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Discussion On RHIC Lattice

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April 1984

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USDOE Office of Science (SC)

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RHIC-PG-46

DISCUSSION ON RHIC LATTICE

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April 2, 1984

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RHIC Lattice

History: CBA 1 in 1, symmetric, $\beta_x^* = 40$, $\beta_y^* = 7.5 - 2$ m

CBA 2 in 1, anti-symmetric, $\beta_x^* = \beta_y^* = 7 - 2$ m

RHIC Feasability Study

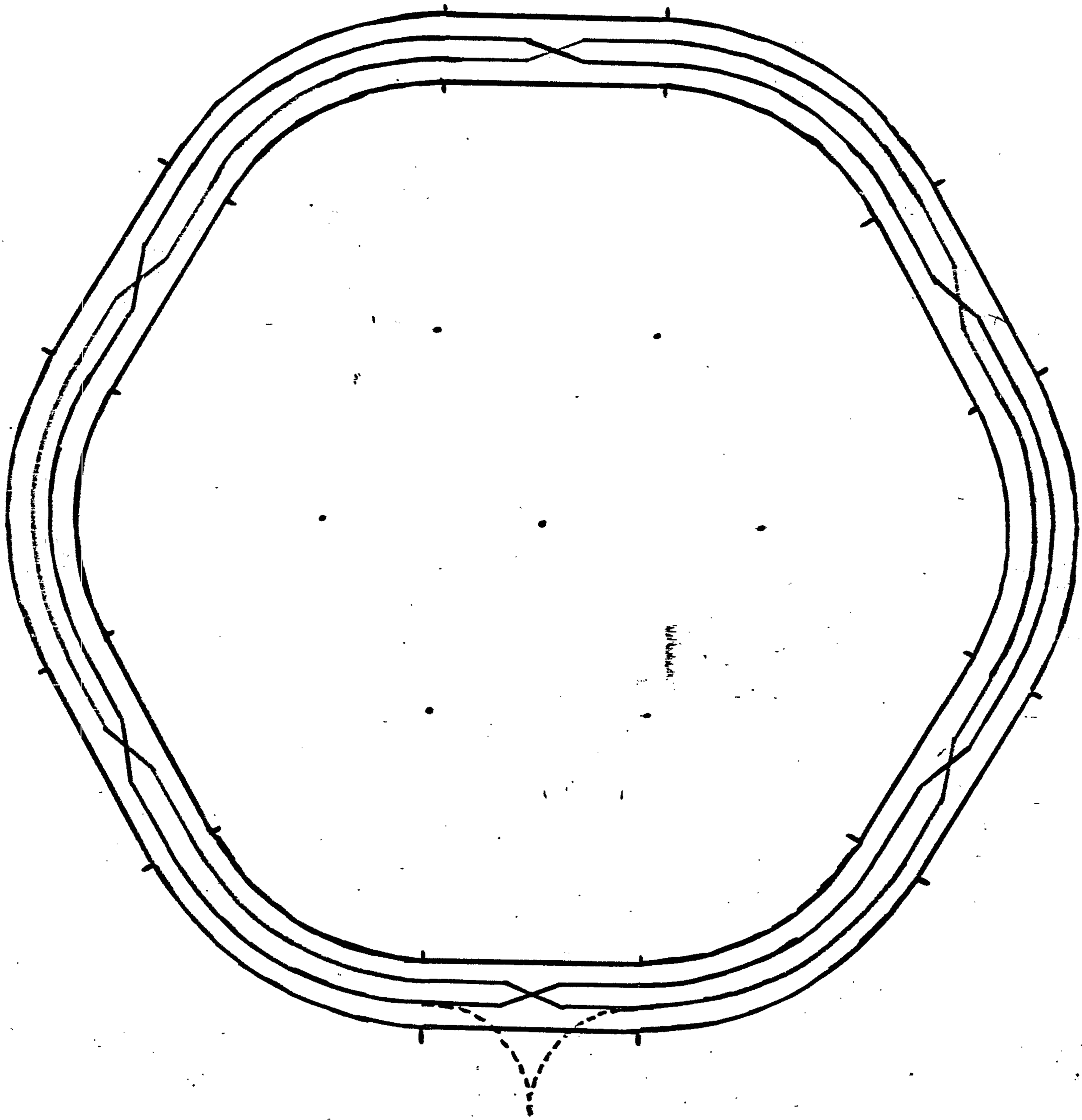
CBA 2 in 1, symmetric, missing magnets

RHIC 1, symmetric, 9 x 90, $\beta_x^* = 40$, $\beta_y^* = 7.5$ m

RHIC 2, symmetric, 12 x 100, $\beta_x^* = 17$, $\beta_y^* = 3$ m

RHIC2 Parameters:

Circumference (m)	3883.845
Radius of Arcs (m)	381.2332
Distance between Rings (m)	0.15 – 0.18 – 0.24 – 0.30
Number of cells / arc	12
Half cell length (m)	14.811
Deflection angle / half cell ($\int B\,dl / B\rho$ per arc dipole in mrad)	38.85
$\int B' dl / B\rho$ per arc quadrupole (m^{-1})	0.1065
Number of dipoles / ring	144 + 24 + 24
Number of quadrupoles / ring	234
Distance from crossing point to nearest magnet (m)	10.
ν_x / ν_y	31.6 / 31.6
$\Delta\psi_x / \Delta\psi_y$ per arc cell (units of $\frac{2\pi \text{ rad}}{360^\circ}$)	0.2722 / 0.2722
$\hat{\beta}_x / \check{\beta}_y$ in arcs (m)	51.58 / 7.46
$\hat{\beta}_y / \check{\beta}_y$ in arcs (m)	51.58 / 7.46
$\hat{x}_p / \check{x}_p$ in arcs (m)	1.385 / 0.640
$\Delta\psi_x / \Delta\psi_y$ per insertion (units of $\frac{2\pi \text{ rad}}{360^\circ}$)	2.0 / 2.0
$\beta_x^* / \beta_y^* / x_p^*$ (m)	17.7 / 3.0 / 0.0
$\hat{\hat{\beta}}_x / \hat{\hat{\beta}}_y$ (m)	267. / 667.



