

Discussion On RHIC Lattice

J. Claus

April 1984

Collider Accelerator Department
Brookhaven National Laboratory

U.S. Department of Energy
USDOE Office of Science (SC)

Notice: This technical note has been authored by employees of Brookhaven Science Associates, LLC under Contract No.DE-AC02-76CH00016 with the U.S. Department of Energy. The publisher by accepting the technical note for publication acknowledges that the United States Government retains a non-exclusive, paid-up, irrevocable, world-wide license to publish or reproduce the published form of this technical note, or allow others to do so, for United States Government purposes.

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or any third party's use or the results of such use of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof or its contractors or subcontractors. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCUSSION ON
RHIC LATTICE

J. Claus

April 2, 1984

Brookhaven National Laboratory

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 Feasibility Study

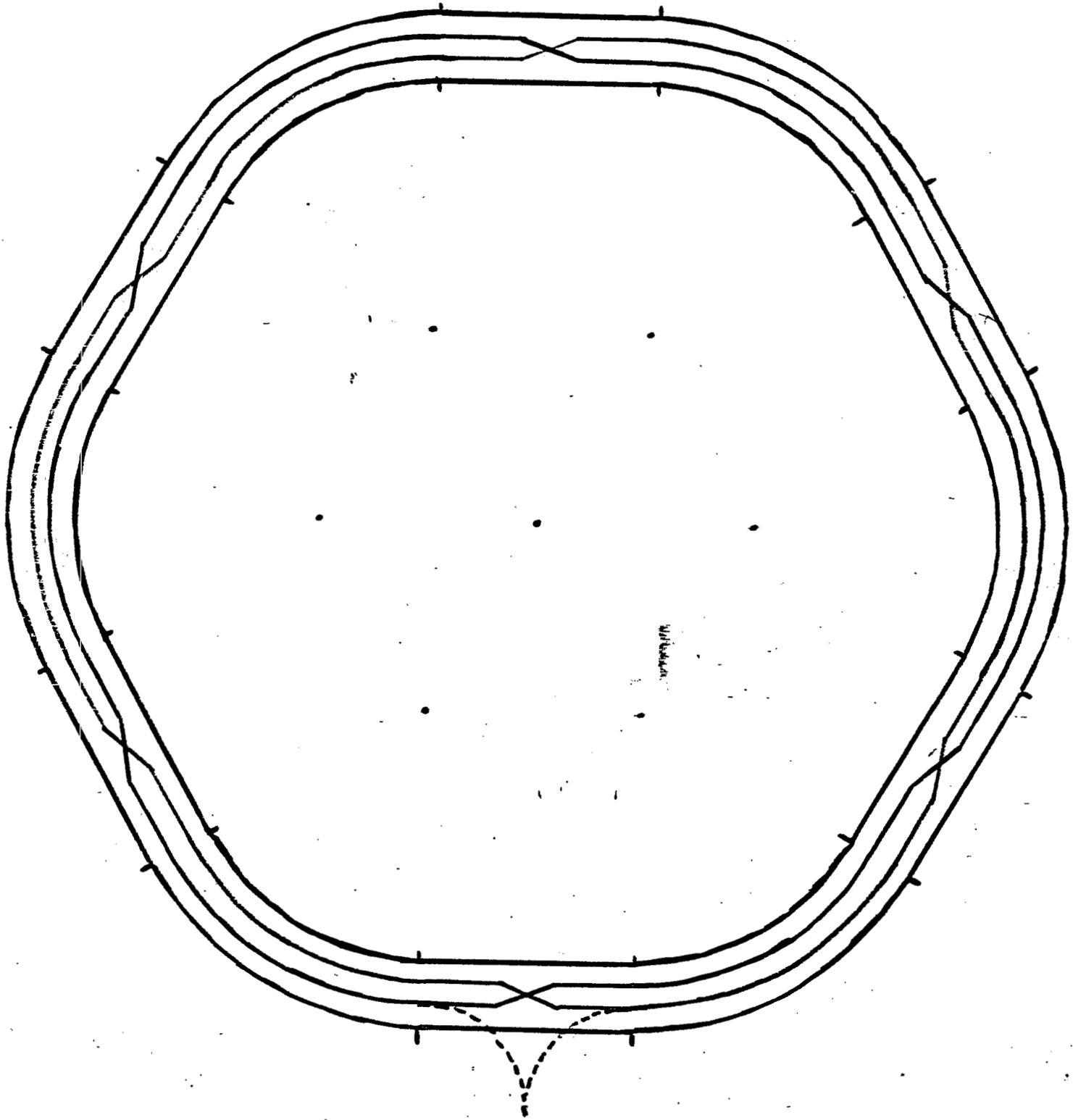
CBA 2 in 1, Symmetric, missing magnets

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

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

RHIC 2 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.
D_x / D_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
$\hat{\beta}_x / \hat{\beta}_y$ in arcs (m)	51.58 / 7.46
$\hat{\beta}_y / \hat{\beta}_y$ in arcs (m)	51.58 / 7.46
\hat{x}_p / \hat{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
$\hat{\beta}_x / \hat{\beta}_y$ (m)	267. / 667.



