Location of Septum Magnets

by Steve Milton

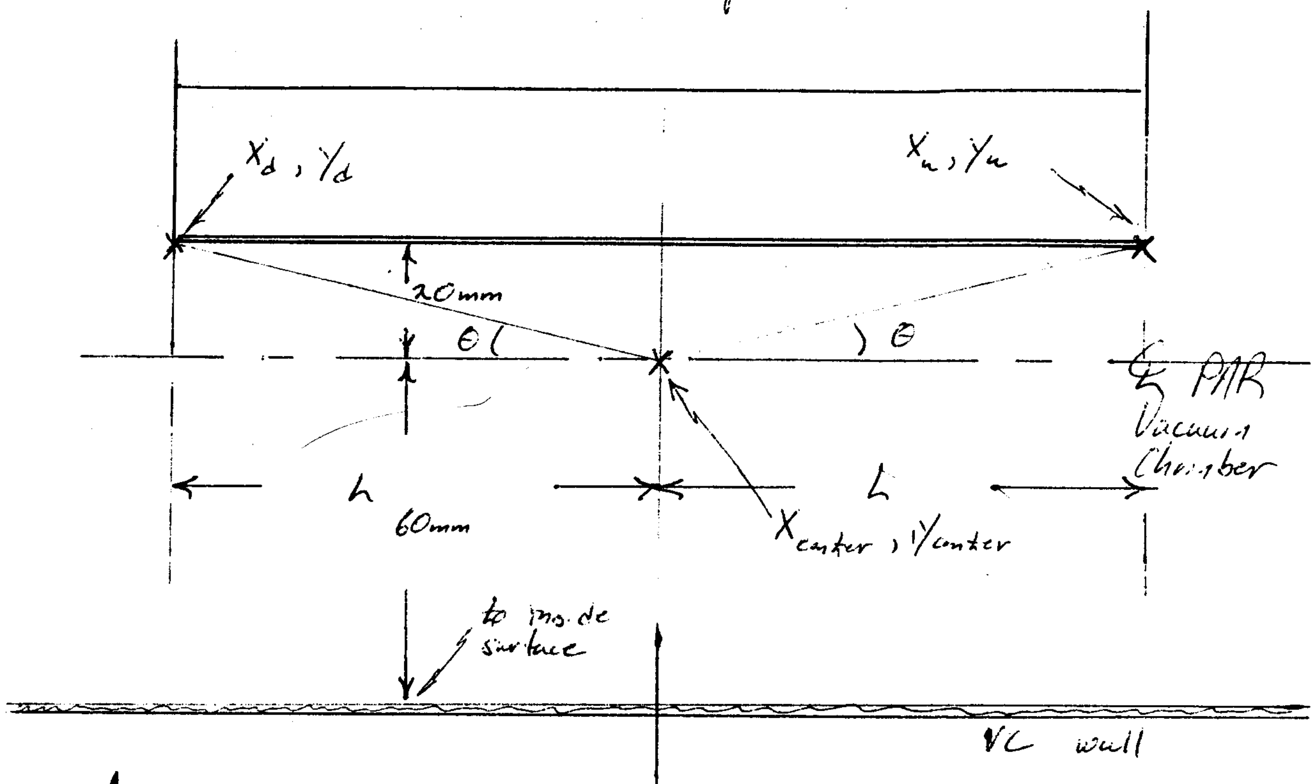
1. Placement of PAR Septum
2. Locating the Booster Injection Septum Magnet
3. Location of the Booster Extraction Septum Magnet
4. Location of the Storage Ring Injection Septum Magnet

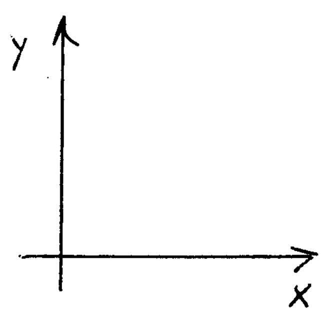
Prepared for Mark Jaski and Jim Humbert

April 30, 2003

1. Placement of PAR Septum

Placement of the PIR Septum





$X_u = X_{center} + L$

$Y_u = Y_{center} + 20mm$

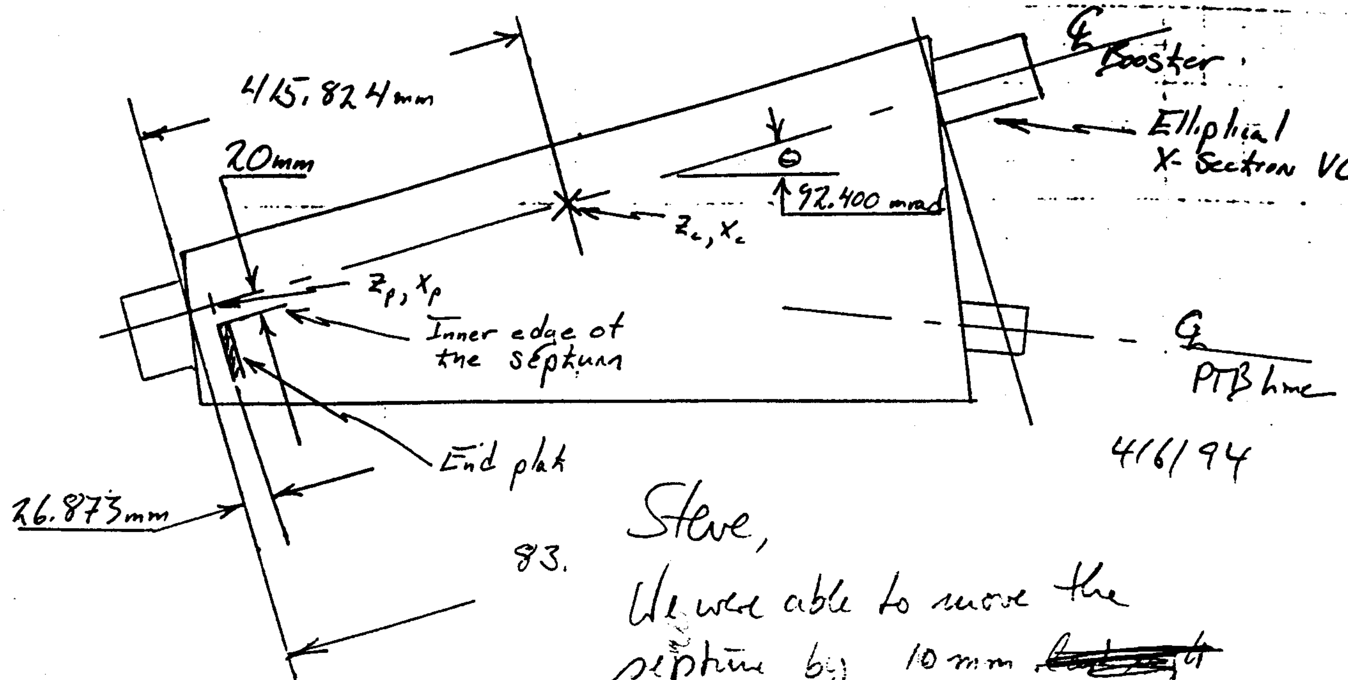
All dimensions assumed to be in mm

$X_d = X_{center} - L$

$Y_d = Y_{center} + 20mm$

2. Locating the Booster Injection Septum Magnet

Locating the Booster Injection Septum Magnet



4/6/94

Steve,
We were able to move the septum by 10 mm ~~[illegible]~~

Beam centroid at magnet

Hank
I would like to discuss with you the results of the smoothing process.

Beam perpendicular offset

$Z_p = Z^b_{out} - d^b \sin\theta = 15.57711$

$X_p =$

$x = 629.0438637$ 15.97771 $\Delta = 0.017284$ m (0.68")

$y = 2685.07806291$ 68.20098 $\Delta = 1.60272$ mm

The midpoint are defined by septum box end

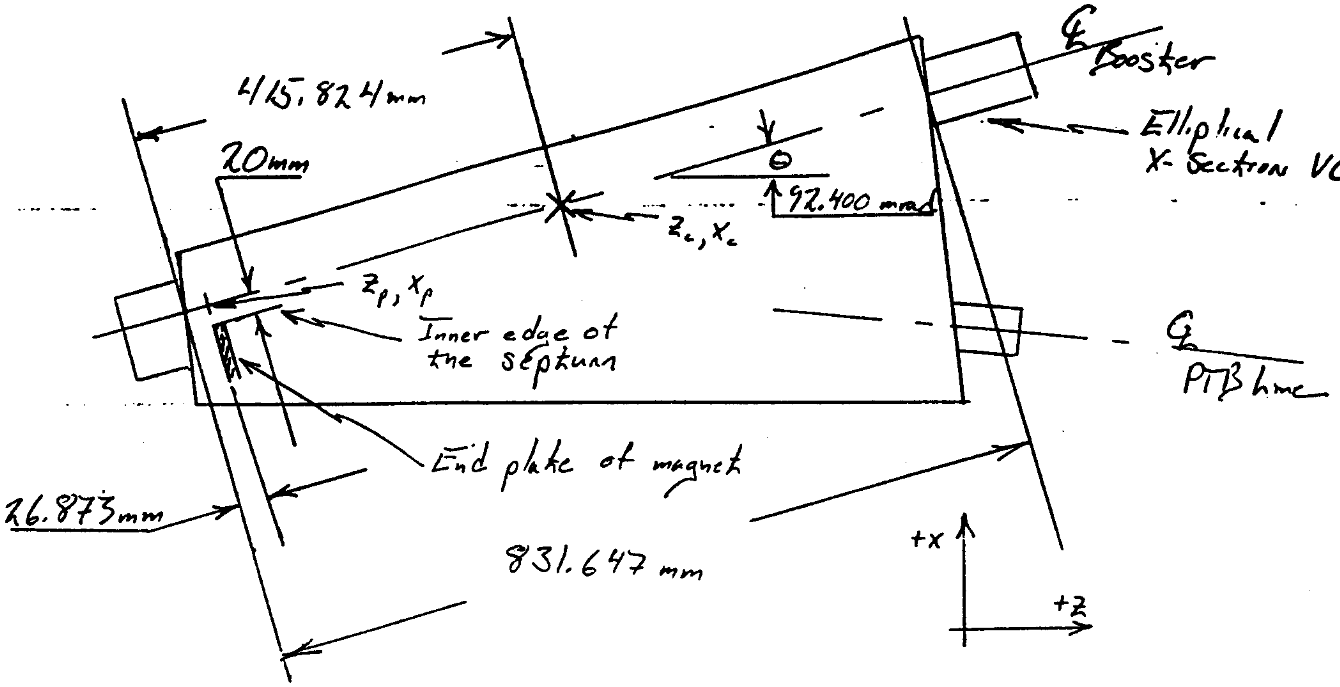
$\Delta x = 1.0502"$ (26.67508 mm)

STEVE - PLEASE [illegible] THESE NUMBERS [illegible] INSTEAD OF THESE [illegible] THIS [illegible] THANKS [illegible]

$Z_c = Z_p + ($

$X_c = X_p + ($

Locating the Booster Injection Septum Magnet



Beam centroid at magnet exit $z^b_{out} = 15.575925$ m

$x^b_{out} = 68.133436$ m

Beam perpendicular offset at exit $d^b = 30.187$ mm

$$z_p = z^b_{out} - d^b \sin\theta = 15.57314 \text{ m}$$
$$x_p = x^b_{out} + d^b \cos\theta = 68.16349 \text{ m}$$

The midpoint of the line formed by the two points which are defined by the intersection of the Booster ℄ and the septum box end plates is

$$z_c = z_p + (0.415824 - 0.026873)\cos\theta = 15.96043 \text{ m}$$
$$x_c = x_p + (0.415824 - 0.026873)\sin\theta = 68.19938 \text{ m}$$

- Step-by-Step Procedure
  1) Determine the center of the upstream elliptical X-section UC
  2) Determine the line in space which is exactly 20mm from the septum wall at the exit of the magnet
  -- You now have the desired line which should lie on the Booster ℄.
  3) Determine the intersection of this line with the box end plates. I've assumed the box was level and the lines was on the end plates were drawn plumb.
  4) Determine the location of all fiducial blocks with respect to the above lines on the end plate.
  5) Locate point z_c, x_c and the yaw angle θ. Note, the vertical position should be set by symmetrically locating the box about the nominal beam height.
  6) If, after performing the above procedure, the magnet does not perfectly line up with the images then slide point z_c, x_c forward or back along the Booster ℄. The new location of z_c^{new}, x_c^{new} should fall on the line