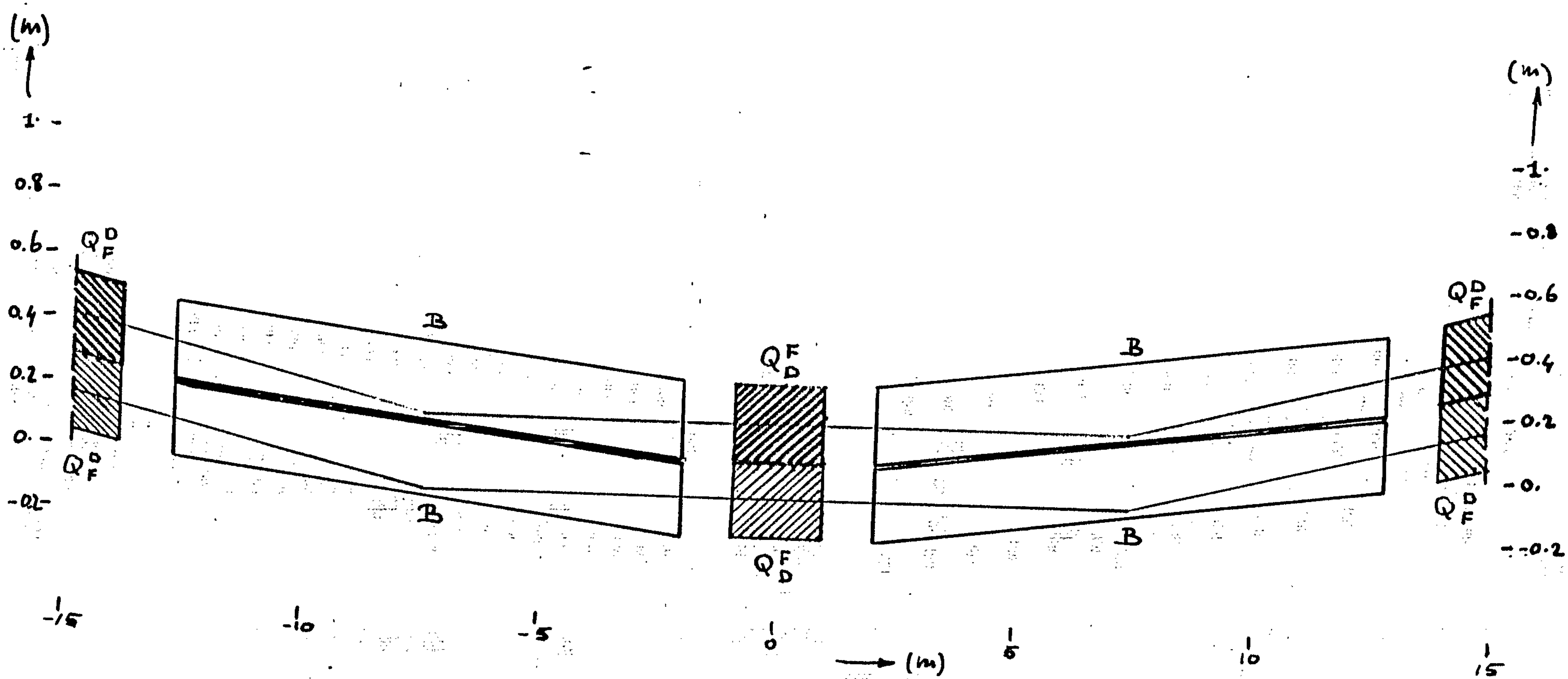
RHIC Regular Cell Pair

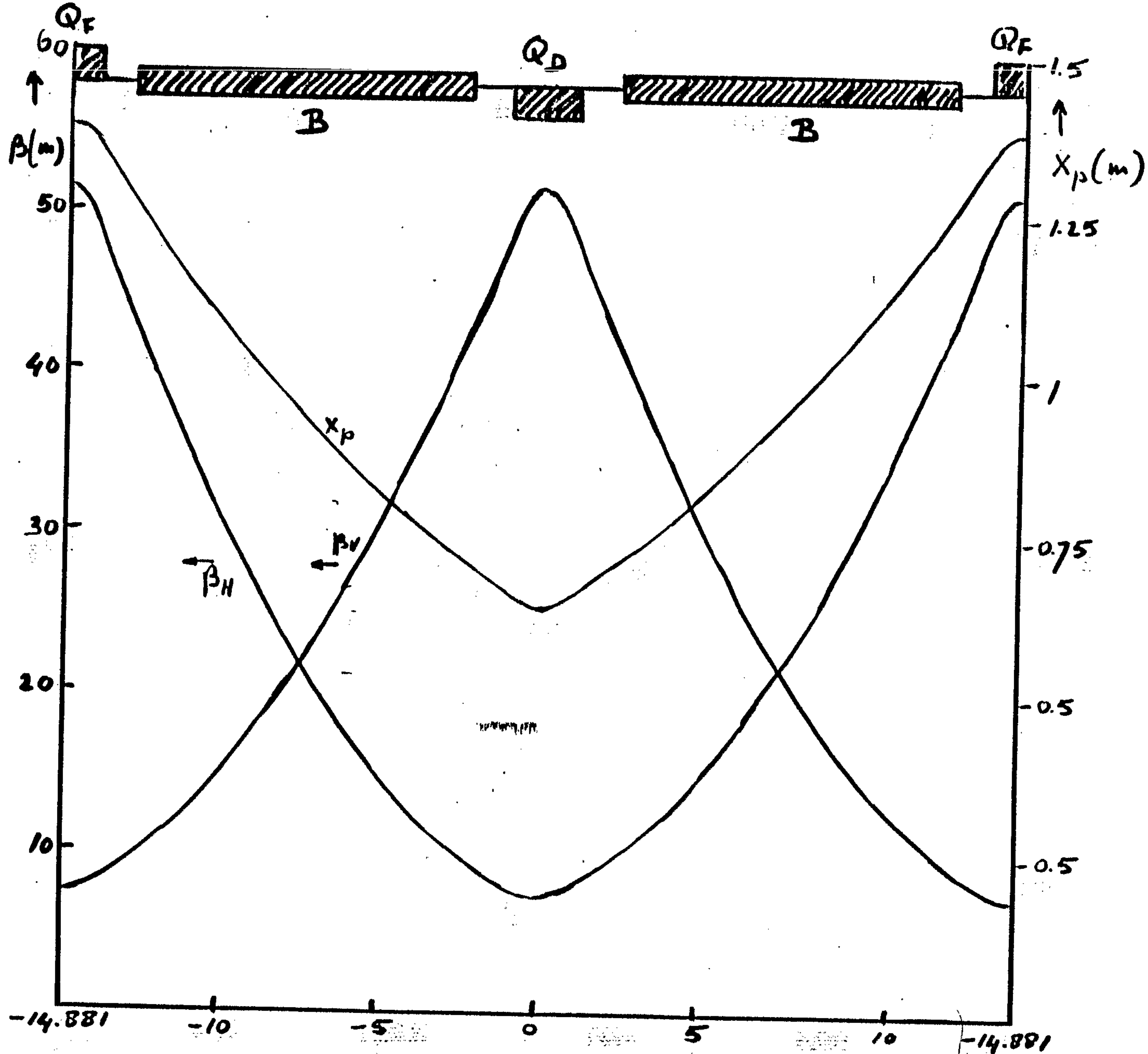
$$\Theta_H = \frac{\int B\,dl}{B\rho} = 0.03885 \text{ rad}$$

$$\frac{\int B'\,dl}{B\rho} = 0.1065 \text{ m}^{-1}$$

$$R_{av} = 381.23 \text{ m}$$

$$L_{HC} = 114.811 \text{ m}$$

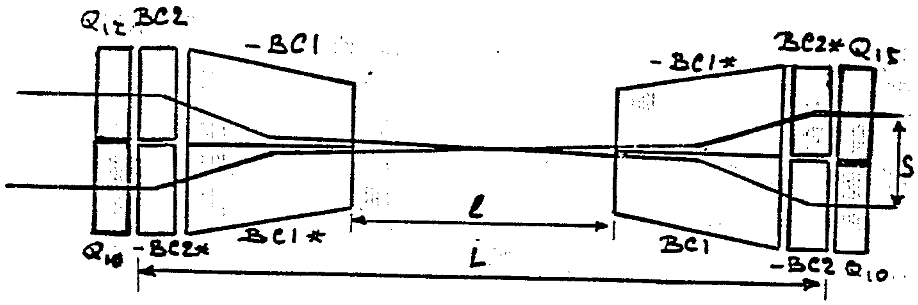




RHIC REGULAR ARC CELL (02/14/84 09.48.54)