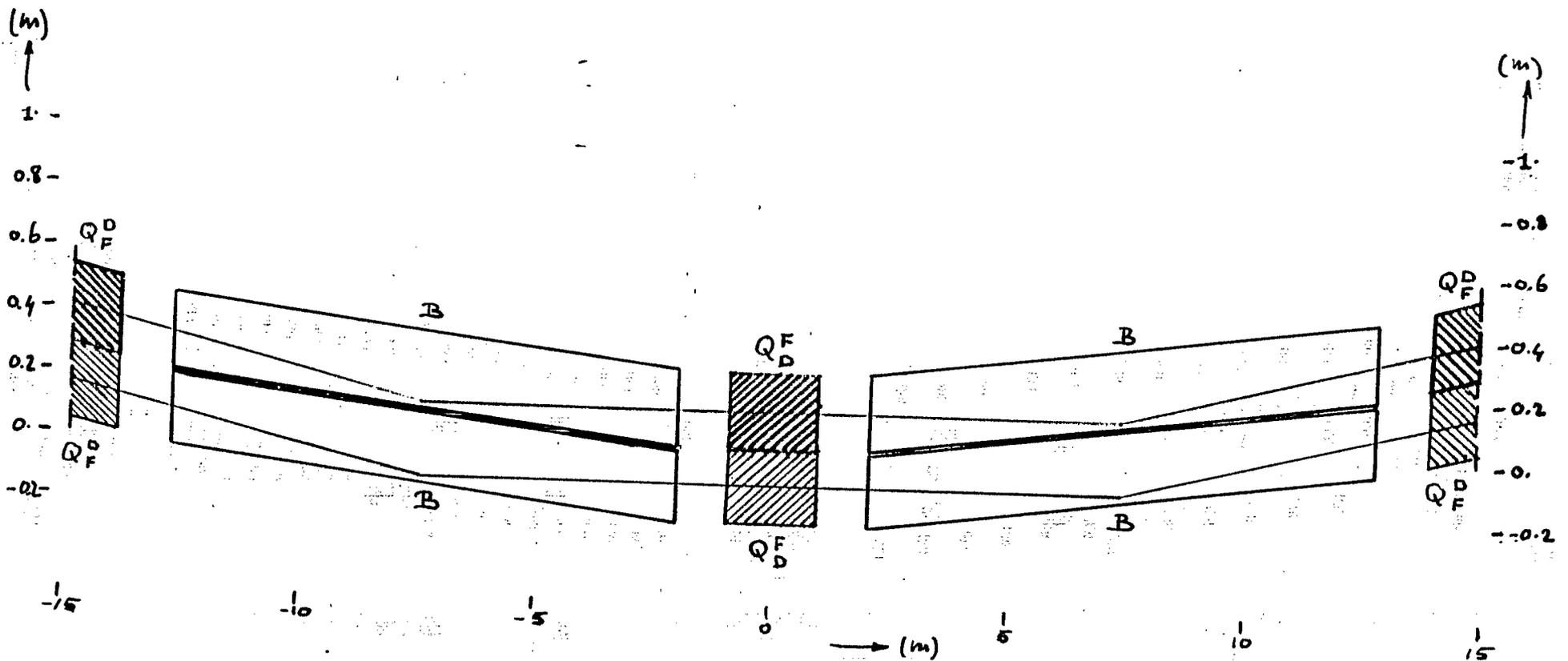
RHIC Regular Cell Pair