$$x_c^{new} = 0.0926635 \, z_c^{new} + 66.72043$$

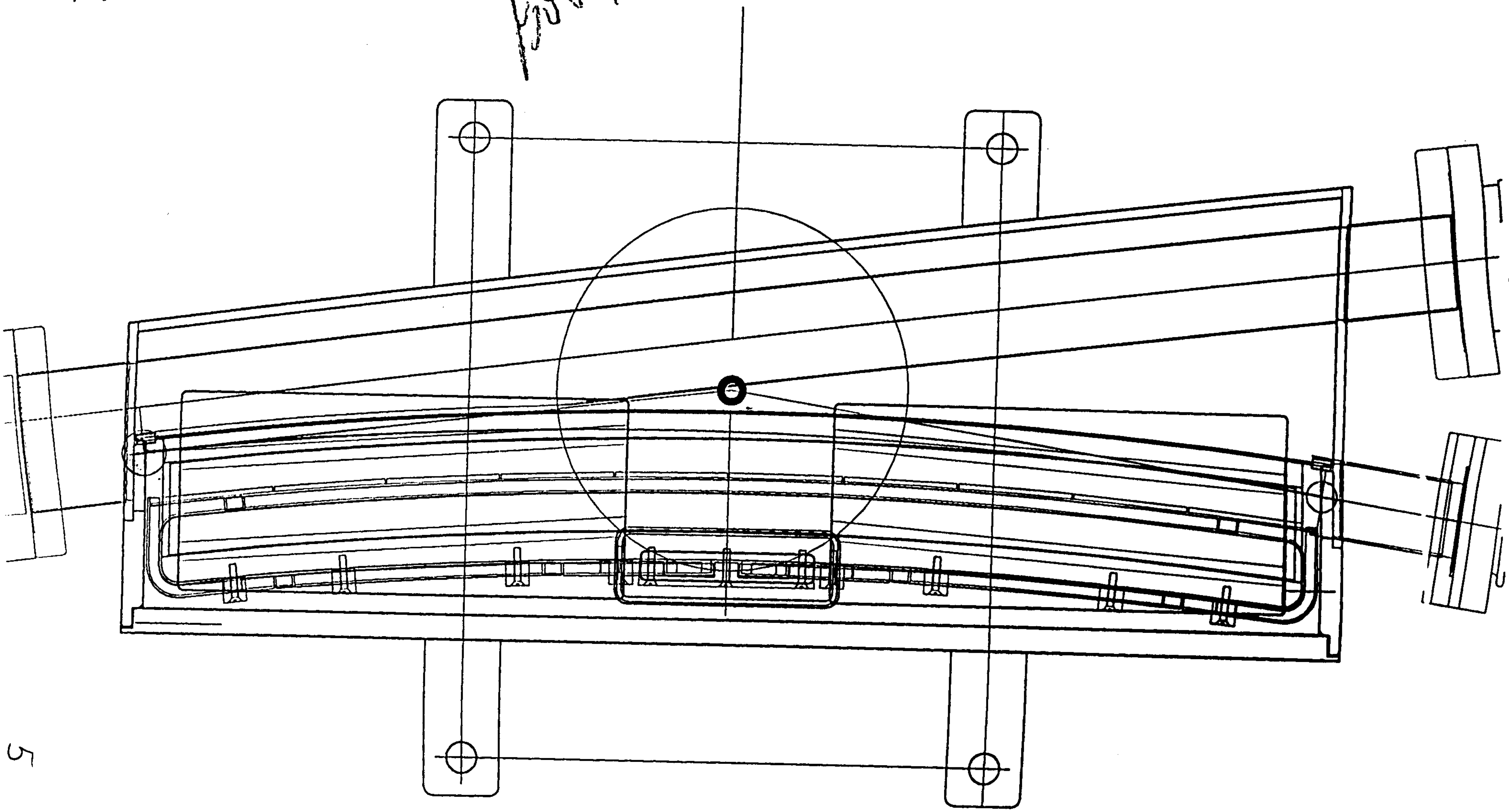
• Further Notes

- The distance from the line drawn perpendicular to the Booster VC ℄ at the end plate to ℄ intersection point ~~show~~ to the magnet end plate inside the box should be 26.873mm.
- The length of the line decribed in ~~the~~ step 1)+2) of the step-by-step procedure should be 831.647mm.
- Variations in the above 2 numbers will be due to variations in construction vs. drawing. These variations may force the sliding of point z_c, x_c as described in 6) above.
- I'm assuming that the construction is accurate enough to allow sensible connection to the ATB line.
- I have no good solution as to how one accurately sets the magnet roll. This will have to be determined when the magnet is finally assembled in the box. I'm hoping the top plate of the box will be an accurate enough reference. I would like to see the magnet leveled to within 7mrad. Better is always appreciated.

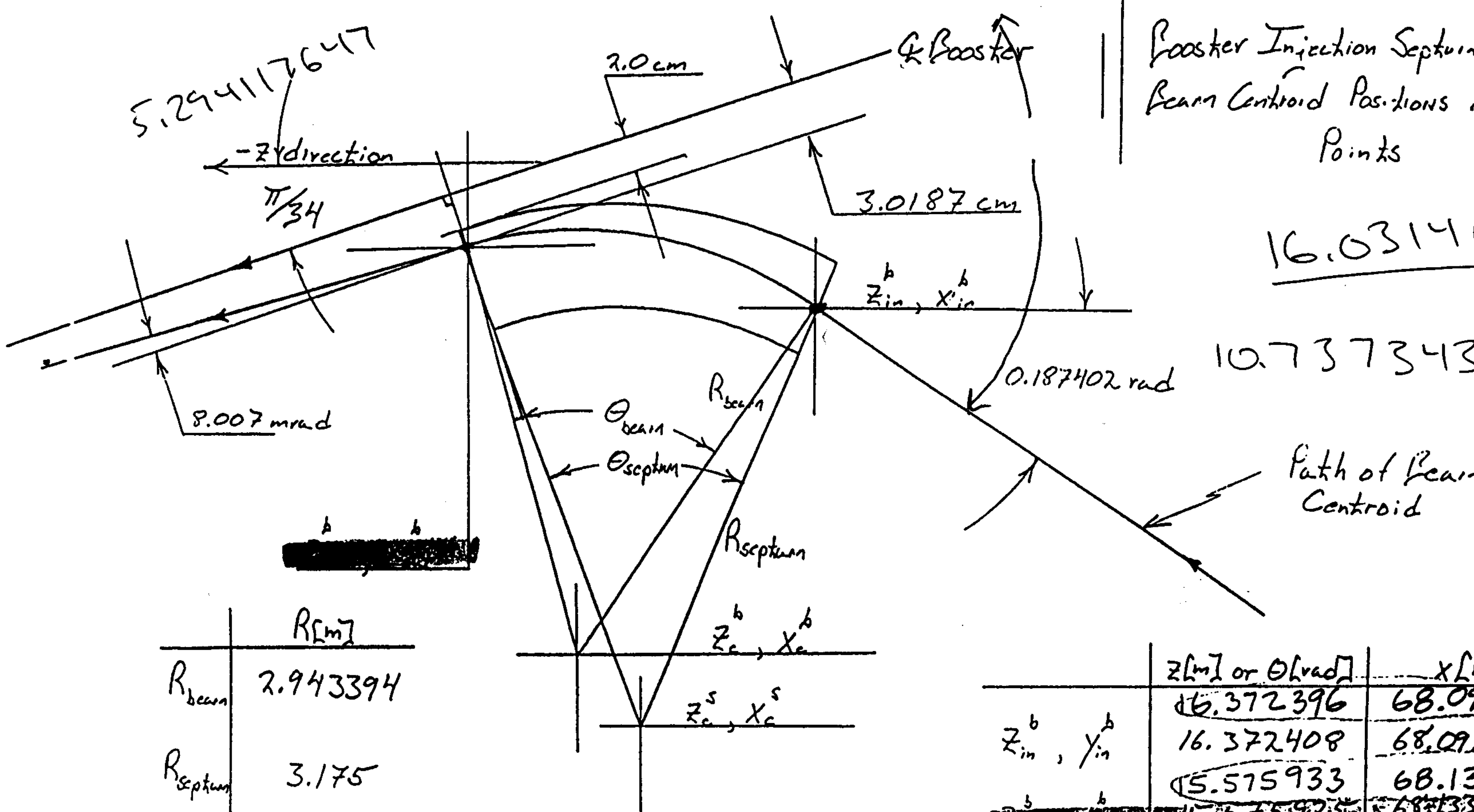
STEVE

IT LOOKS AS THOUGH I ORIGINALLY USED TWO CIRCLES (INDICATED BLUE & YELLOW) ON GLEN'S MAGNET LAYOUT AS PLACEMENT POINTS. I'M WONDERING IF I WAS CORRECT IN USING THOSE POINTS.

Bob K.



Booster Injection Septum and Injected Beam Centroid Positions at Key Points



	R[m]
R_{beam}	2.943394
R_{septum}	3.175

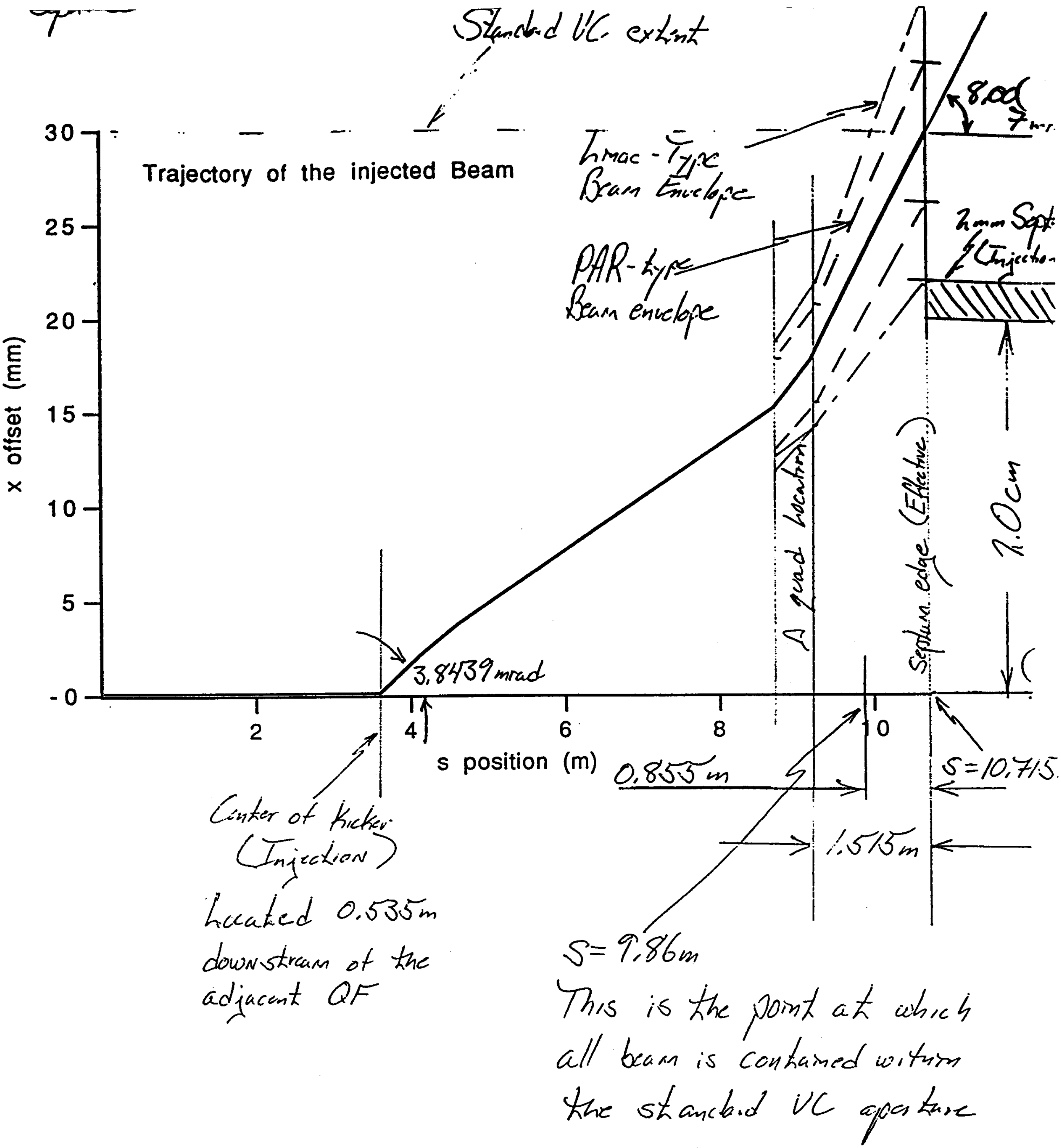
	z[m] or Θ[rad]	x[m]	Notes
z_{in}^b , y_{in}^b	16.372396	68.092378	1)
	16.372408	68.092377	
	15.575933	68.133626	
[redacted]	[redacted]	[redacted]	
z_c^b , y_c^b	15.824031	65.200517	
z_c^s , y_c^s	15.842929	64.977125	
Θ_{beam}	0.2717951		
Θ_{septum}	0.251970		

ACTUAL PTS. ON MY DWG 1)

Coordinate system 0,0 located at the storage ring center point.

+X, +Z

Notes: 1) The location of z_c^s, x_c^s will be close to that quoted in the table but nevertheless approximate. Slight adjustment may be necessary to place point z_{in}^b, x_{in}^b into the center of the upstream end of the septum magnet aperture.



