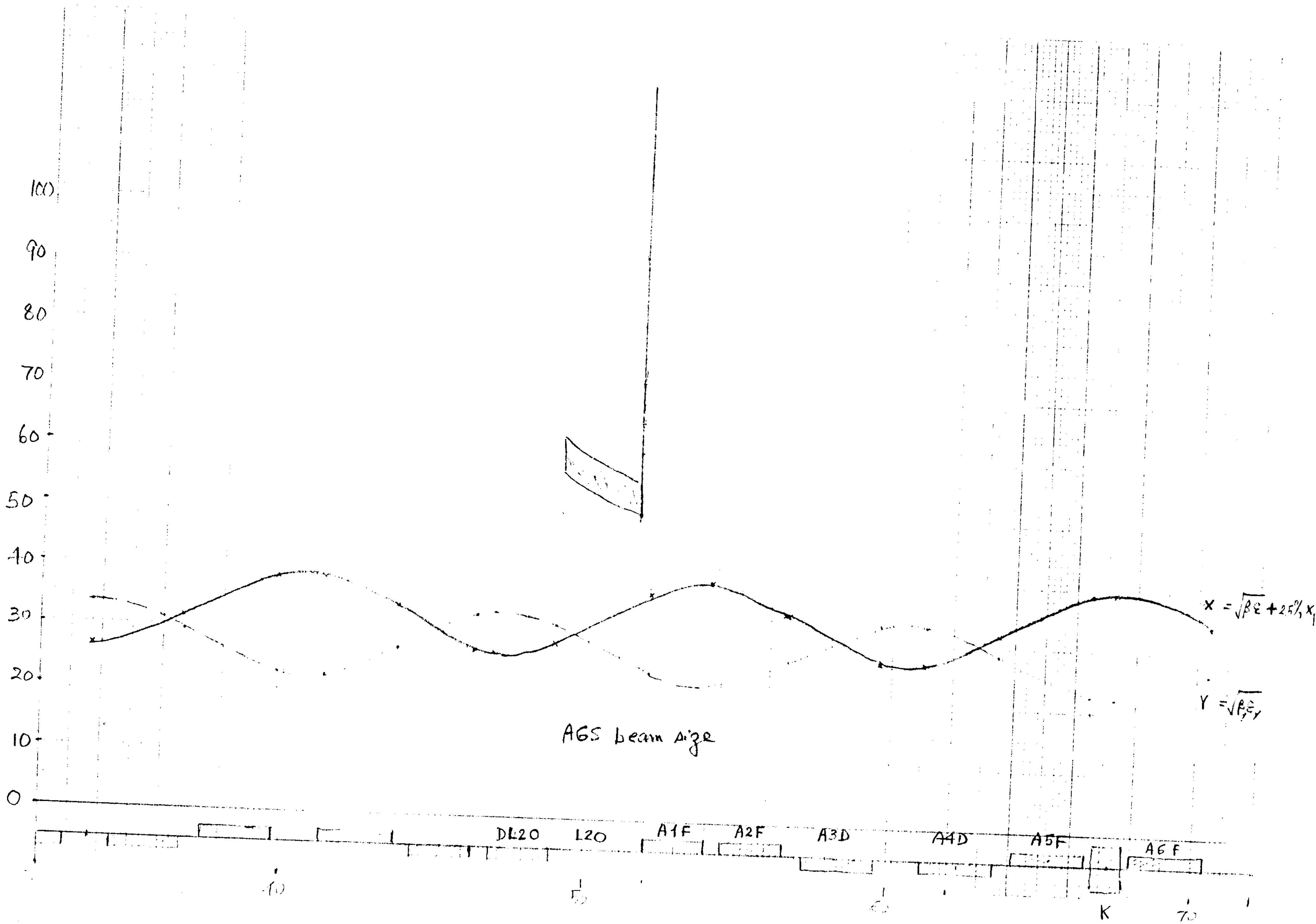
4. AGS injection components

The AGS lattice beam size is shown in Fig. **5**, where the emittance is taken to be 50 mmmrad and the p/p = .25% . The beam is injected through the open magnets of L19 L20 . The septum is located at S20 about 50 mm away from the horizontal central orbit. The kicker located at A5 straight section kicks the beam 50 mm. Table 2 summeries the kicker strength needed for various kick distances. At =11 Tm, we observe that

lk	=	1.00	m
θ_k	=	2.94	mrad
V	=	32.95	KVolts
I	=	1.97	KA
L	=	2.51	microH
B	=	0.32	KG