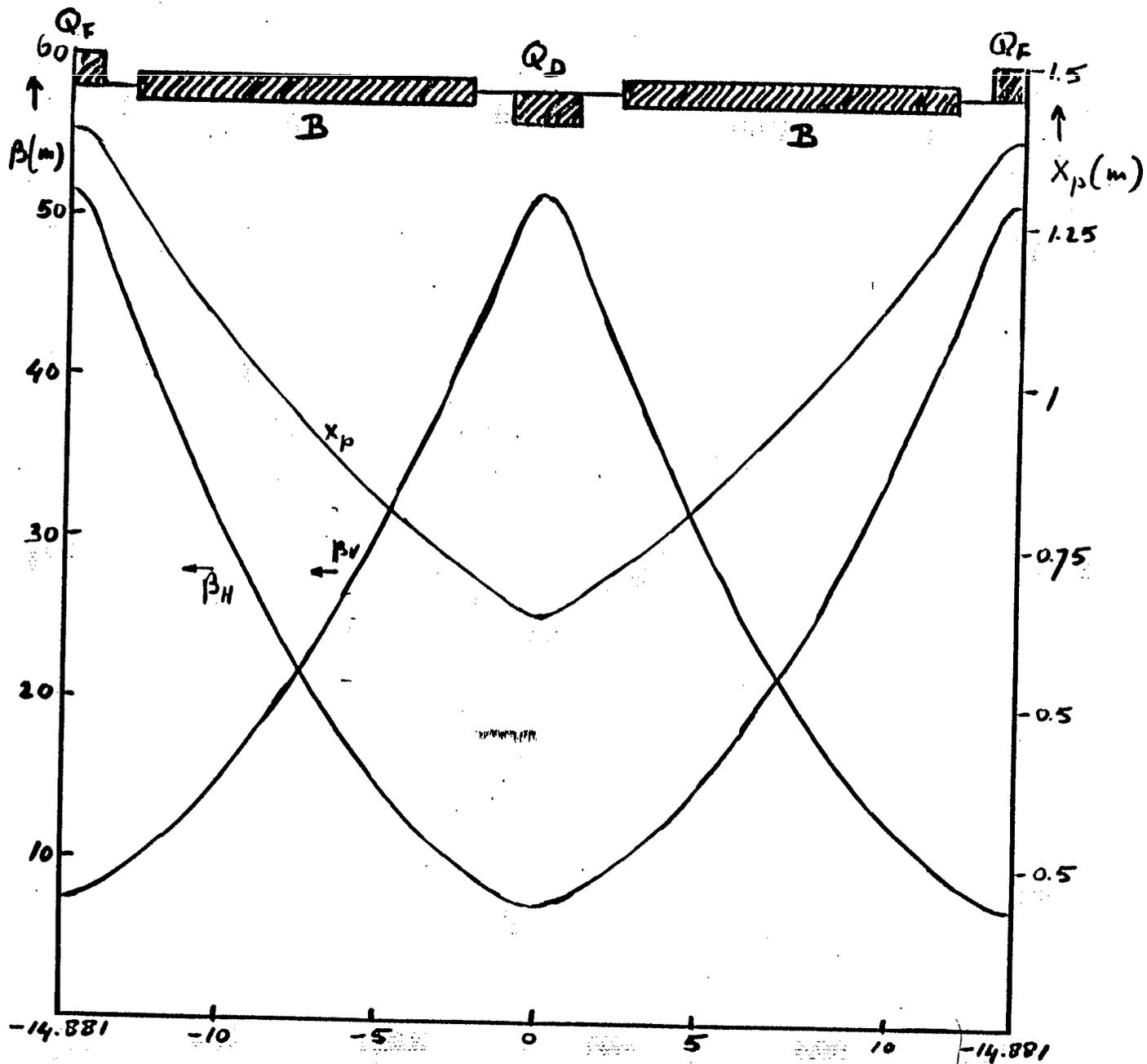
$$\theta_H = \frac{\int B' dl}{B\rho} = 0.03885 \text{ rad}$$