Standard VC extent
Trajectory of the injected Beam
x offset (mm)
30
25
20
15
10
5
-0
2
4
6
8
10
s position (m)
Linac-Type Beam Envelope
PAR-type Beam envelope
8.0d
7mm
2mm Sept
& Injection
3.8439 mrad
A quad location
Septum edge (Effective)
7.0cm
0.855m
1.515m
S=10.715
Center of Kicker (Injection)
Located 0.535m downstream of the adjacent QF
S=9.86m
This is the point at which all beam is contained within the standard VC aperture

||Drawing 2||

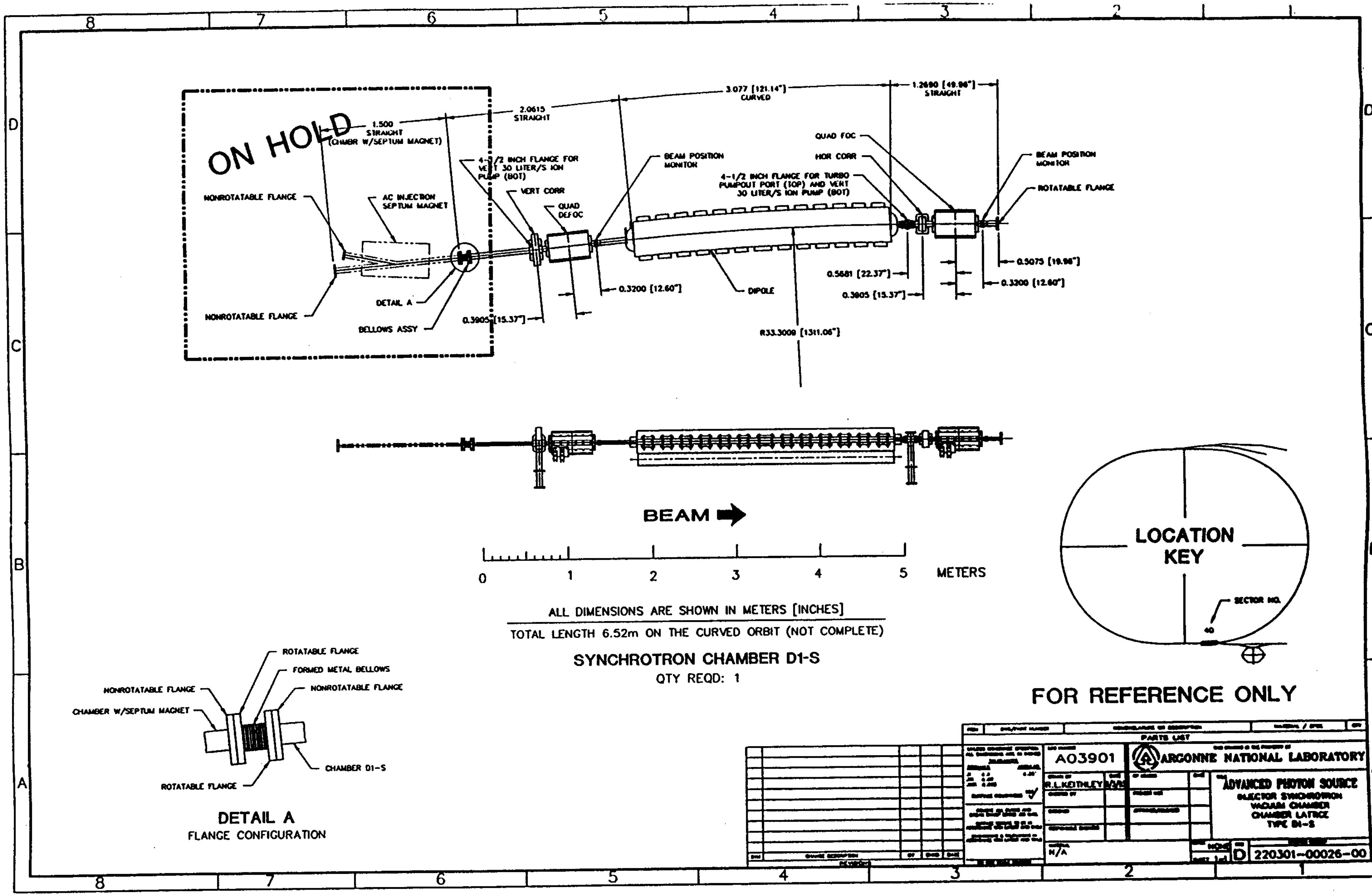
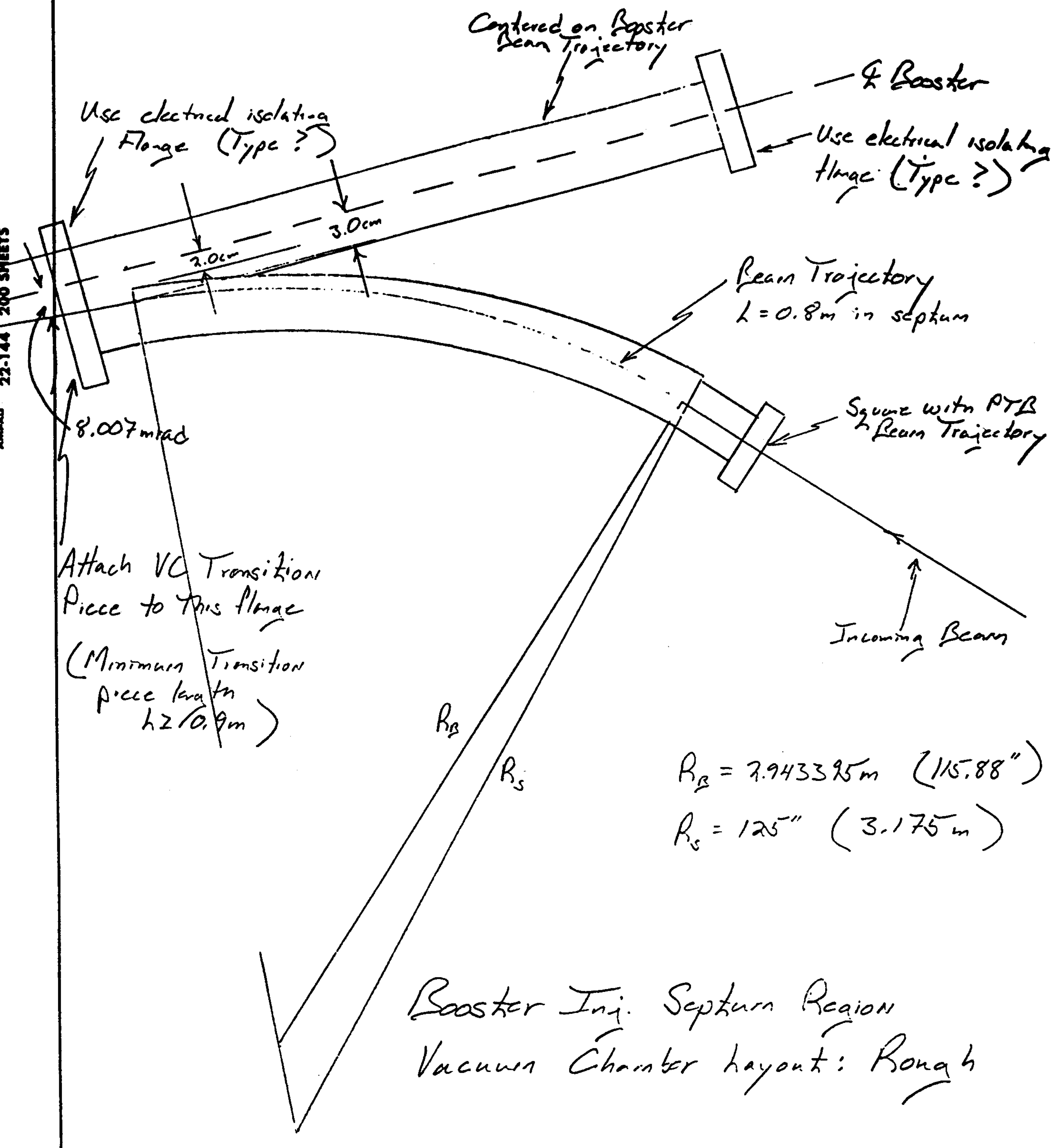

ON HOLD
1.500 STRAIGHT (CHMBR W/SEPTUM MAGNET)
2.0615 STRAIGHT
3.077 [121.14"] CURVED
1.2690 [49.96"] STRAIGHT
NONROTATABLE FLANGE
AC INJECTION SEPTUM MAGNET
DETAIL A
BELLOWS ASSY
4-1/2 INCH FLANGE FOR VERT 30 LITER/S ION PUMP (BOT)
VERT CORR
QUAD DEFOC
BEAM POSITION MONITOR
4-1/2 INCH FLANGE FOR TURBO PUMPOUT PORT (TOP) AND VERT 30 LITER/S ION PUMP (BOT)
QUAD FOC
HOR CORR
ROTATABLE FLANGE
DIPOLE
0.3905 [15.37"]
0.3200 [12.60"]
0.5681 [22.37"]
0.5075 [19.98"]
R33.3000 [1311.06"]
BEAM
0 1 2 3 4 5 METERS
ALL DIMENSIONS ARE SHOWN IN METERS [INCHES]
TOTAL LENGTH 6.52m ON THE CURVED ORBIT (NOT COMPLETE)
SYNCHROTRON CHAMBER D1-S
QTY REQD: 1
LOCATION KEY
SECTOR NO.
FOR REFERENCE ONLY
FORMED METAL BELLOWS
CHAMBER W/SEPTUM MAGNET
CHAMBER D1-S
DETAIL A
FLANGE CONFIGURATION
A03901
R.L.KEITHLEY
ARGONNE NATIONAL LABORATORY
ADVANCED PHOTON SOURCE
INJECTOR SYNCHROTRON
VACUUM CHAMBER
CHAMBER LATTICE
TYPE D1-S
N/A
D 220301-00026-00

Figure 1



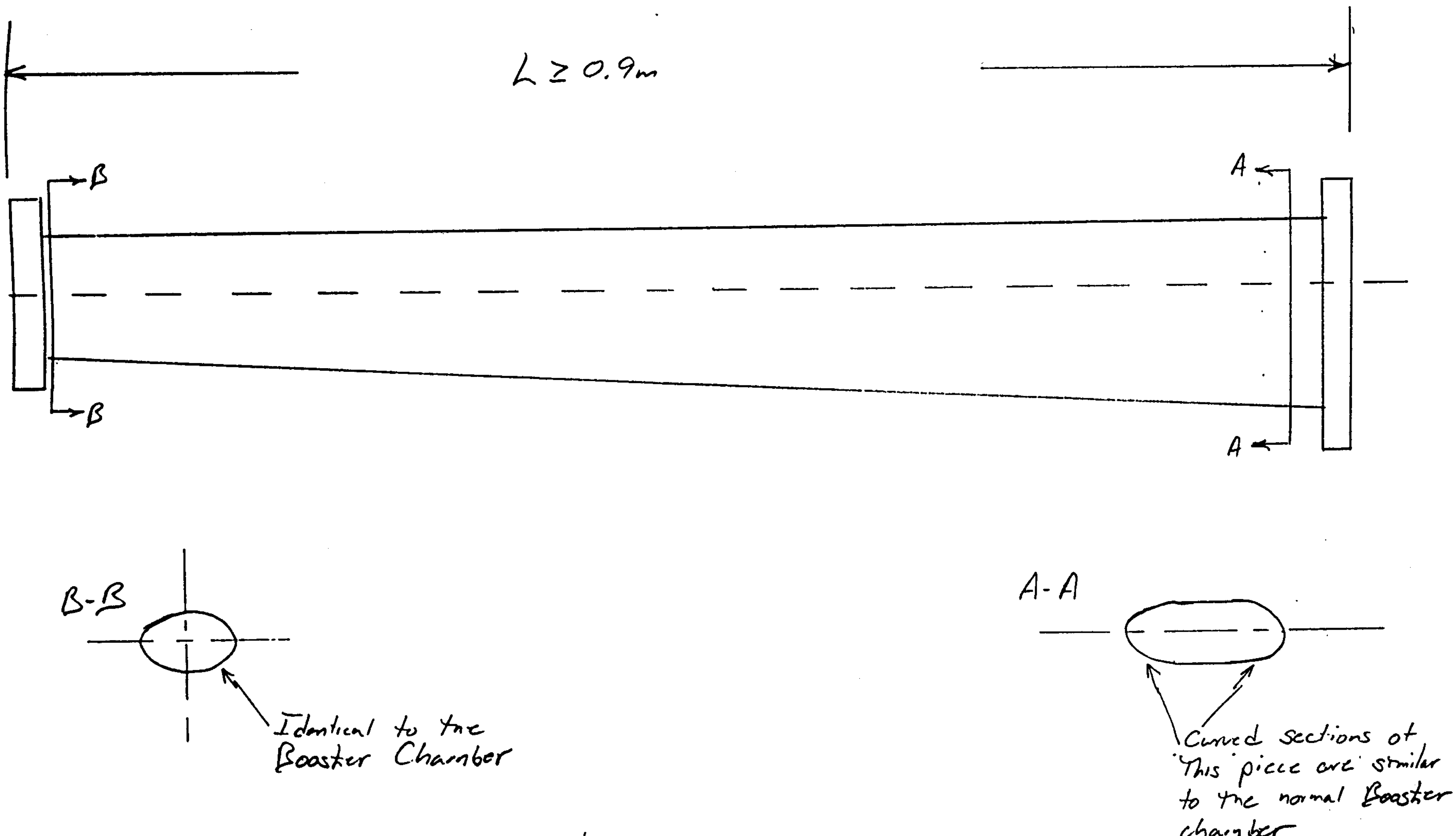
Booster Inj. Septum Region
Vacuum Chamber Layout: Rough