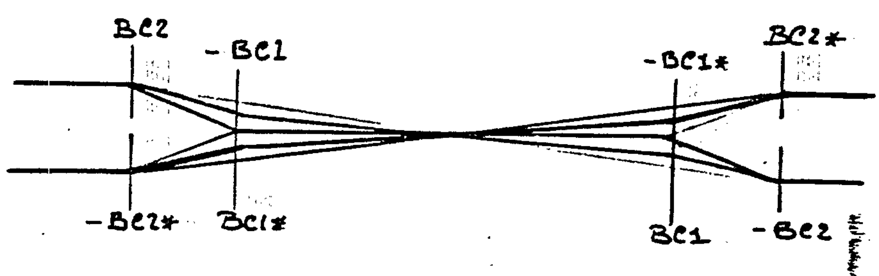
Crossing Point Regions

Present arrangement:



$\ell = 22\,m$
$\alpha = 2 - 8.7,\ 10.8$ mrad
$S = 0.24\,m,\ 0.30\,m$
$L = 58\,m$

stylize to:



$\pm$ BC1, $\pm$ BC2, $\pm$ BC1*, $\pm$ BC2* are dipoles with parallel entrance and exit edges, $\pm$ indicates polarity.

For operation with equal momenta ($B\rho$ values) in the two rings: (-BC1, BC1*) and (BC1, -BC1*) can each be a one aperture magnet, but aperture must be large enough to accomodate the desired range of α

Colinear beams: equal deflection angles in all magnets.
"Natural" crossing angle: no deflection in units BC1.

For operation with different momenta $\left((B\rho)_1/(B\rho)_2 \le 2.5\right)$
$|BC^1_2| \neq |BC^1_2{*}|$: colinear beams impossible.

In order to minimize α, maximize effective aperture:

Construct (-BC1/BC1*) and (BC1/-BC1*) as two aperture septum magnets.

Septum must carry current (for unequal $B\rho$'s) and be thin: low fields and therefore long magnets.

Present arrangement can be improved upon by sectionalizing these magnets into shorter units with increasing fields and septum thicknesses.

Optimisation Problem: L should be minimized at fixed ℓ in order to maximize effective aperture elsewhere in the rings → BC1 and BC2 should be short and therefore strong

Ring design Problem: the crossing dipoles cause significant dispersion, antisymmetric relative to the crossing point, a major per perturbation in an otherwize symmetric lattice.

Present approach: Try to live with it.

Consequences: severe loss of symmetry properties, effective aperture and flexibility.

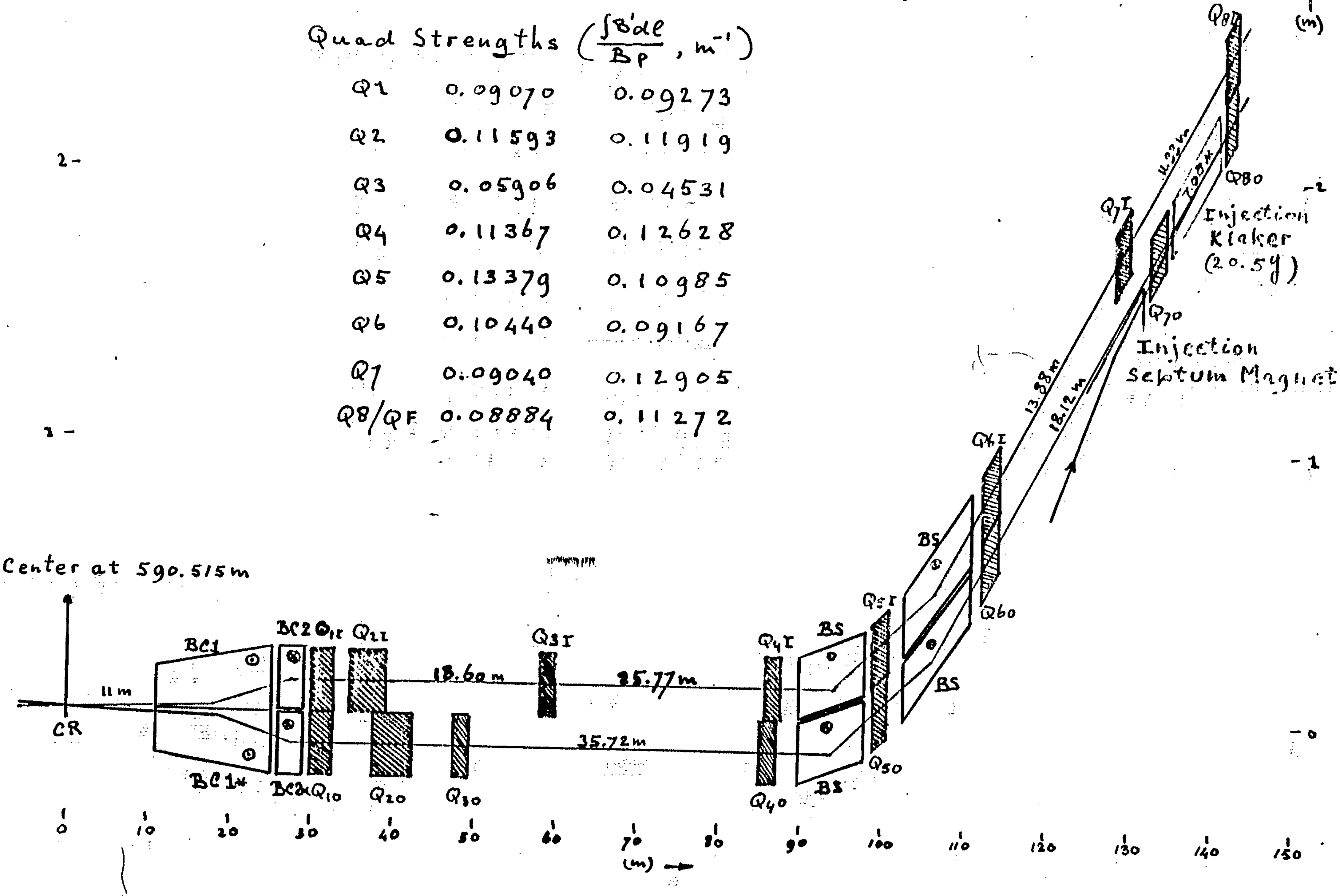
Alternatives: a) introduce extra quad to remove dispersion. Promising results sofar.