These parameters are the parameters needed for the consideration of power supplies. The corresponding septum is given by

ls	=	2.50	m
θ_s	=	40.	mrad



AGS beam size
$X = \sqrt{\beta\varepsilon} + 25\% x_1$
$Y = \sqrt{\beta_y \varepsilon_y}$
DL20
L20
A1F
A2F
A3D
A4D
A5F
K
A6F
0
10
20
30
40
50
60
70
80
90
100

Table . parameters for kicker and septum of AGS injection

1			1	1.033	
-0.09	1		0	1	
		1			1
1	2.616		1	1.033	0
	1		-0.09	0.899	0
		1	0	0	1
1			0.746	3.387	0
-0.09	1		-0.09	0.899	0
		1	0	0	1
1	2.806		0.746	3.387	0
	1		-0.16	0.571	0
		1	0	0	1
1			0.271	4.991	0
0.115	1		-0.16	0.571	0
		1	0	0	1
1	3.911		0.271	4.991	0
	1		-0.13	1.149	0
		1	0	0	1
1			-0.26	9.485	0
0.115	1		-0.13	1.149	0
		1	0	0	1
1	2.997		-0.26	9.485	0
	1		-0.16	2.246	0
		1	0	0	1
1			-0.77	16.22	0
-0.11	1		-0.16	2.246	0
		1	0	0	1
1	1.955		-0.77	16.22	0
	1		-0.07	0.375	0
		1	0	0	1
			-0.93	16.95	0
			-0.07	0.375	0
			0	0	1

The kicker parameters:

lk= 1 m

dt= 150 ns

dimen=0.152 0.076 (6'x3')

Brho= 11 Tm

thk	V(KV)	I(A)	B(KG)	Lm(muH)
-2.94	32.95	1967.	0.324	2.513
-3.53	39.54	2360.	0.389	2.513
-3.83	42.84	2557.	0.421	2.513
-4.12	46.14	2753.	0.454	2.513
-4.42	49.43	2950.	0.486	2.513
-4.71	52.73	3147.	0.519	2.513