||Drawing 1||

26 Aug 93

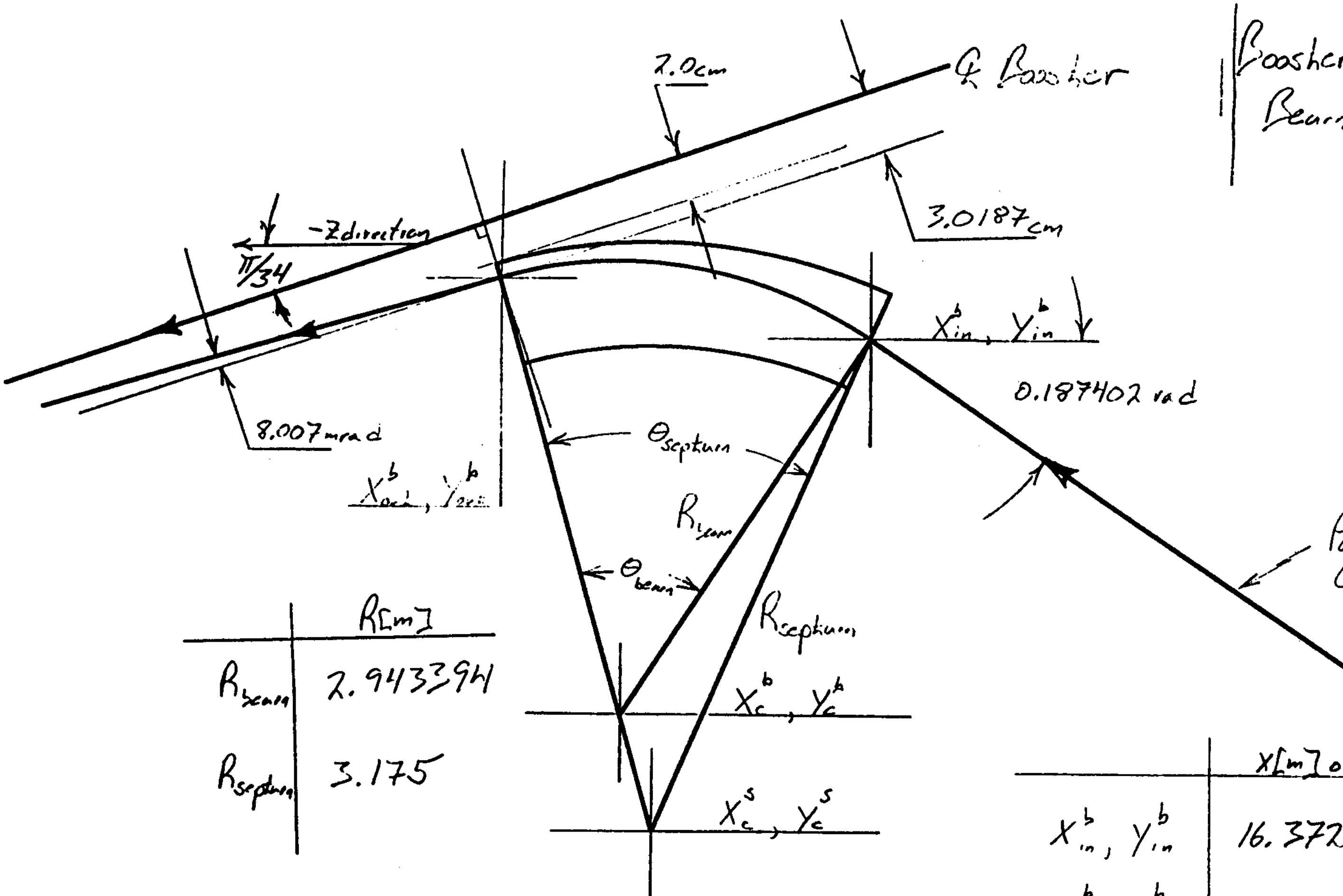
SM

Transition Piece Near the Booster Inj. Septum: Rough



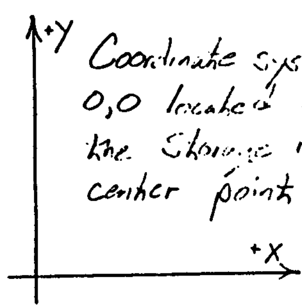
Drawing 3

Booster Injection Septum and Injected Beam Centroid Positions at Key Points



	R[m]
R_{beam}	2.9433394
R_{septum}	3.175

	X[m] or Θ[rad]	Y[m]	Notes
X^b_{in}, Y^b_{in}	16.372408	68.092377	1)
X^b_{out}, Y^b_{out}	15.575925	68.133436	
X^b_c, Y^b_c	15.824031	65.200517	
X^s_c, Y^s_c	15.842929	64.977125	1)
Θ_{beam}	0.2717951		
Θ_{septum}	0.25197		



Coordinate system 0,0 located at the Storage ring center point

Notes: 1) The location of X^s_c, Y^s_c is close to quoted but approximate. Slight adjustment may be necessary to place point X^b_{in}, Y^b_{in} into the center of the upstream end of the septum magnet aperture

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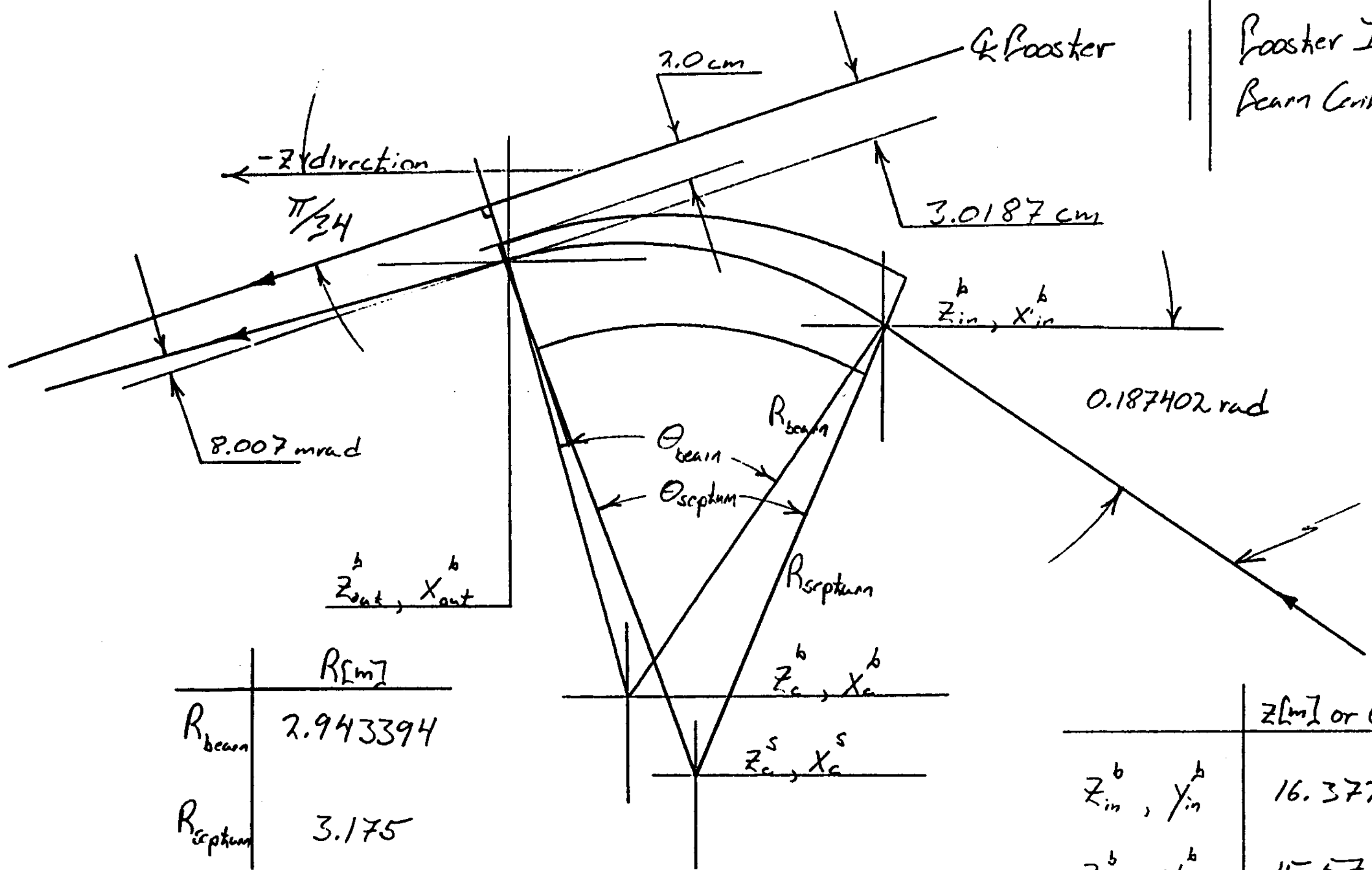
Booster Injection Septum and Injected Beam Centroid Positions at Key Points



	R[m]
R_{beam}	2.943394
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	Z[m] or Θ[rad]	X[m]	Notes
Z^b_{in}, Y^b_{in}	16.372408	68.092377	1)
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Z^s_c, Y^s_c	15.842929	64.977125	1)
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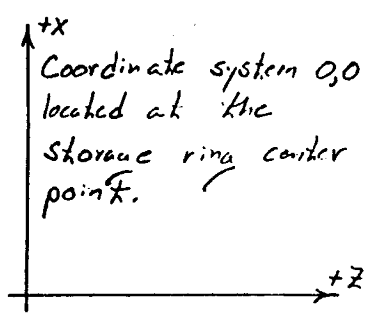

Coordinate system 0,0 located at the storage ring center point.

Notes: 1) The location of Z^s_c, X^s_c will be close to that quoted in the table but nevertheless approximate. Slight adjustment may be necessary to place point Z^b_{in}, X^b_{in} into the center of the upstream end of the septum magnet aperture.

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Injection Septum

Beam Size

Machine Functions

Septum

${}^{s}\beta_x^{in} = 6.909$ ${}^{s}\beta_y^{in} = 6.329$ ${}^{s}\eta_x^{in} = +0.535$

${}^{s}\beta_x^{out} = 4.908$ ${}^{s}\beta_y^{out} = 8.903$ ${}^{s}\eta_x^{out} = +0.532$

1st Downstream Quad

${}^{2}\beta_x^{in} = 2.173$ ${}^{2}\beta_y^{in} = 15.562$ ${}^{2}\eta_x^{in} = +0.266$

${}^{2}\beta_x^{out} = 2.175$ ${}^{2}\beta_y^{out} = 15.590$ ${}^{2}\eta_x^{out} = +0.200$

Beam Parameters

e^+ from PAR

$\varepsilon_x^{p} = 0.38 \times 10^{-6}$ m-rad (0% coupling)

$\varepsilon_y^{p} = 0.19 \times 10^{-6}$ m-rad (100% coupling)

$\delta = 4 \times 10^{-4}$

e^+ from Linac

$\varepsilon_x^{95\%} = 6.6 \times 10^{-6}$ m-rad

$\varepsilon_y^{95\%} = 6.6 \times 10^{-6}$ m-rad

$\delta^{95\%} = 0.01$

Computed Sizes

Septum

e^+ beam

$2.45\,{}^{s}\sigma_x^{in} = \pm 4.0$ mm $2.45\,{}^{s}\sigma_y^{in} = \pm 2.7$ mm

$2.45\,{}^{s}\sigma_x^{out} = \pm 3.4$ mm $2.45\,{}^{s}\sigma_y^{out} = \pm 3.2$ mm

e^- beam

$2.45\,{}^{s}\sigma_x^{in} = \pm 8.6$ mm $2.45\,{}^{s}\sigma_y^{in} = \pm 6.5$ mm

$2.45\,{}^{s}\sigma_x^{out} = \pm 7.8$ mm $2.45\,{}^{s}\sigma_y^{out} = \pm 7.7$ mm

1st Downstream Quad

e^+ beam

$2.45\,{}^{2}\sigma_x^{in} = \pm 2.2$ mm $2.45\,{}^{2}\sigma_y^{in} = \pm 4.2$ mm

$2.45\,{}^{2}\sigma_x^{out} = \pm 2.2$ mm $2.45\,{}^{2}\sigma_y^{out} = \pm 4.2$ mm

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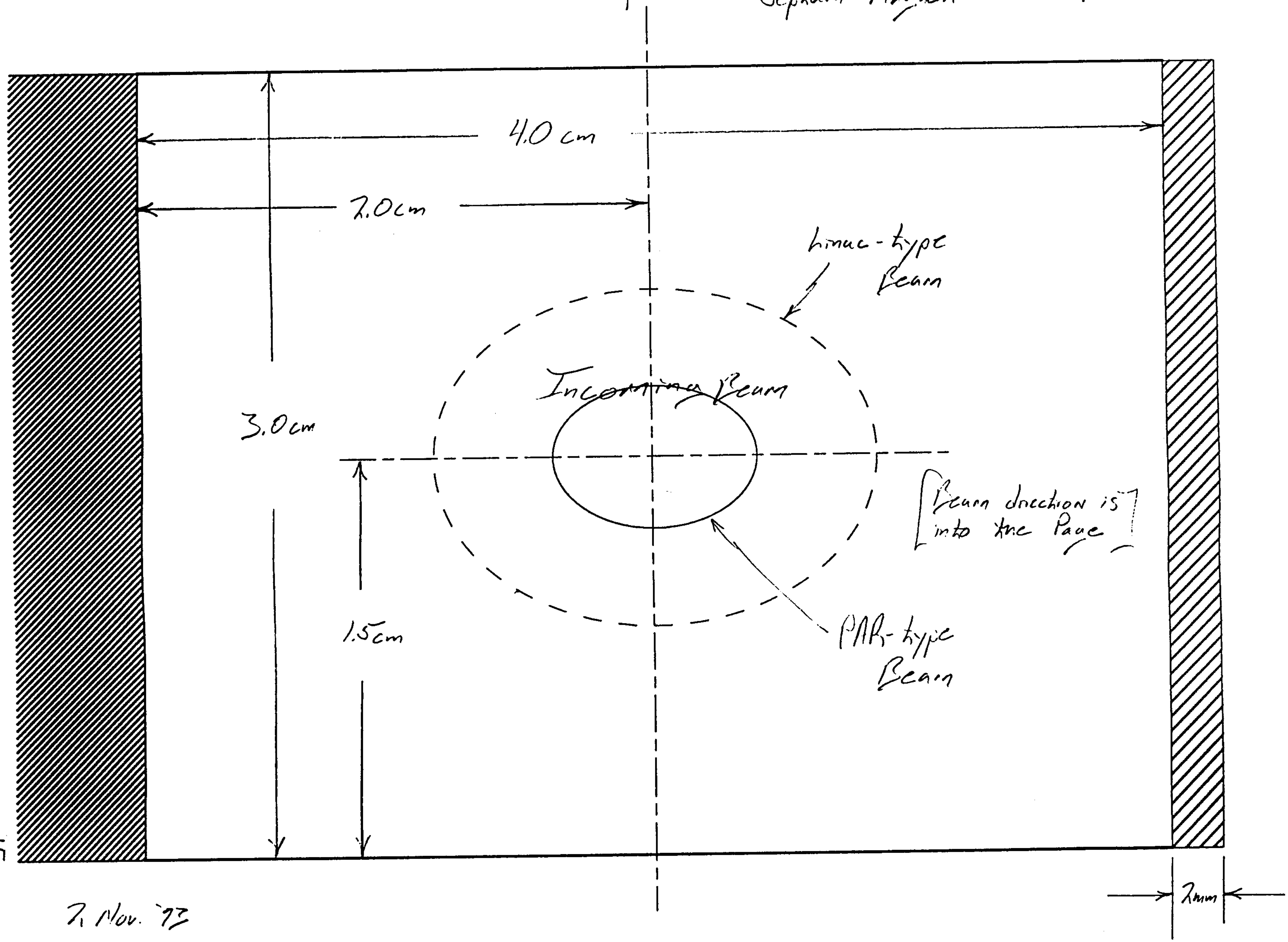
(1st Quad Continued)