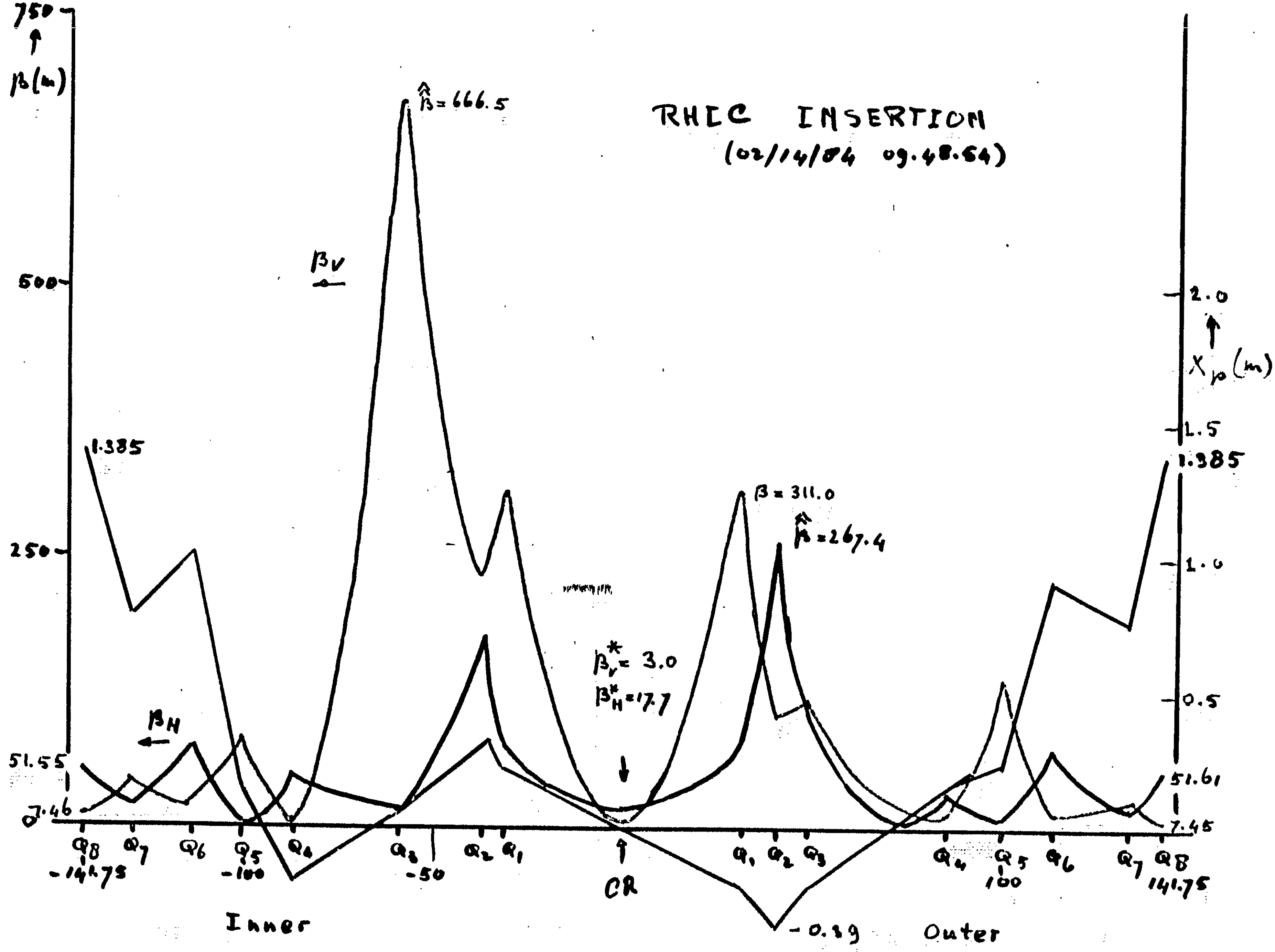
b) use antisymmetric lattice, like CBA's antisymmetric 2 in 1.

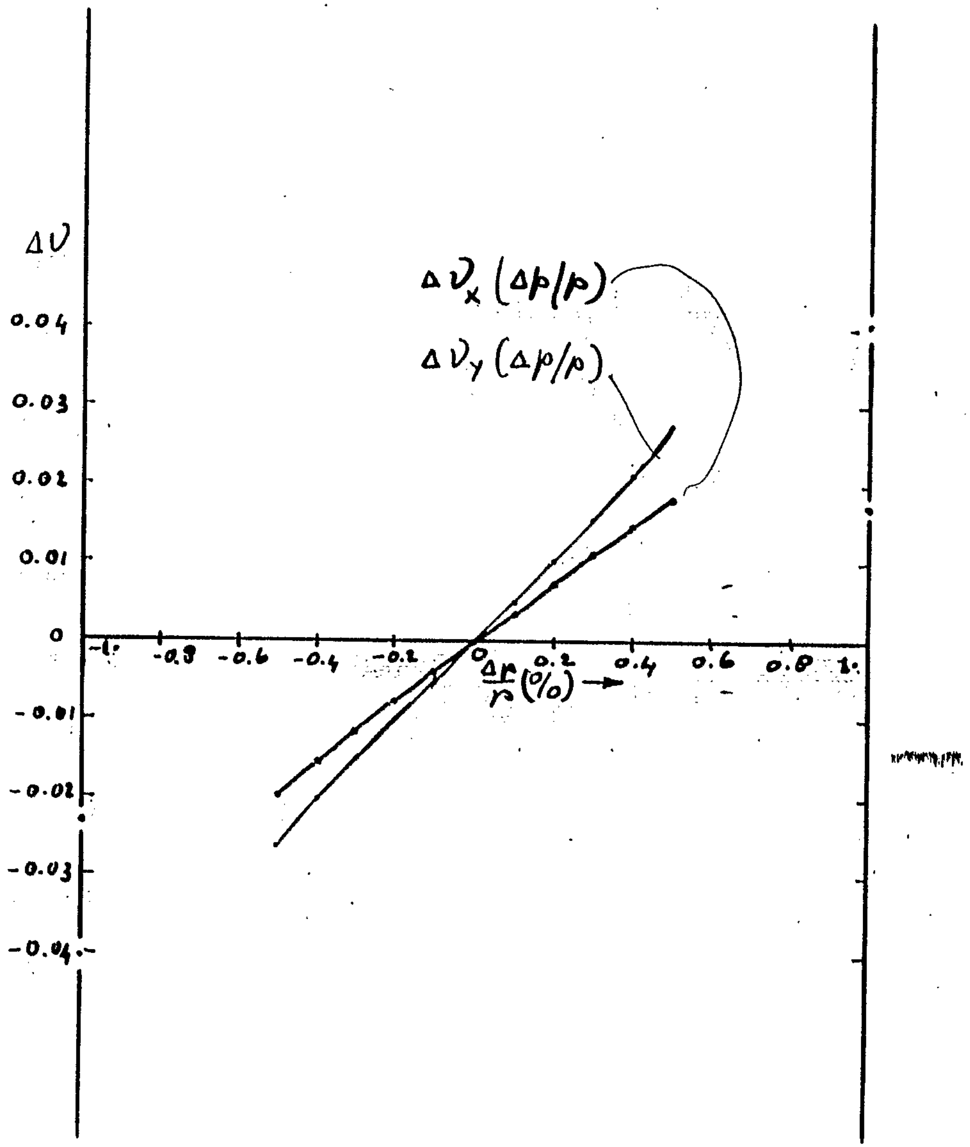
RHIC Half Insertion (02/14/84 09.48.54)