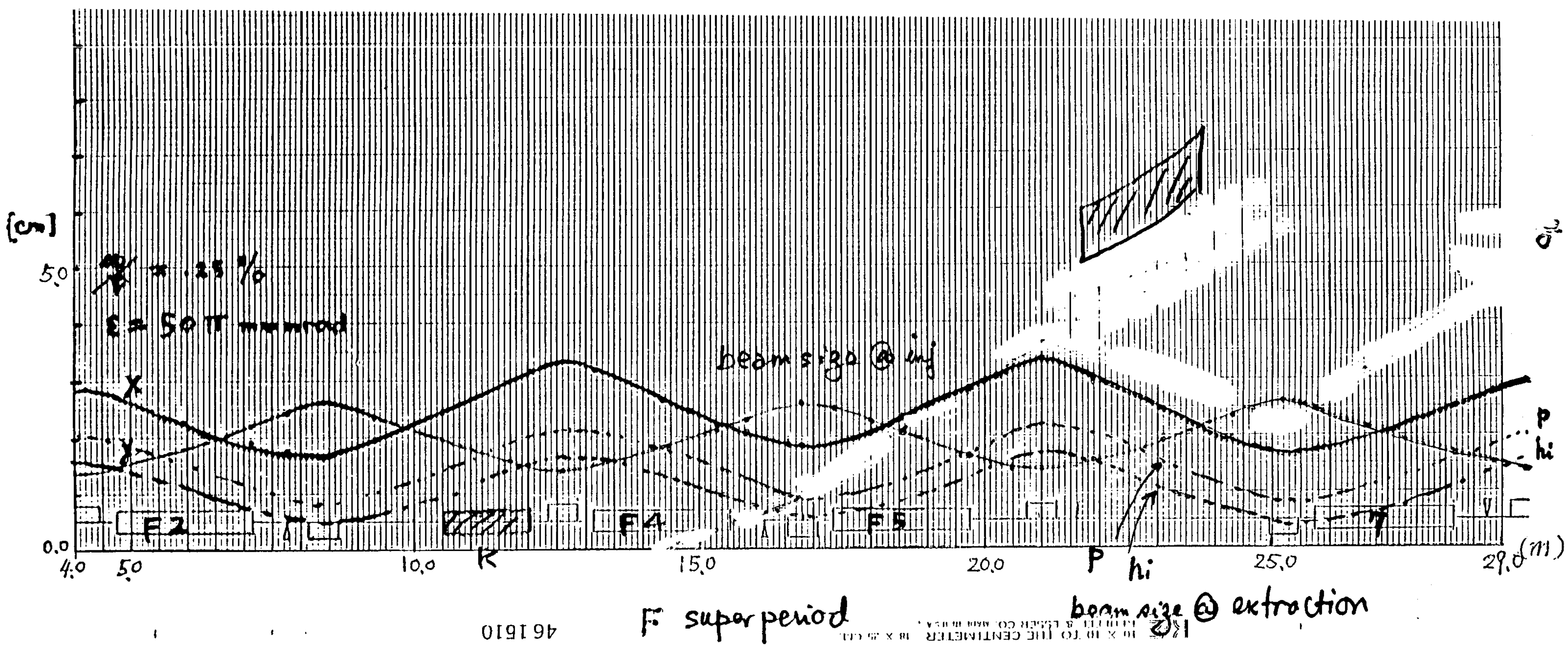
xs(mm)	xs'-mr	thk(mrad)
50	2.744	-2.94
60	3.293	-3.53
65	3.568	-3.83
70	3.842	-4.12
75	4.116	-4.42
80	4.391	-4.71

						xs	xs'	thk		
Septum consideration						50	2.744	-2.94		
1			1	1.612		60	3.293	-3.53		
	1	23.50		1		65	3.568	-3.83		
		1			1	70	3.842	-4.12		
						75	4.116	-4.42		
1	2.616		1	1.612	0	80	4.391	-4.71		
	1		0	1	23.50	xs	xs'	x	x'	ths
		1	0	0	1	50	2.744	475	-90.0	45.83
1			1	4.229	61.48					
	1	23.50	0	1	23.50	xs=50mm,xs'=2.744mrad@exit of				
		1	0	0	1	x@118	x'	ths		septum
1	2.527		1	4.229	61.48	400	-78.9	34.73		
	1		0	1	47.00	425	-82.6	38.43		
		1	0	0	1	450	-86.3	42.13		
						475	-90.0	45.83		
			1	6.756	180.2	500	-93.7	49.53		
			0	1	47.00					
			0	0	1					

Appendix.

1. Booster beam size at the injection energy and at the extraction energy.
2. Booster arrangement at the extraction region.
3. Relation between the AGS and the Booster ring.