e^- beam

$2.45 \cdot 2\sigma_x^{in} = 4.6\,mm$ $2.45 \cdot 2\sigma_y^{in} = 10.1\,mm$

$2.45 \cdot 2\sigma_x^{out} = 4.3\,mm$ $2.45 \cdot 2\sigma_y^{out} = 10.1\,mm$

Injected Beam Envelopes at the Upstream end of the Injection Septum Magnet



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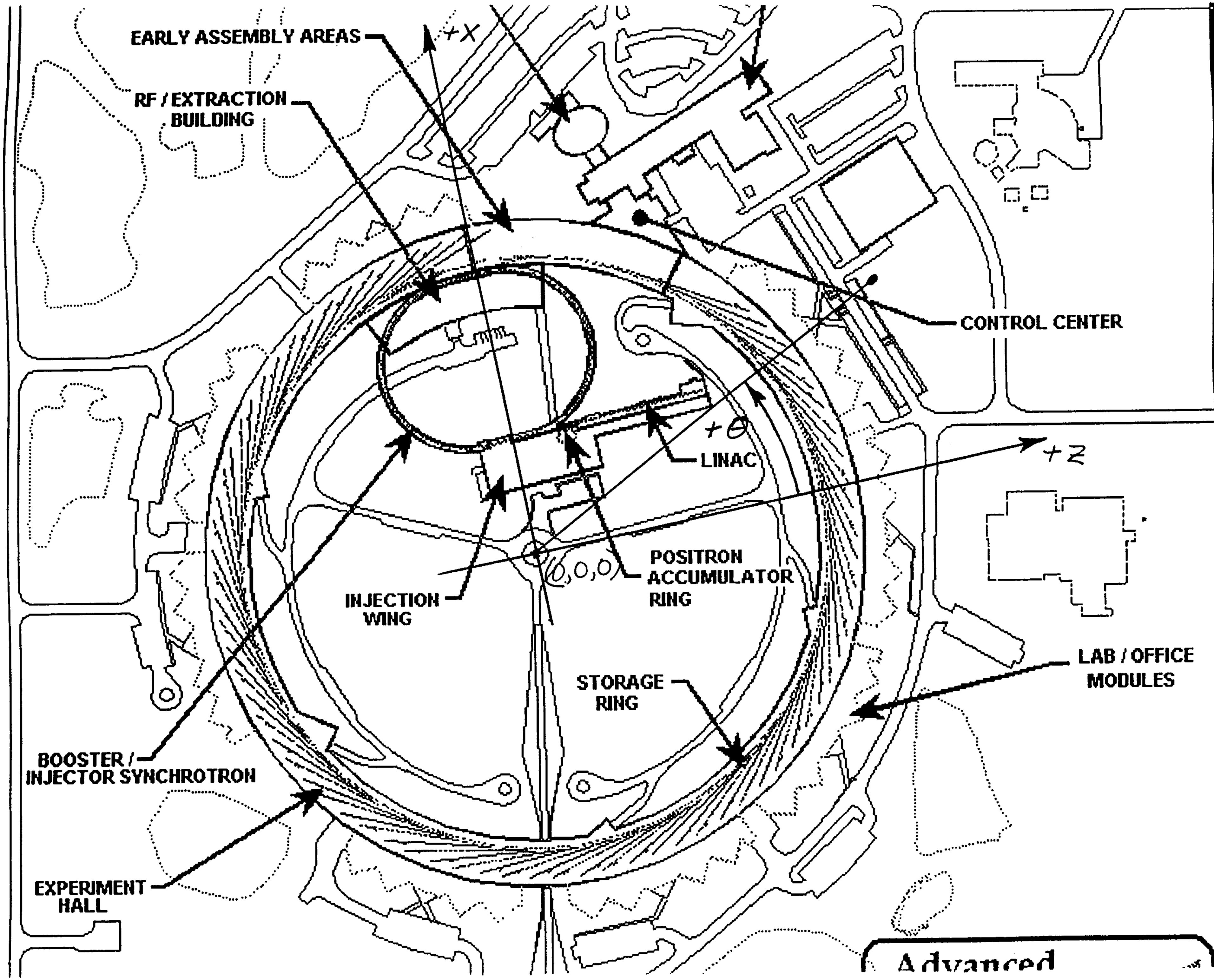
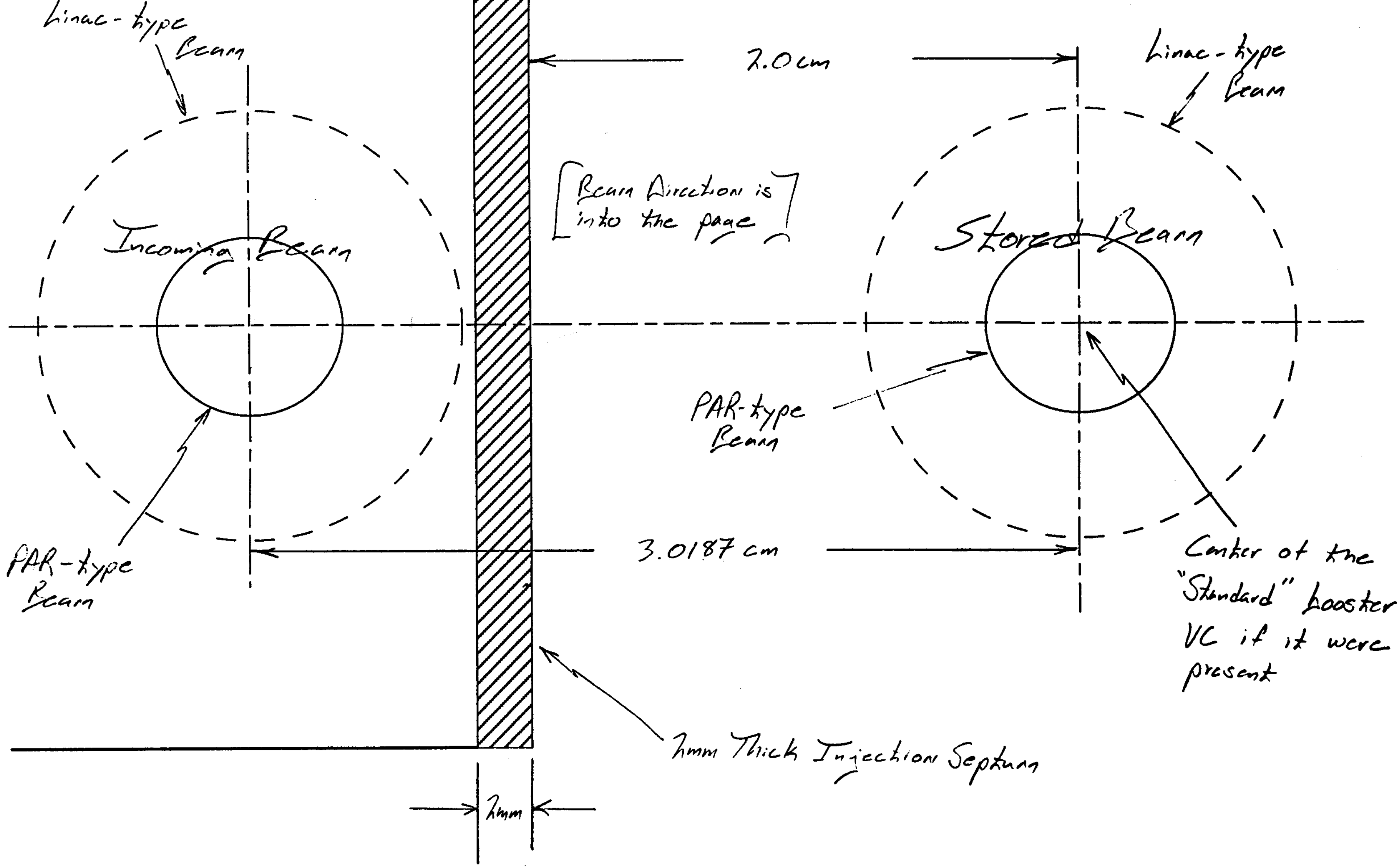

EARLY ASSEMBLY AREAS
RF / EXTRACTION BUILDING
CONTROL CENTER
+X
+Z
+θ
(0,0,0)
LINAC
POSITRON ACCUMULATOR RING
INJECTION WING
STORAGE RING
LAB / OFFICE MODULES
BOOSTER / INJECTOR SYNCHROTRON
EXPERIMENT HALL
Advanced

Injected Beam Envelopes at the Downstream End of the Injection Septum Magnet



2 Nov. '93
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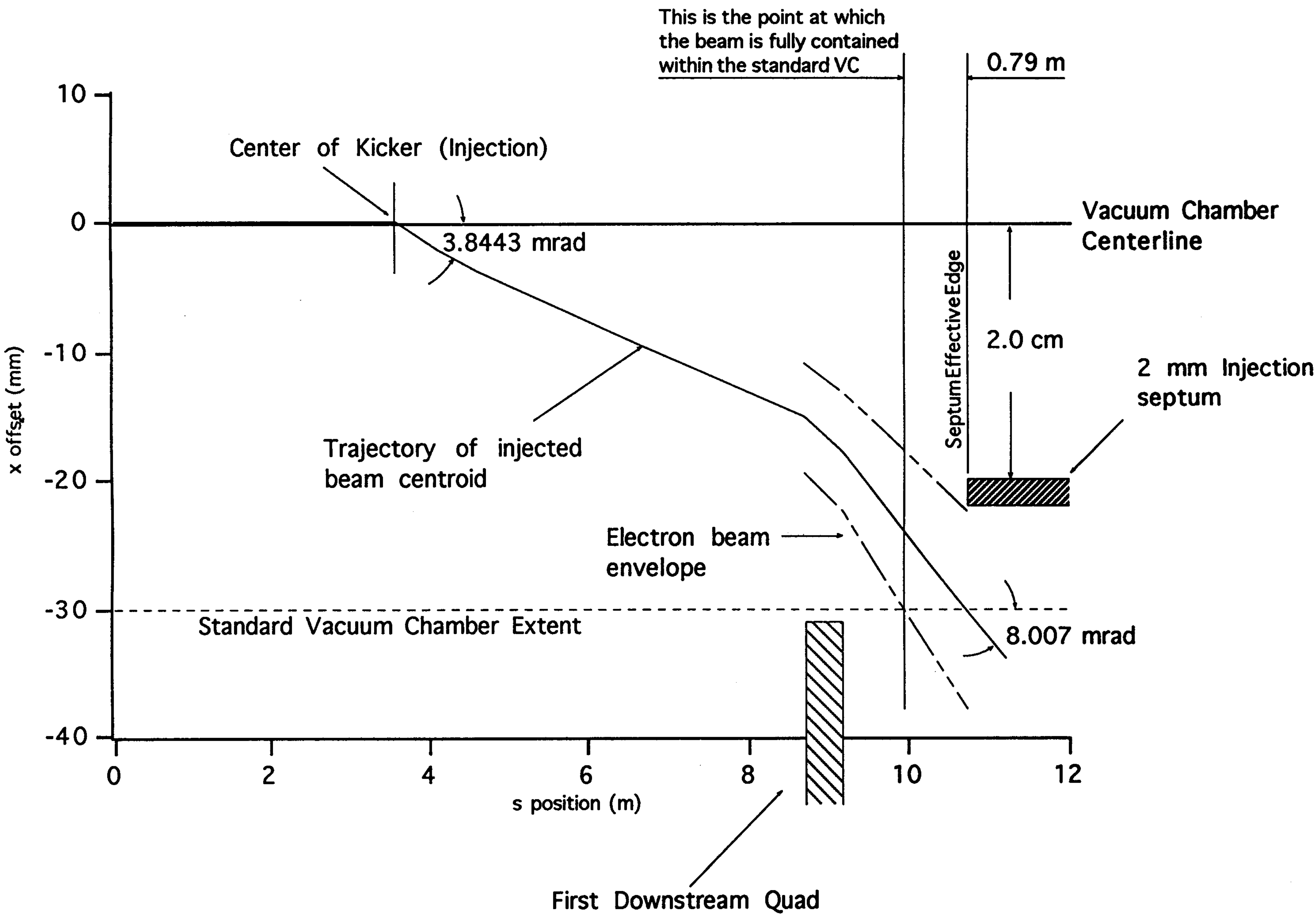
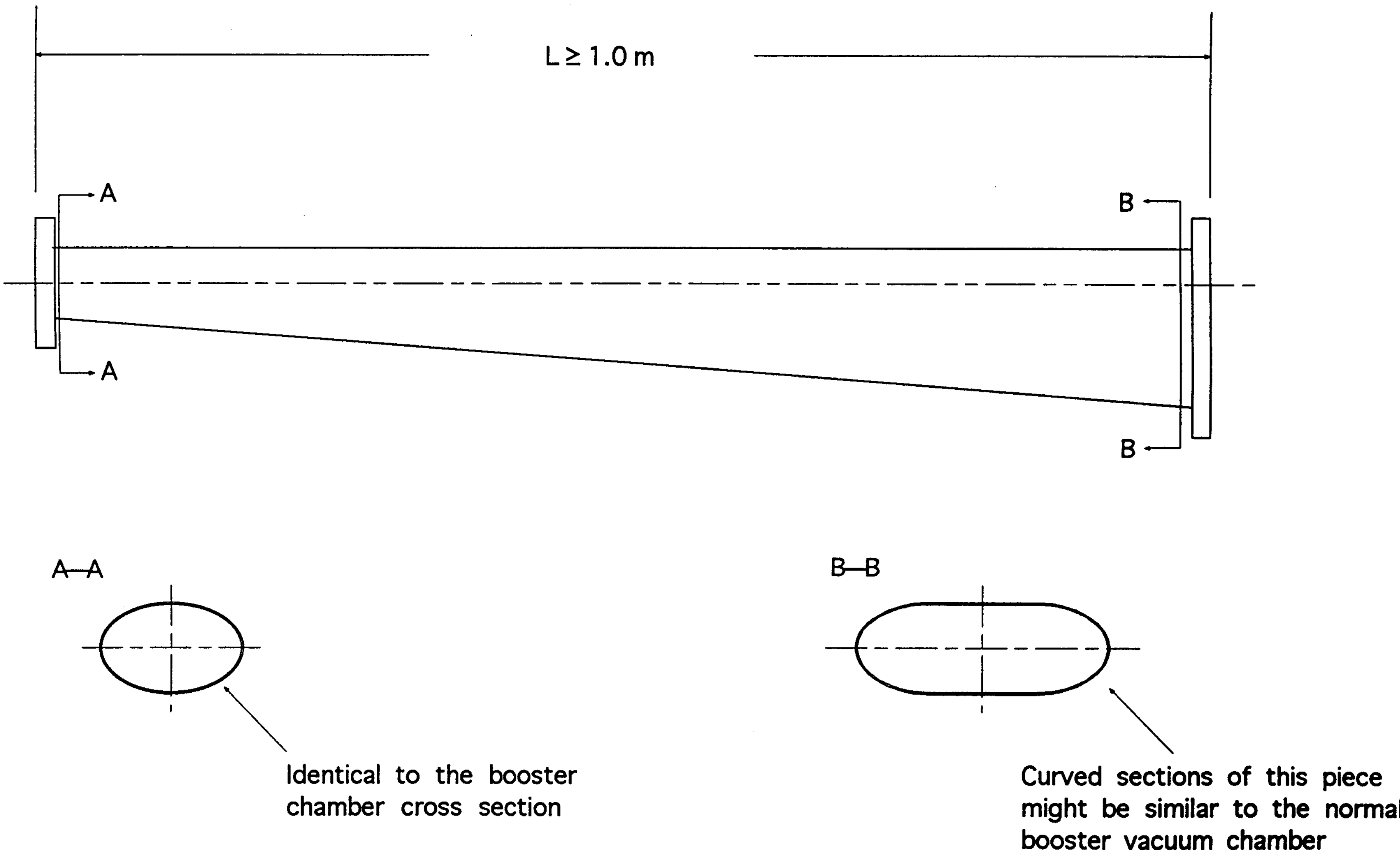