Quad Strengths $\left(\frac{\int B' dl}{B\rho}, m^{-1}\right)$

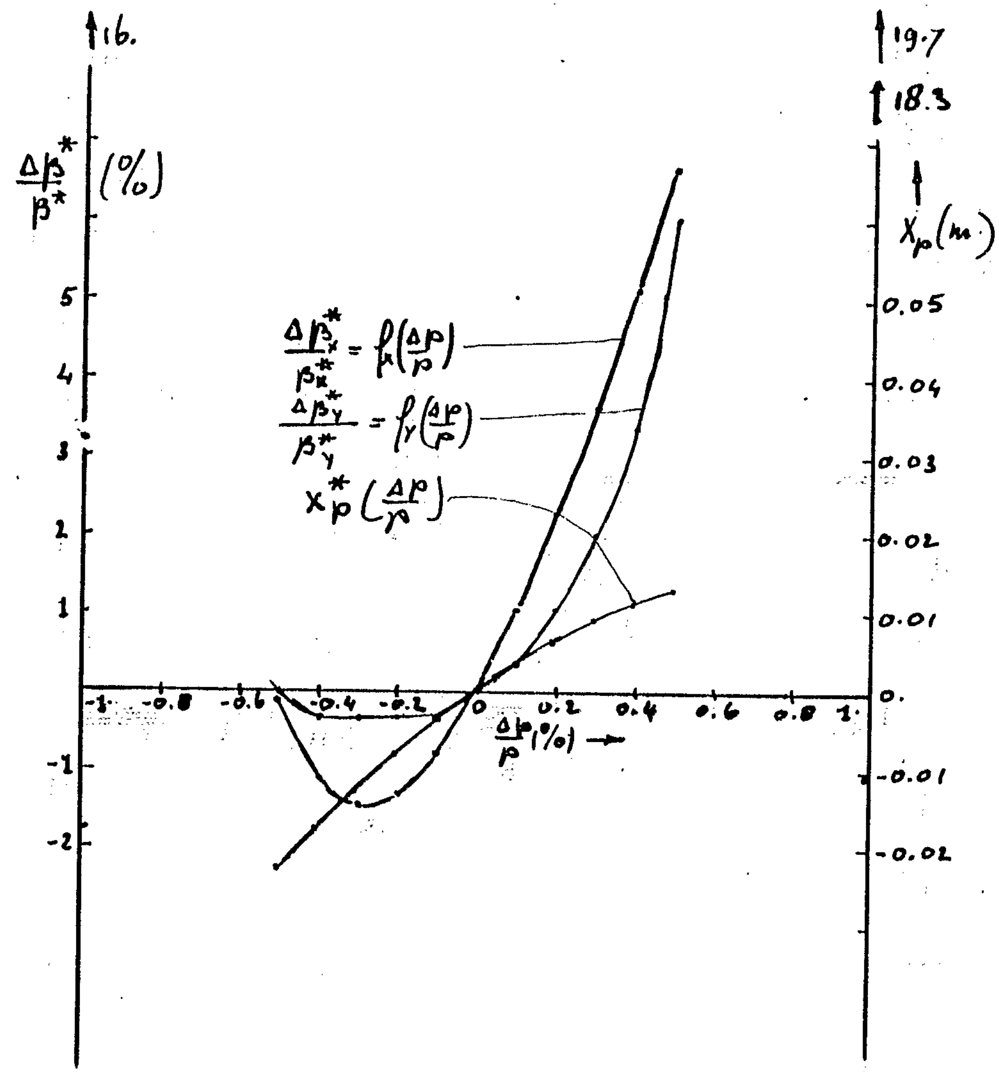
Q1	0.09070	0.09273
Q2	0.11593	0.11919
Q3	0.05906	0.04531
Q4	0.11367	0.12628
Q5	0.13379	0.10985
Q6	0.10440	0.09167
Q7	0.09040	0.12905
Q8/QF	0.08884	0.11272



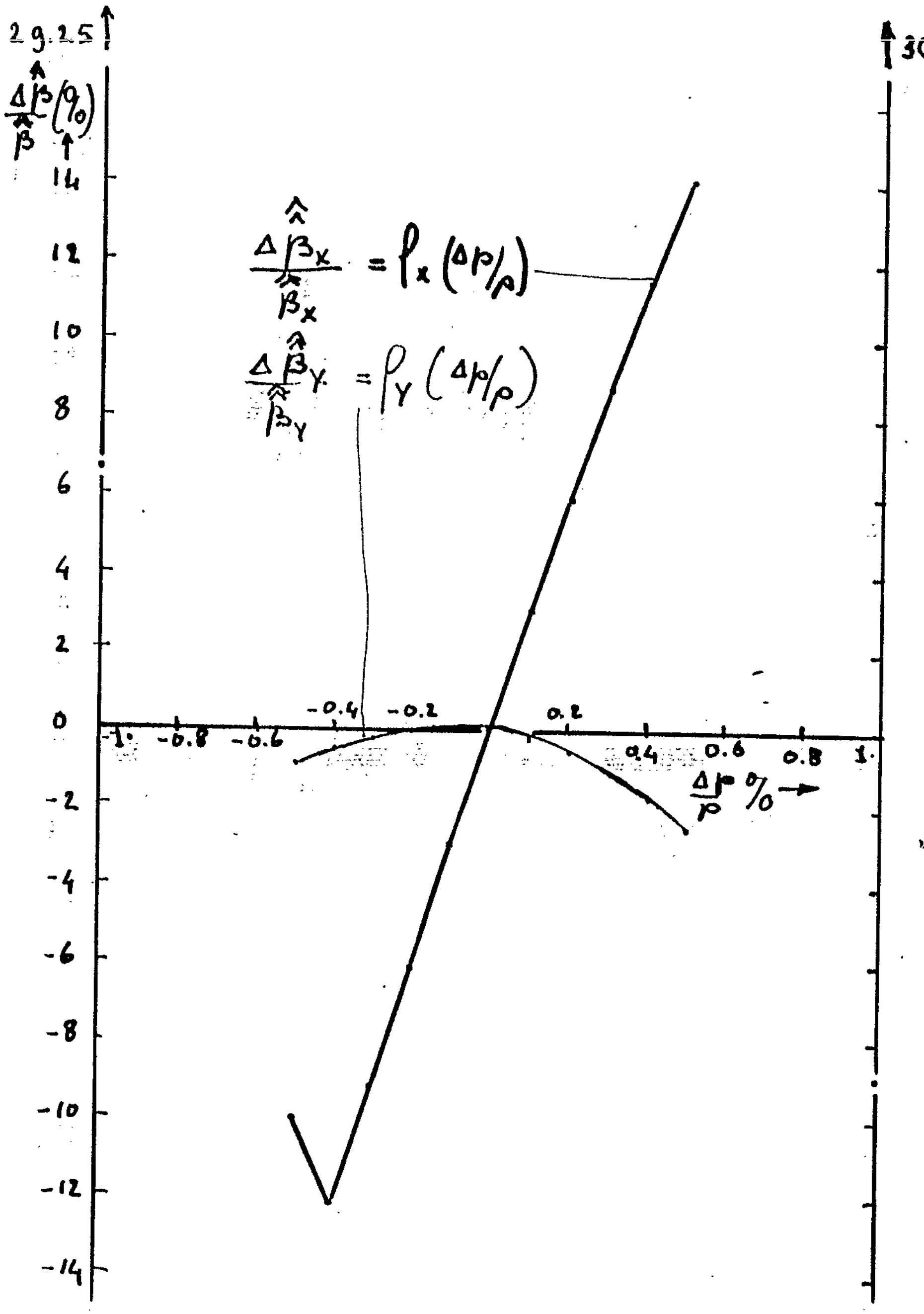

RHIC INSERTION
(02/14/84 09.48.54)
750
β(m)
$\hat{\beta}$ = 666.5
βV
500
250
1.385
β = 311.0
$\hat{\beta}$ = 267.4
β_V^* = 3.0
β_H^* = 17.7
βH
51.55
7.46
0
2.0
X_p(m)
1.5
1.385
1.0
0.5
51.61
7.45
Q8 Q7 Q6 Q5 Q4 Q3 Q2 Q1
-141.75
-100
-50
CR
Q1 Q2 Q3 Q4 Q5 Q6 Q7 Q8
100
141.75
-0.39
Inner
Outer