Beam size for the booster @ injection
and extraction



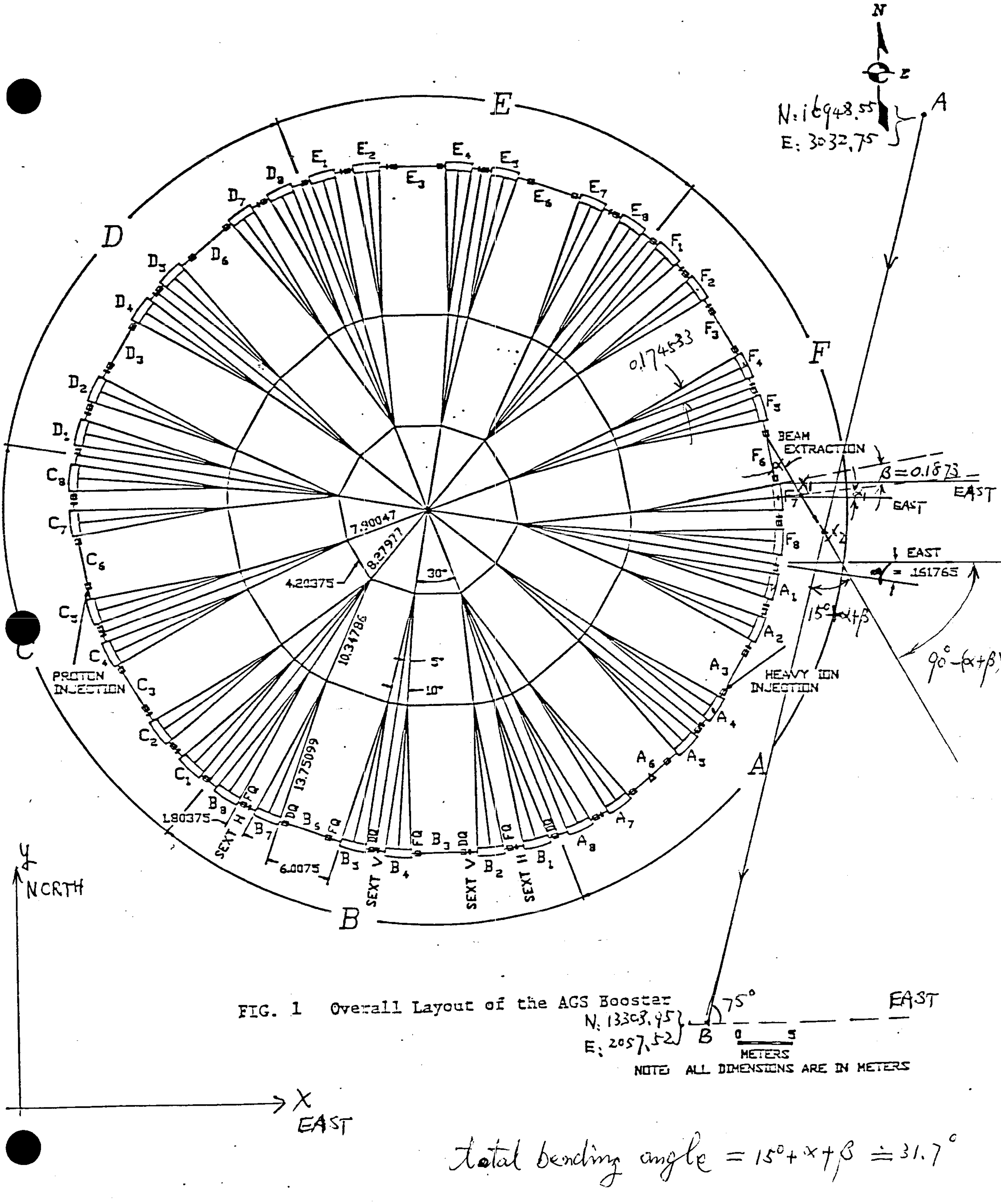
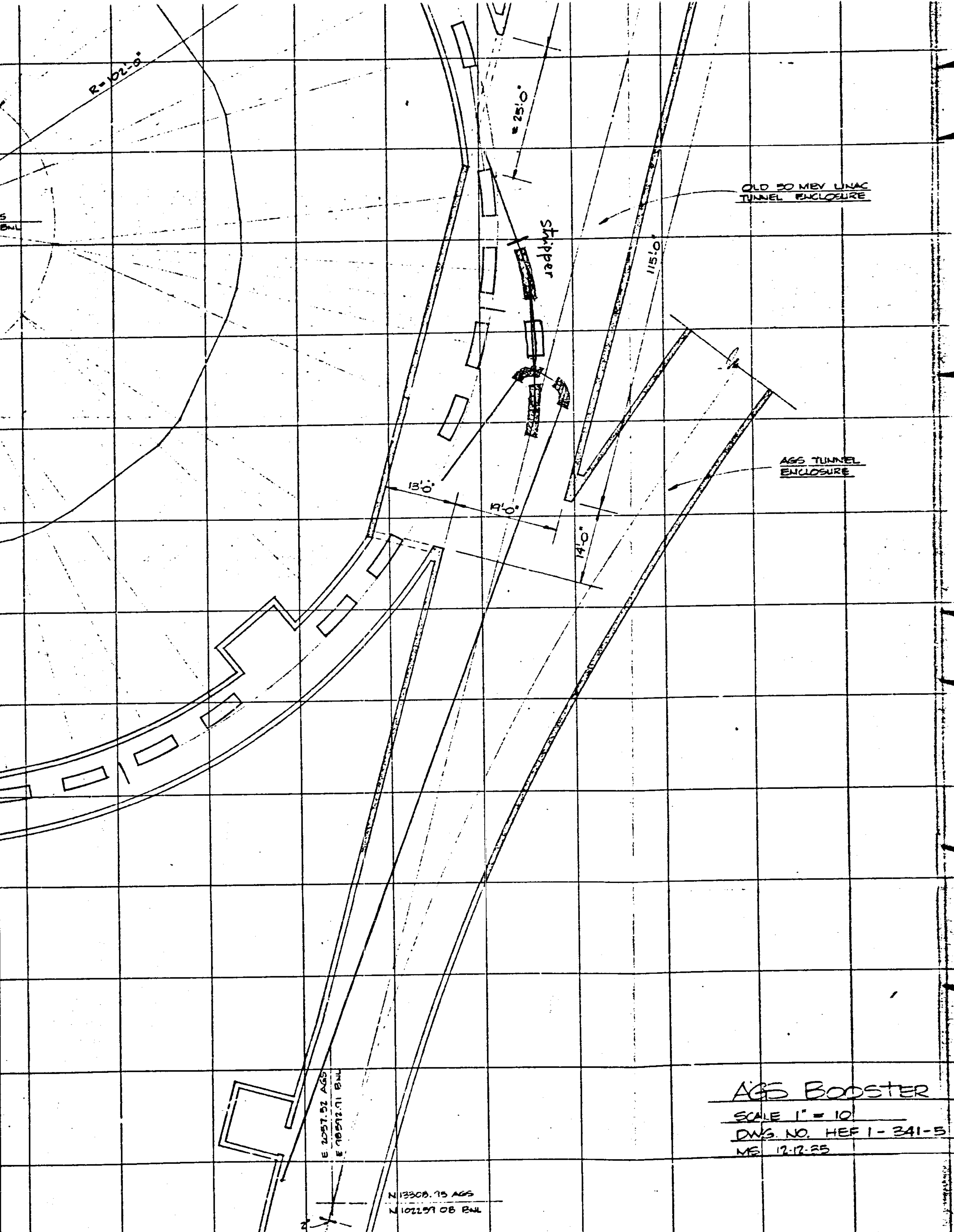


FIG. 1 Overall Layout of the AGS Booster

total bending angle $= 15^\circ + \alpha + \beta \doteq 31.7^\circ$


R=102'-0"
25'-0"
stripper
115'-0"
OLD 50 MEV LINAC TUNNEL ENCLOSURE
AGS TUNNEL ENCLOSURE
13'-0"
19'-0"
14'-0"
E 2057.52 AGS
E 78592.71 BNL
N 13308.75 AGS
N 102259.08 BNL
AGS BOOSTER
SCALE 1" = 10'
DWG. NO. HEF 1-341-5
MS 12-12-85