This is the point at which the beam is fully contained within the standard VC
0.79 m
Center of Kicker (Injection)
3.8443 mrad
Vacuum Chamber Centerline
SeptumEffectiveEdge
2.0 cm
2 mm Injection septum
Trajectory of injected beam centroid
Electron beam envelope
Standard Vacuum Chamber Extent
8.007 mrad
x offset (mm)
s position (m)
First Downstream Quad
10
0
-10
-20
-30
-40
0
2
4
6
8
10
12

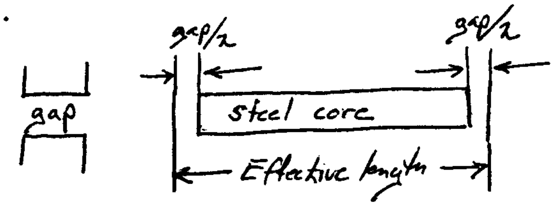
Transistion Piece Near the Injection Septum: Concept



3. Location of the Booster Extraction Septum Magnet

Location of the Booster Extraction Septum Magnets

- General Comments & Definitions
  - Effective Length
    1) Designs were all based on magnet effective lengths
    2) The effective length is defined to be equal to the length of the steel core plus 1 vertical gap.
    3)



  - Use of a Recipe

    Only certain coordinates will be givens. Others should follow if the recipe given below is executed correctly.

- Thin Septum magnet
  - General
    1) The effective length of this magnet is

$$L_{eff}^{thin} = 1.05\,m \quad (gap = 0.02\,m)$$

In principle this is the length of the beam arc within the field of the magnet. To simplify, however, it will be defined as stated above. The incurred error here is miniscule.

    2) This magnet is straight.

3) All coordinates will be given at the effective length boundaries

- Locating (See figure 1)
  1) The septum wall is parallel to the booster vacuum chamber centerline, defined in this region by the line drawn from the center of quadrupole B2C9QF to quadrupole B2C9QD.
  2) The face of the septum wall closest to the vacuum chamber centerline is exactly 16 mm from the vacuum chamber ℄.
  3) Points at the effective end boundaries (see fig. 1)

	Z[m]	X[m]	comments
Z_{in}^{septum}, X_{in}^{septum}	-8.70	168.194908	septum wall points
Z_{out}^{septum}, X_{out}^{septum}	-7.65	168.194908	
Z_{in}^{thin}, X_{in}^{thin}	-8.70	168.201272	Beam Centroid location
Z_{out}^{thin}, X_{out}^{thin}	-7.65	168.213834	

- Beam Size

Entrance to the septum
horizontal ± 3.33 mm Vertical ± 1.13 mm

Exit of the septum
horizontal ± 2.69 mm Vertical ± 1.44 mm

- Thick Septum Magnet
  - General
    1) The effective length of this magnet is
       $$L_{eff}^{thick} = 1.75 m \quad (gap = 0.03 m)$$
       See general note 1) thin septum magnet above.
    2) This magnet is <u>curved</u>
    3) All coordinates given are at the effective length boundary.
  - Locating (See figure 2)
    1) There is a fixed point at the upstream end of the magnet
    2) The fixed point is exactly 16mm from the vacuum chamber ℄
    3) The magnet is to be rotated about the fixed point in a manner which centers the outgoing beam in the exit aperture
    4) Points at the effective length boundaries (see figure 2)

	Z[m]	X[m]	comments
$Z_{in}^{septum}, X_{in}^{septum}$	-7.10	168.194908	Fixed point
$Z_{out}^{septum}, X_{out}^{septum}$	~~~	~~~	Determined by the rotati[on]
$Z_{in}^{thick}, X_{in}^{thick}$	-7.10	168.229422	Beam Centroid location
$Z_{out}^{thick}, X_{out}^{thick}$	-5.3545	168.343257	Beam Centroid location

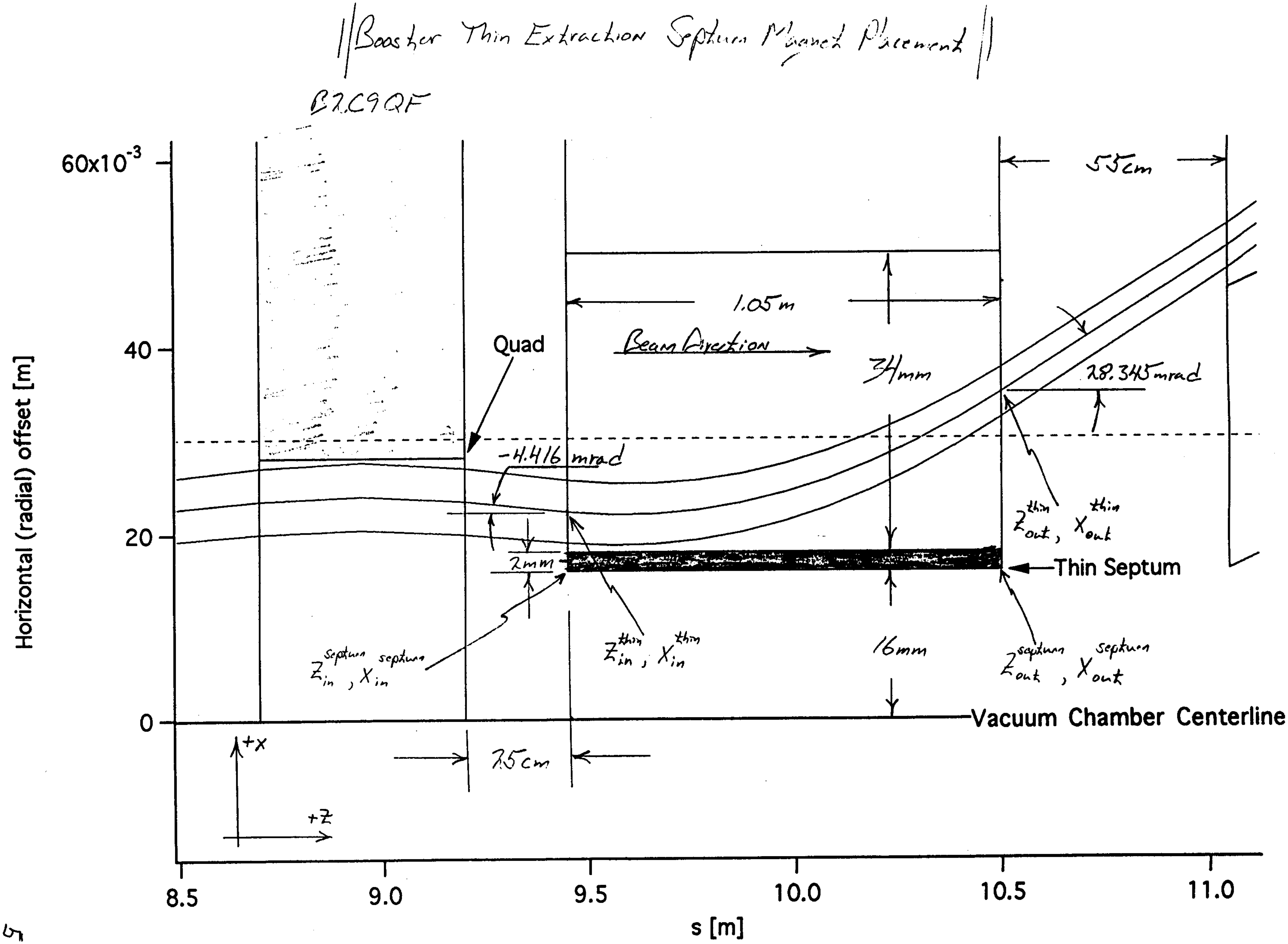
- Beam Size

Entrance to the septum

Horizontal ± 2.37mm Vertical ± 1.63mm

Exit of the septum

Horizontal ± 1.48mm Vertical ± 2.29mm



||Booster Thin Extraction Septum Magnet Placement||
B2C9QF
60x10^-3
40
20
0
Horizontal (radial) offset [m]
Quad
Beam Direction
1.05m
55cm
34mm
16mm
2mm
7.5cm
-4.416 mrad
28.345 mrad
Thin Septum
Vacuum Chamber Centerline
$Z_{in}^{septum}, X_{in}^{septum}$
$Z_{in}^{thin}, X_{in}^{thin}$
$Z_{out}^{thin}, X_{out}^{thin}$
$Z_{out}^{septum}, X_{out}^{septum}$
+x
+z
8.5
9.0
9.5
10.0
10.5
11.0
s [m]