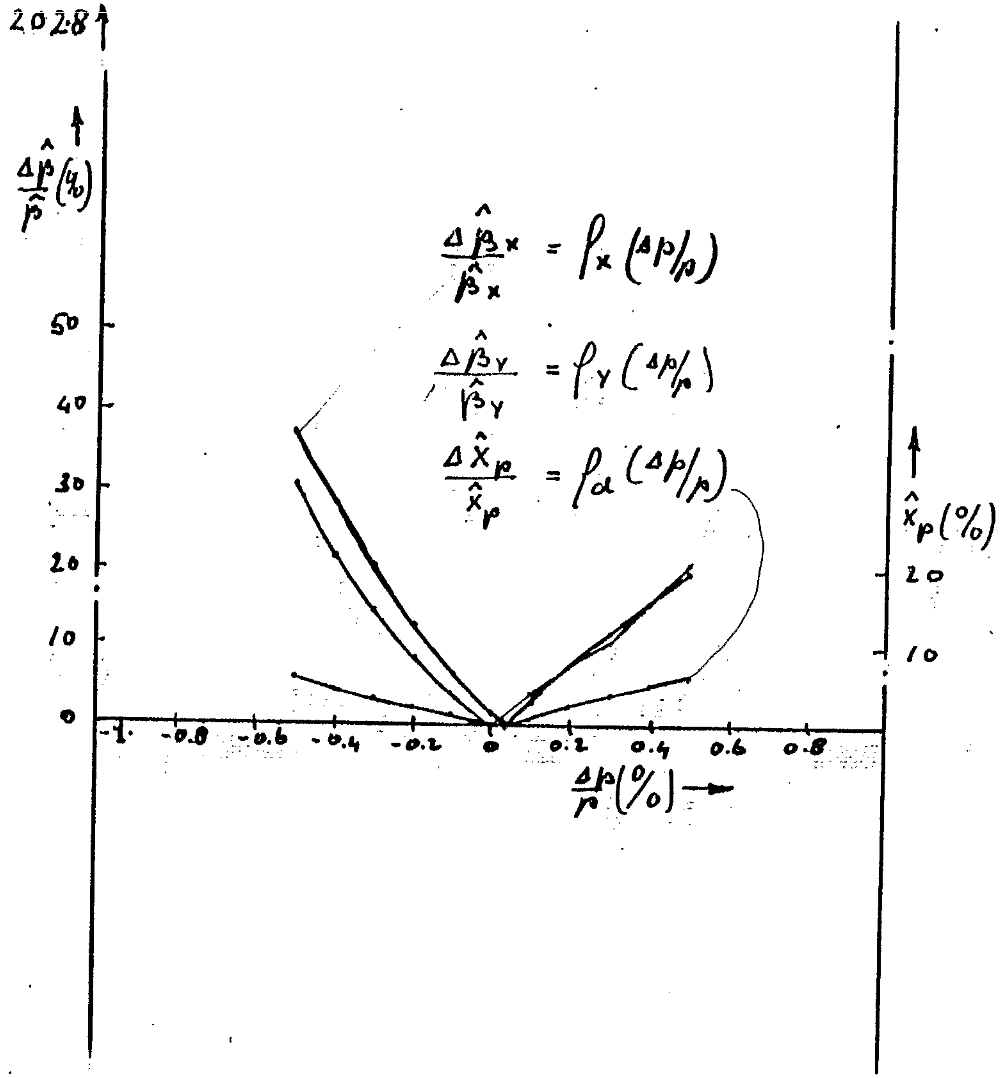
ΔV
$\Delta V_x (\Delta p/p)$
$\Delta V_y (\Delta p/p)$
0.04
0.03
0.02
0.01
0
-0.01
-0.02
-0.03
-0.04
-1.
-0.8
-0.6
-0.4
-0.2
0.2
0.4
0.6
0.8
1.
$\frac{\Delta p}{p}$ (%) →



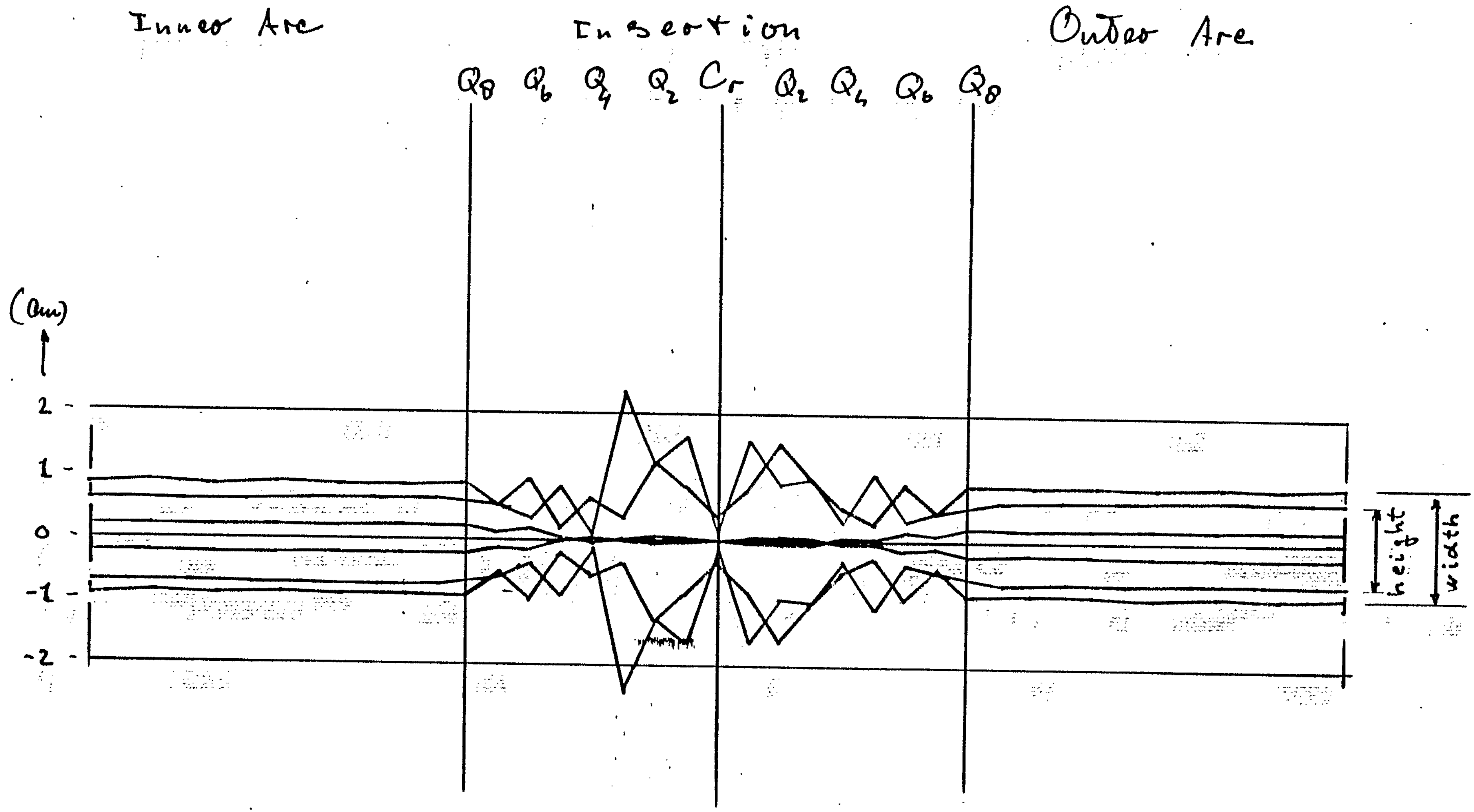
16.
19.7
18.3
$\frac{\Delta \beta^*}{\beta^*}$ (%)
X_p (m.)
$\frac{\Delta \beta_x^*}{\beta_x^*} = f_x\left(\frac{\Delta p}{p}\right)$
$\frac{\Delta \beta_y^*}{\beta_y^*} = f_y\left(\frac{\Delta p}{p}\right)$
$X_p^* \left(\frac{\Delta p}{p}\right)$
5
4
3
2
1
-1
-2
0.05
0.04
0.03
0.02
0.01
0.
-0.01
-0.02
-1.
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
0.8
1.
$\frac{\Delta p}{p}$ (%) →