5

Booster Thick Extraction Septum Magnet Placement

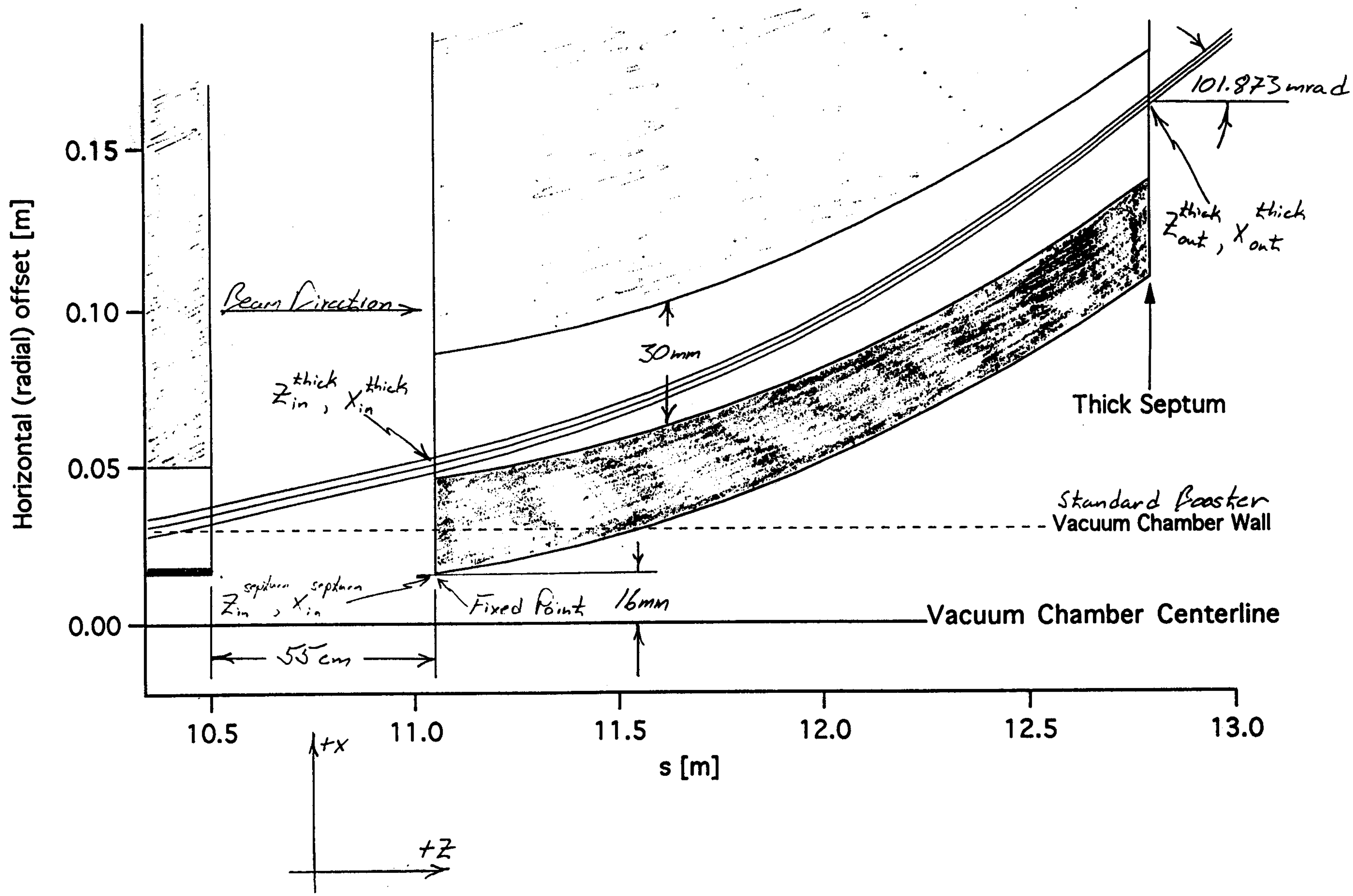


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Figure 2

28 Apr. '94

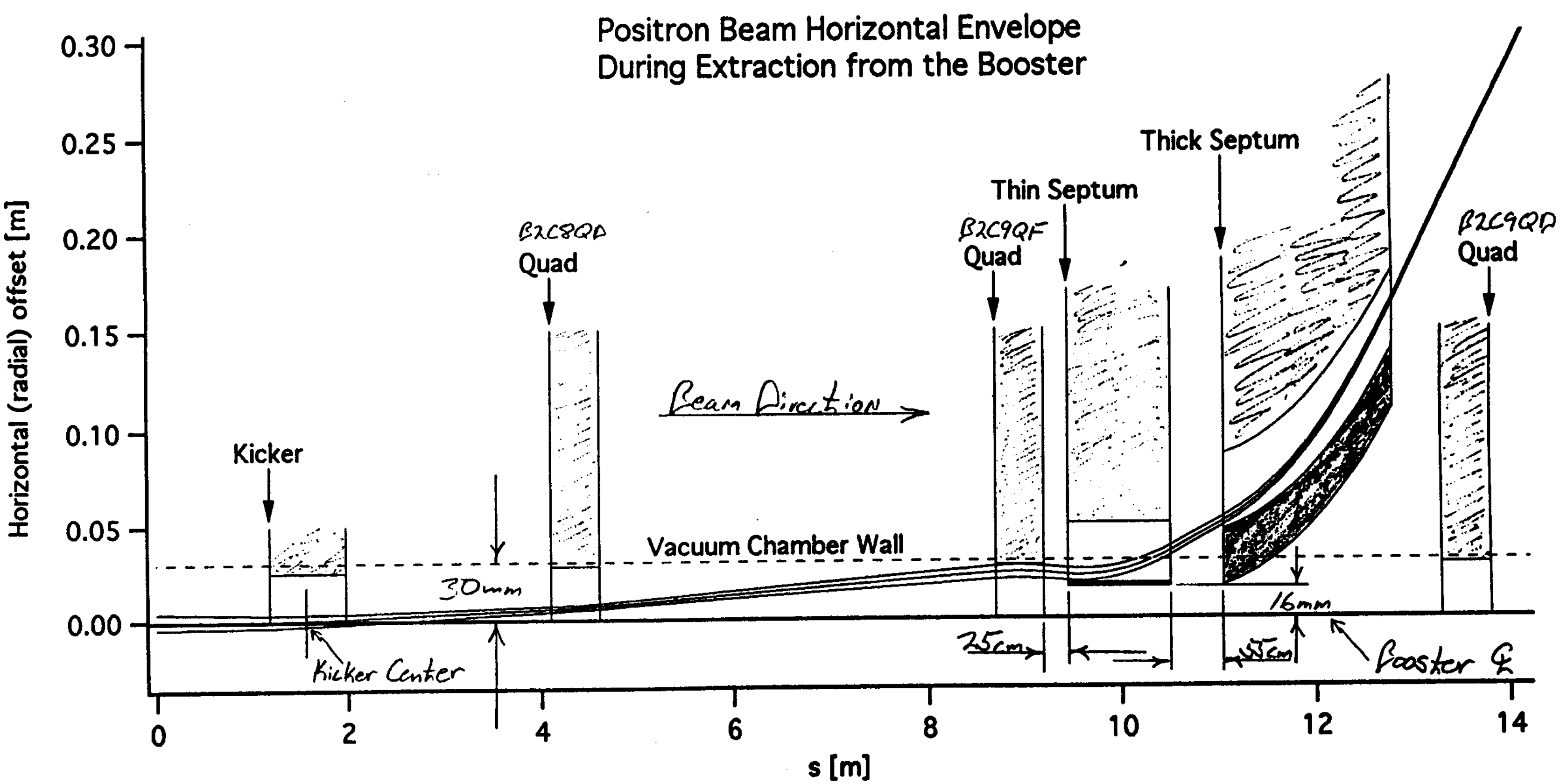

Figure φ

28 Ap. '94

4. Location of the Storage Ring Injection Septum Magnet

Location of the Storage Ring Injection Septum Magnets

- General Comments and Definitions
  - Effective Length
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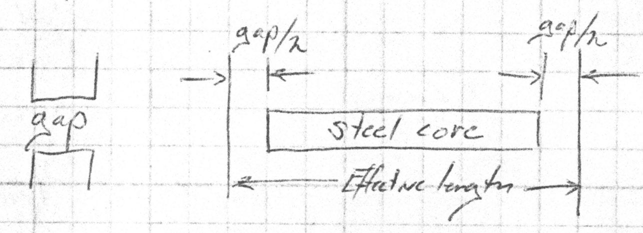
    3) 

  - Use of a Recipe

    Only certain, but sufficient, coordinates will be given. Others will follow if the recipe given below is executed correctly.

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  - General
    1) The effective length of this magnet is

$$L^{thin}_{eff} = 1.05\,m \qquad (gap = 0.02m)$$

In principle this is the length of the beam arc within the field of the magnet. To simplify, however, it will be defined as stated above. The induced error is miniscule.

    2) The magnet is straight.
    3) All coordinates will be given at the effective length boundaries.

- Locating (See figure 1)

1) The septum wall is parallel to the storage ring vacuum chamber centerline, defined in this region by the line drawn from the center of quadrapole S39BQ1 to quadrapole S40AQ1.

2) The face of the septum wall closest to the vacuum chamber centerline is exactly 18mm from the vacuum chamber ℄.

3) Points at the effective end boundaries. (See figure 1)

	Z[m]	x[m]	comments
$Z_{in}^{septum}, X_{in}^{septum}$	54.858713 ✓ 2159.791	166.734316 ✓ 6564.343	Septum Wall points
$Z_{out}^{septum}, X_{out}^{septum}$	55.857323 ✓ 2199.107	166.409848 ✓ 6551.569	
$Z_{in}^{thm}, X_{in}^{thm}$	54.851909 ✓ 2159.524	166.712766 ✓ 6563.495	Beam Centroid location
$Z_{out}^{thm}, X_{out}^{thm}$	55.855654 ✓ 2199.041	166.404712 ✓ 6551.367	

- Beam Size ($\pm 2.45\sigma$)

Entrance to the septum

horizontal ± 3.36 mm   Vertical ± 2.0mm

Exit of the septum

horizontal ± 3.38mm   Vertical ± 2.02mm

- Thick Septum Magnet
  - General
    1) The effective length of this magnet is

$$L_{eff}^{thick} = 1.75m \quad (gap = 0.03m)$$

See general note 1) thin septum magnet above.

    2) This magnet is <u>curved</u>
    3) All magnet coordinates given are at the effective length boundary.
  - Locating (See figure 2)
    1) There is a fixed point at the downstream end of the magnet.
    2) The fixed point is exactly 18mm from the vacuum chamber ℄.
    3) The magnet is to be rotated about the fixed point in a manner which centers the incoming beam in the entrance aperture.
    4) Points at the effective length boundaries (See Figure 2)

	Z(m)	X(m)	Comments
Z_{in}^{septum}, X_{in}^{septum}	~~~	~~~	Determined by the Rotation
Z_{out}^{septum}, X_{out}^{septum}	54.335632 2139.198	166.904275 6571.034	Fixed Point
Z_{in}^{thick}, X_{in}^{thick}	52.626028	167.289257	Beam Centroid location
Z_{out}^{thick}, X_{out}^{thick}	54.323541	166.865500	Beam Centroid location

23.0085

5 Aug.

- Beam Sizes ($\pm 2.45\sigma$)

Entrance to the septum

Horizontal $\pm$ 3.35mm Vertical $\pm$ 1.99mm

Exit of the septum

Horizontal $\pm$ 3.35mm Vertical $\pm$ 1.99mm

22-141 50 SHEETS
22-142 100 SHEETS
22-144 200 SHEETS
AMPAD

20 Apr '93
sm

Injection Into the Storage Ring

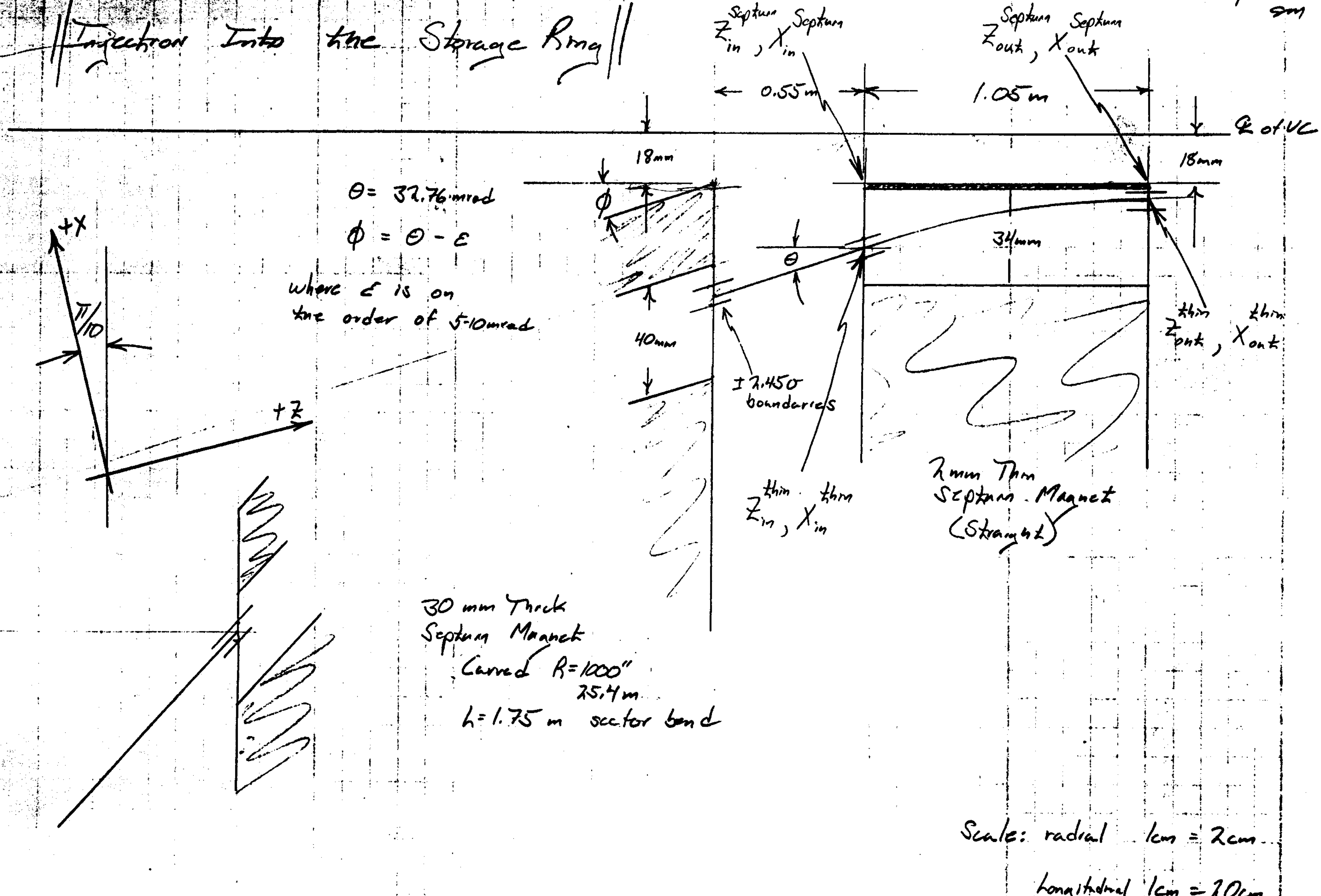
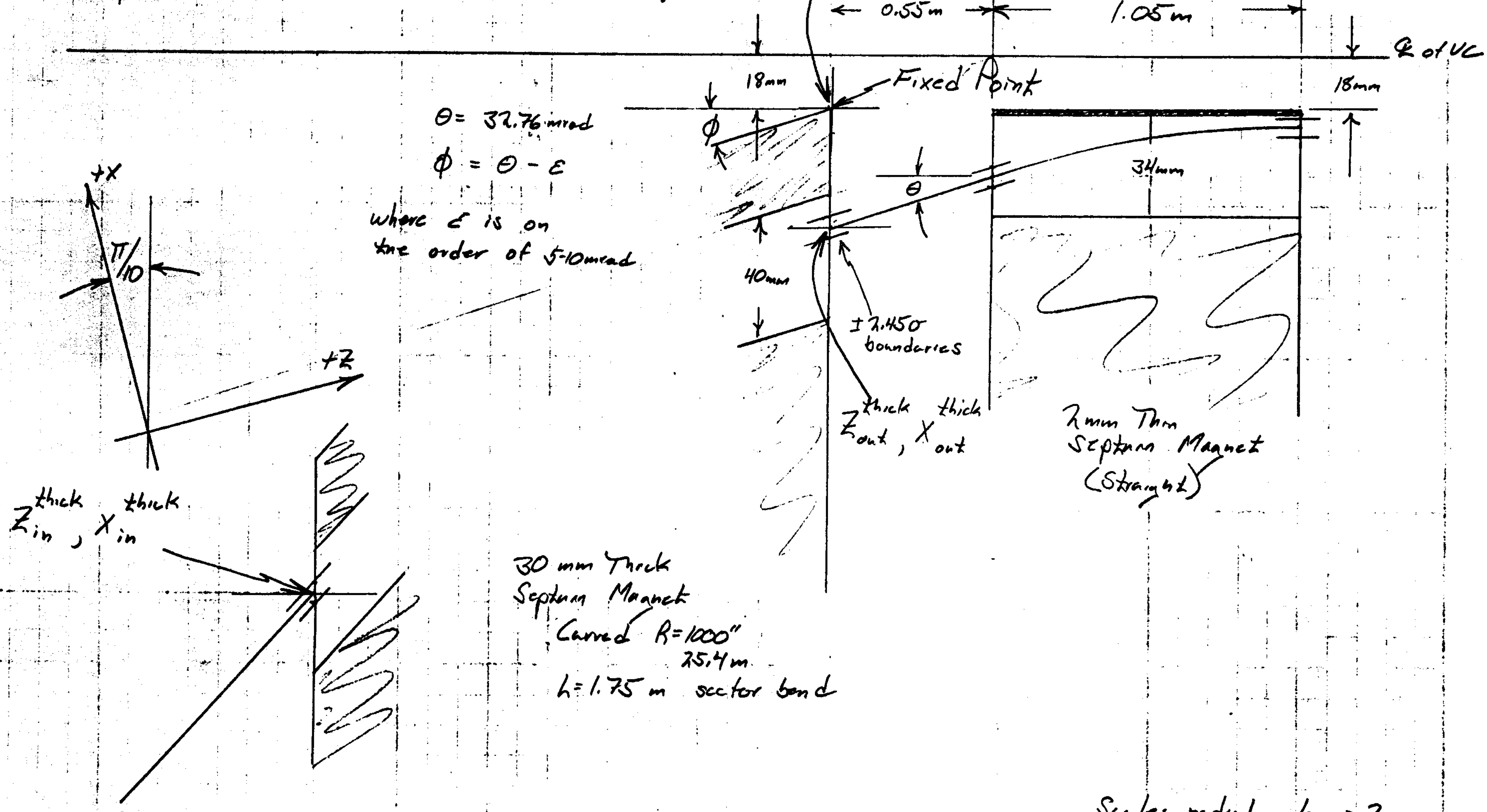