29.25
Δβ̂/β̂ (%)
$\frac{\Delta\hat{\beta}_x}{\hat{\beta}_x} = f_x(\Delta p/p)$
$\frac{\Delta\hat{\beta}_y}{\hat{\beta}_y} = f_y(\Delta p/p)$
30
Δp/p %



2028
Δβ̂/β̂ (%)
$\frac{\Delta\hat{\beta}_x}{\hat{\beta}_x} = f_x(\Delta p/p)$
$\frac{\Delta\hat{\beta}_y}{\hat{\beta}_y} = f_y(\Delta p/p)$
$\frac{\Delta\hat{X}_p}{\hat{X}_p} = f_\alpha(\Delta p/p)$
$\hat{X}_p$ (%)
Δp/p (%)

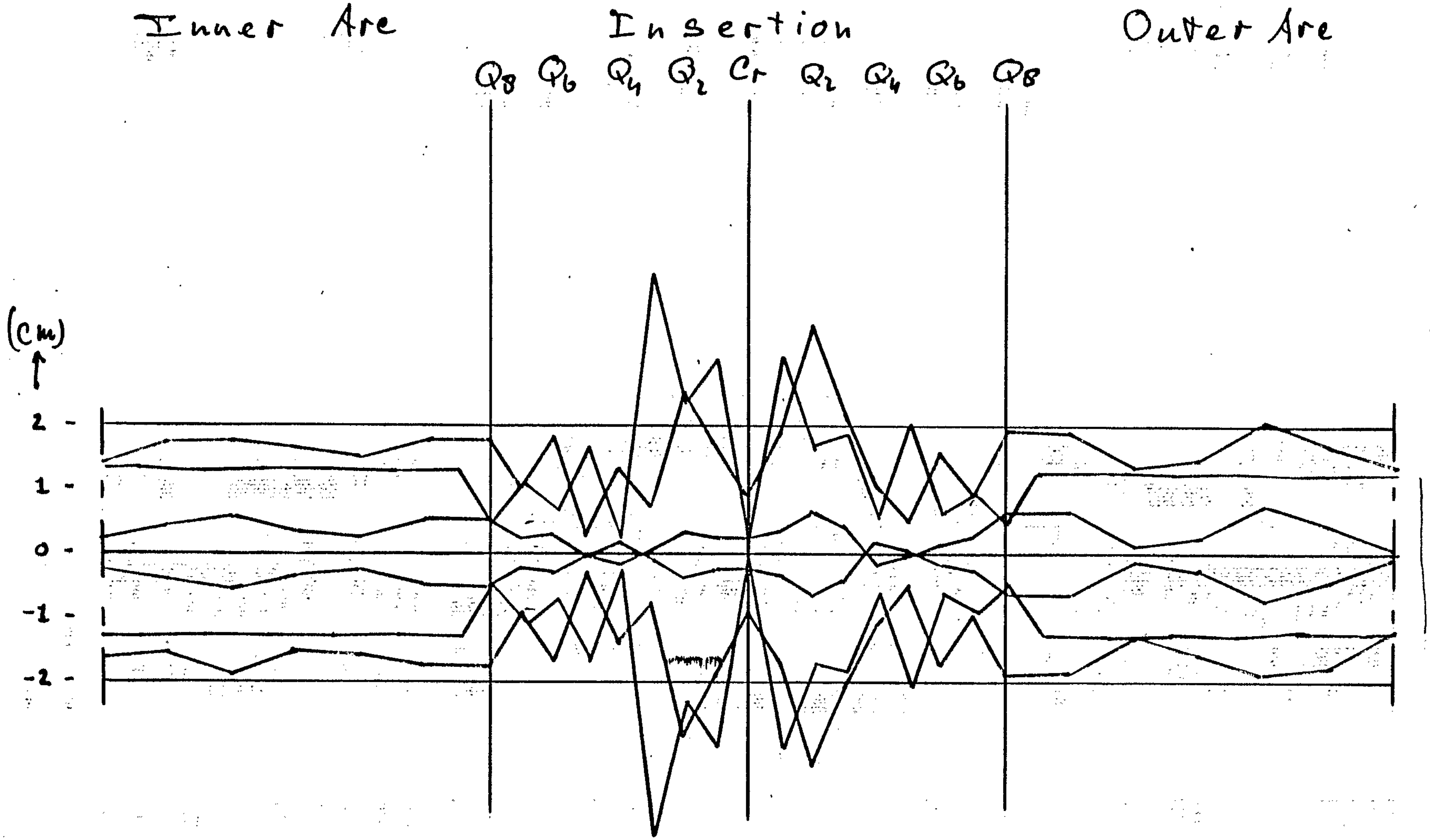


Beam dimensions at injection

$\gamma = 12$

$\varepsilon = 10 \times 10^{-6}$ rad-m (2.5σ)

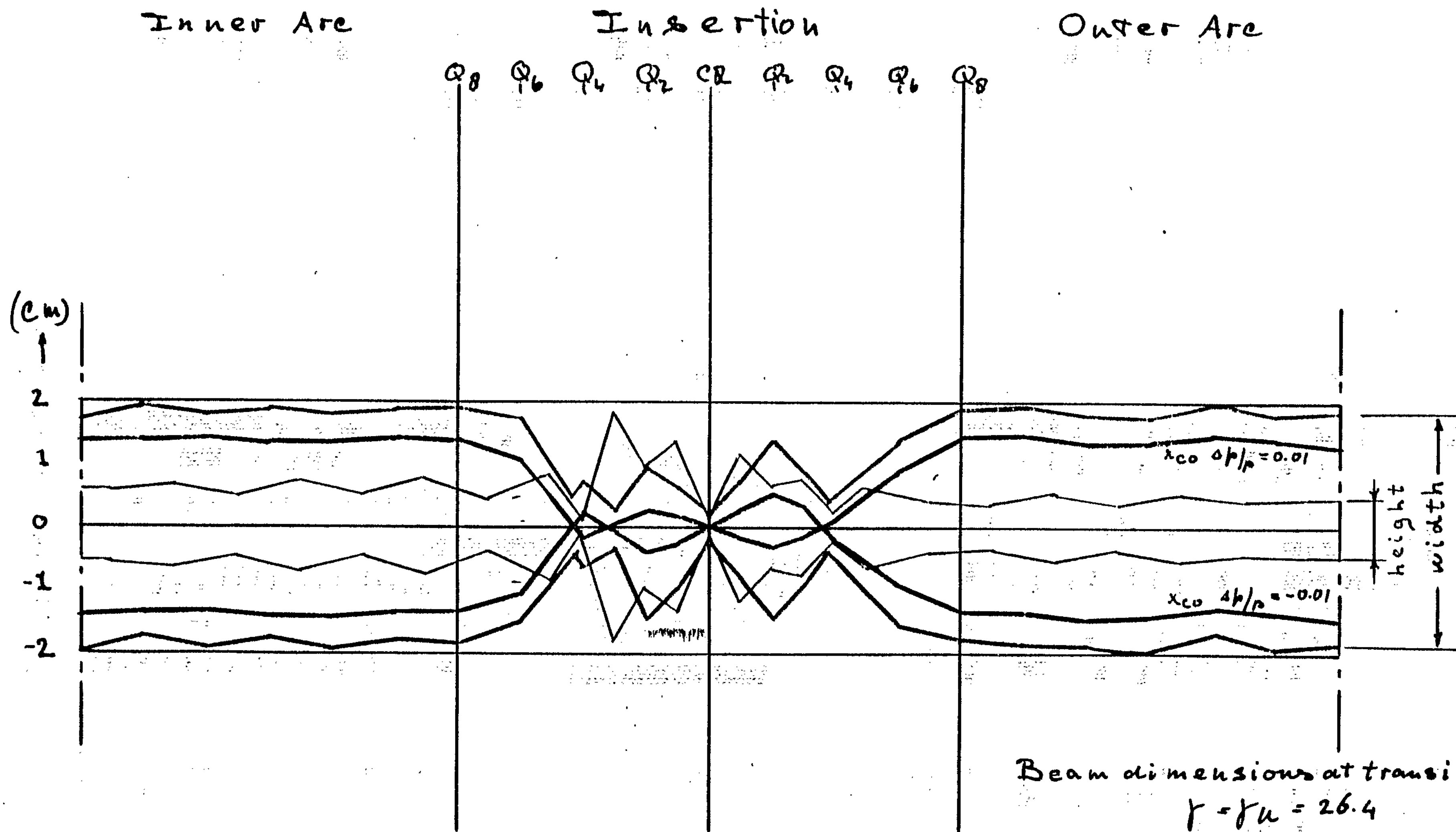
$\frac{\Delta p}{p} = \pm 1.62 \times 10^{-3}$



Beam dimensions after 2hrs at $\gamma = 12$

$\varepsilon = 34.5 \times 10^{-6}$ rad-m (2.5σ)

$\frac{\Delta p}{p} = \pm\ 3 \times 10^{-3}$



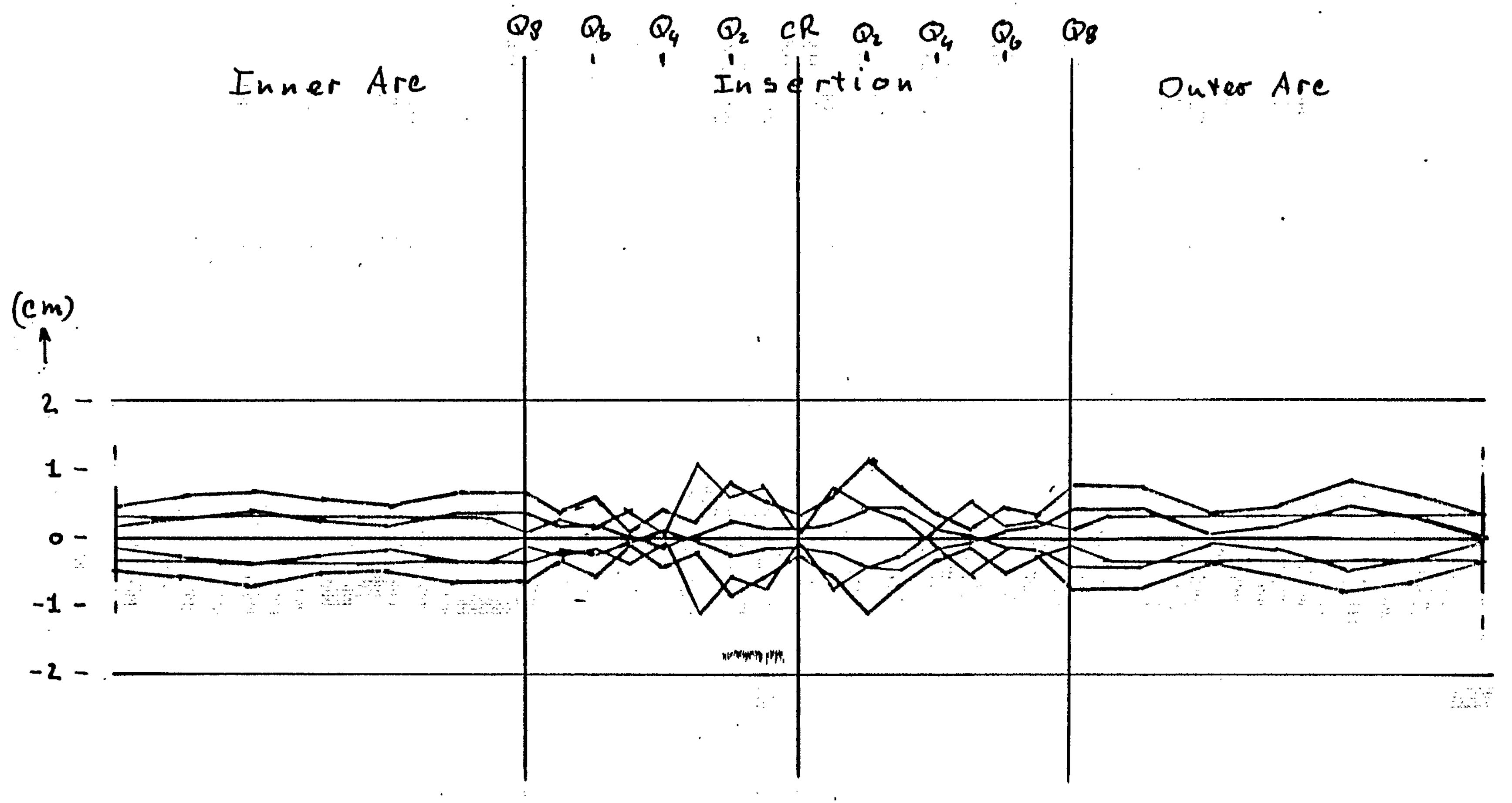
Beam dimensions at transition

$\gamma = \gamma_{tr} = 26.4$

$\varepsilon = 10 \times 10^{-6}$ rad-m (2.5σ)

$\Delta p/p = \pm\ 0.01$

03/06/84 16.34.47 JCL



Beam dimensions after 2 hrs at $\gamma = 100$

$\varepsilon = 18.4 \times 10^{-6}$ rad-m (2.5σ)

$\frac{\Delta p}{p} = \pm 2 \times 10^{-3}$