Figure 1

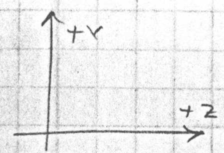
||Injection Into the Storage Ring||

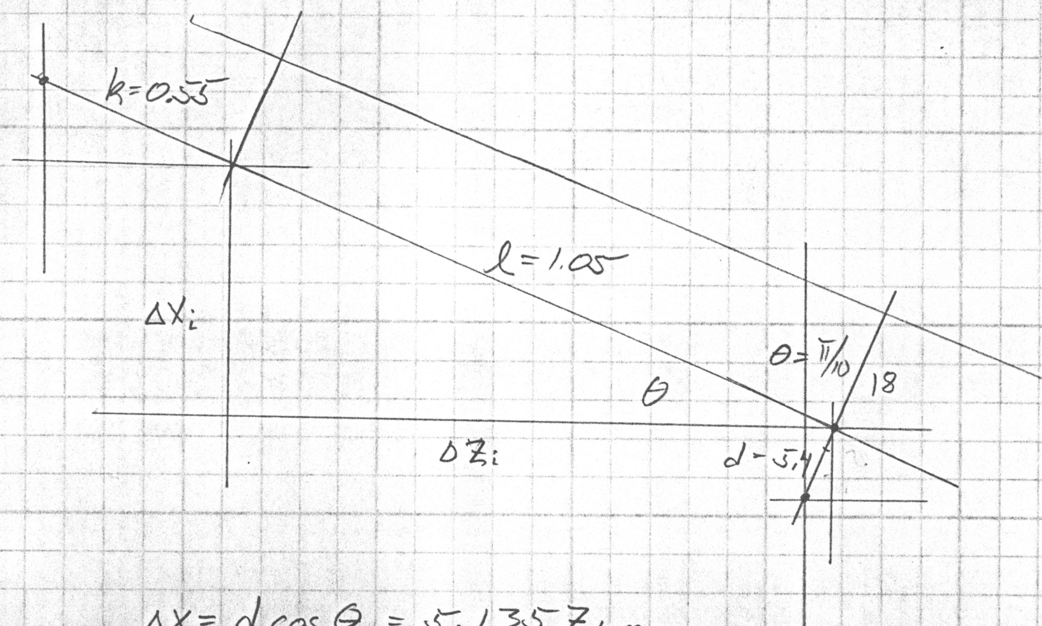


Scale: radial 1cm = 2cm

Longitudinal 1cm = 20cm

Figure 2





$\Delta X_0 = d\cos\theta = 5.1357\,mm$

$\Delta Z_0 = d\sin\theta = 1.6687\,mm$

$\Delta X_i = l\sin\theta = 0.3244678\,m$

$\Delta Z_i = -l\cos\theta = -0.9986093\,m$

$\Delta X_k = k\sin\theta = 0.1699594$

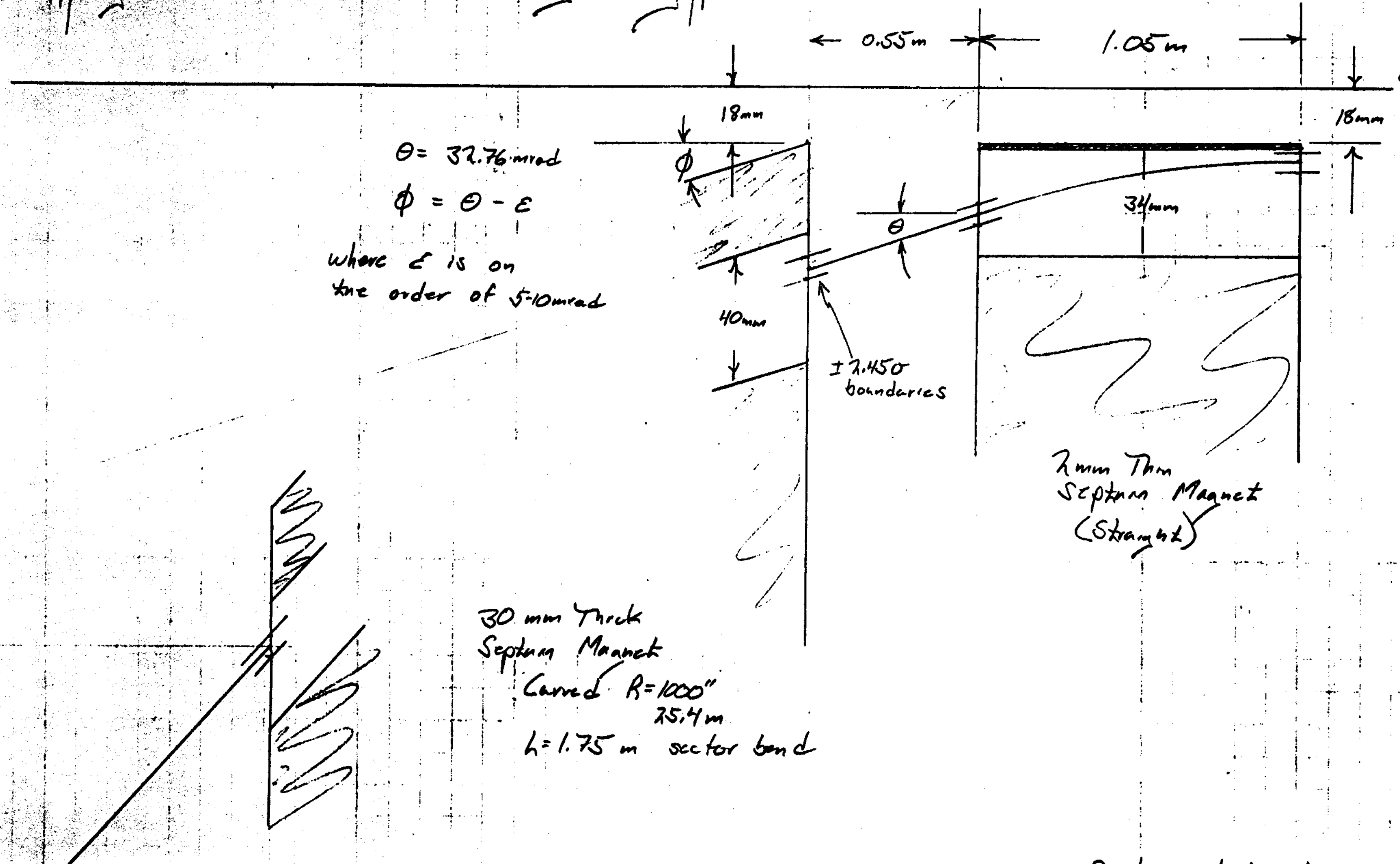
$\Delta Z_k = -k\cos\theta = -0.5230811$

$Z_{out} = 55.855654$
.0016687
55.8573227
−.9986093
54.8587134
−.5230811
54.3356323

$X_{out} = 166.404712$
.0051357
166.4098477
.3244678
166.7343155
.1699594
166.9042749

20 Apr '93
sm

Injection Into the Storage Ring



$\theta = 32.76$ mrad

$\phi = \theta - \varepsilon$

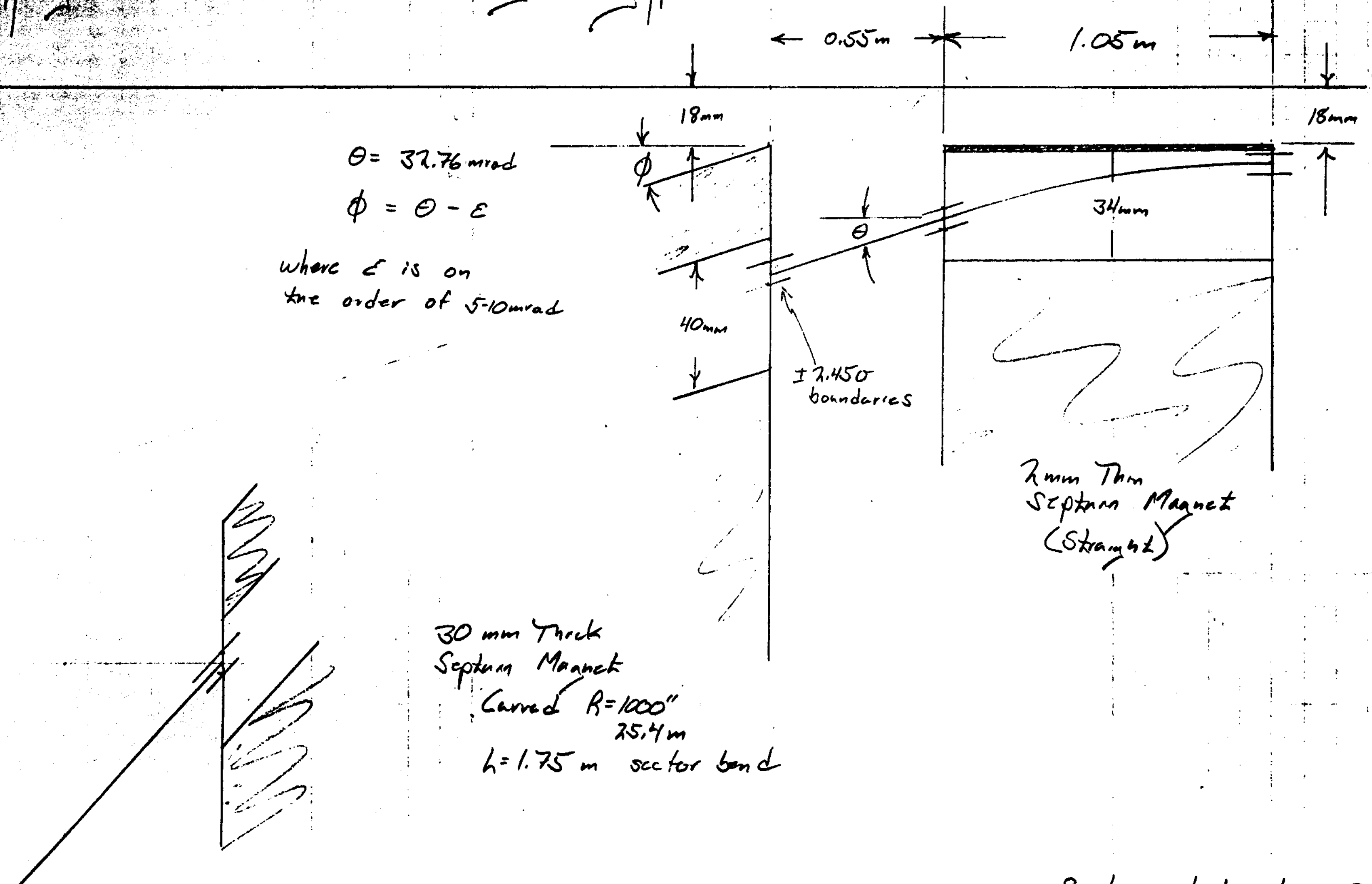
where ε is on the order of 5-10 mrad

Scale: radial 1 cm = 2 cm

Longitudinal 1 cm = 20 cm

20 Apr '93
sm

Injection Into the Storage Ring



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