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

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

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

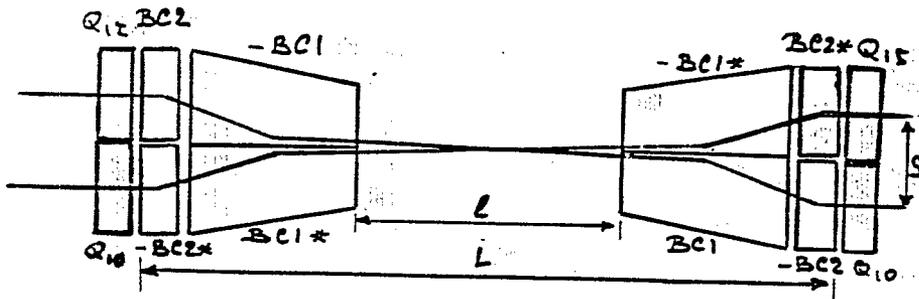




RHIC REGULAR ARC CELL (02/14/84 09.48.54)

Crossing Point Regions

Present arrangement:



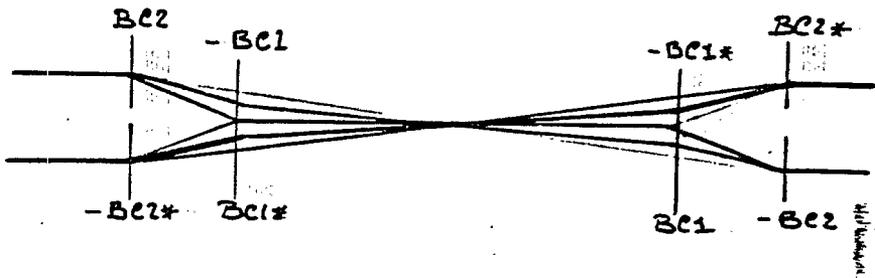
$$l = 22 \text{ m}$$

$$\alpha = 2 - 8.7, 10.8 \text{ mrad}$$

$$S = 0.24 \text{ m}, 0.30 \text{ m}$$

$$L = 58 \text{ m}$$

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_p values) in the two rings: $(-BC1, BC1^*)$ and $(BC1, -BC1^*)$ can each be a one aperture magnet, but aperture must be large enough to accommodate 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 $(B_p)_1 / (B_p)_2 \leq 2.5$

$|BC_2^1| \neq |BC_2^{1*}|$: 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 Bp '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 \rightarrow $BC1$ and $BC2$ should be short and therefore strong.

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

Present approach: try to live with it.

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

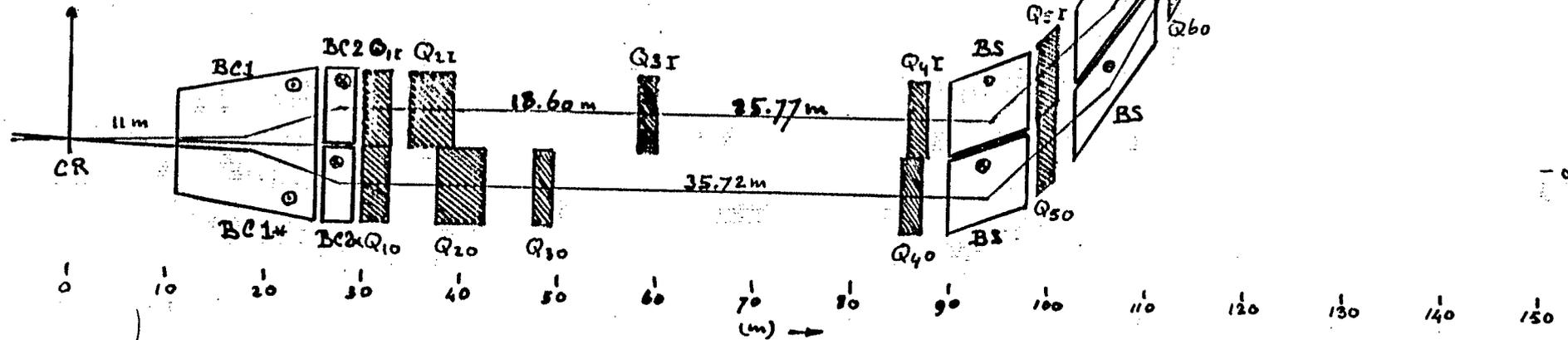
Alternatives: a) introduce extra quad to remove dispersion. Promising results so far.
b) use anti symmetric lattice, like CBA's anti symmetric $2u1$.

RHIC Half Insertion (02/14/84 09:48:54)

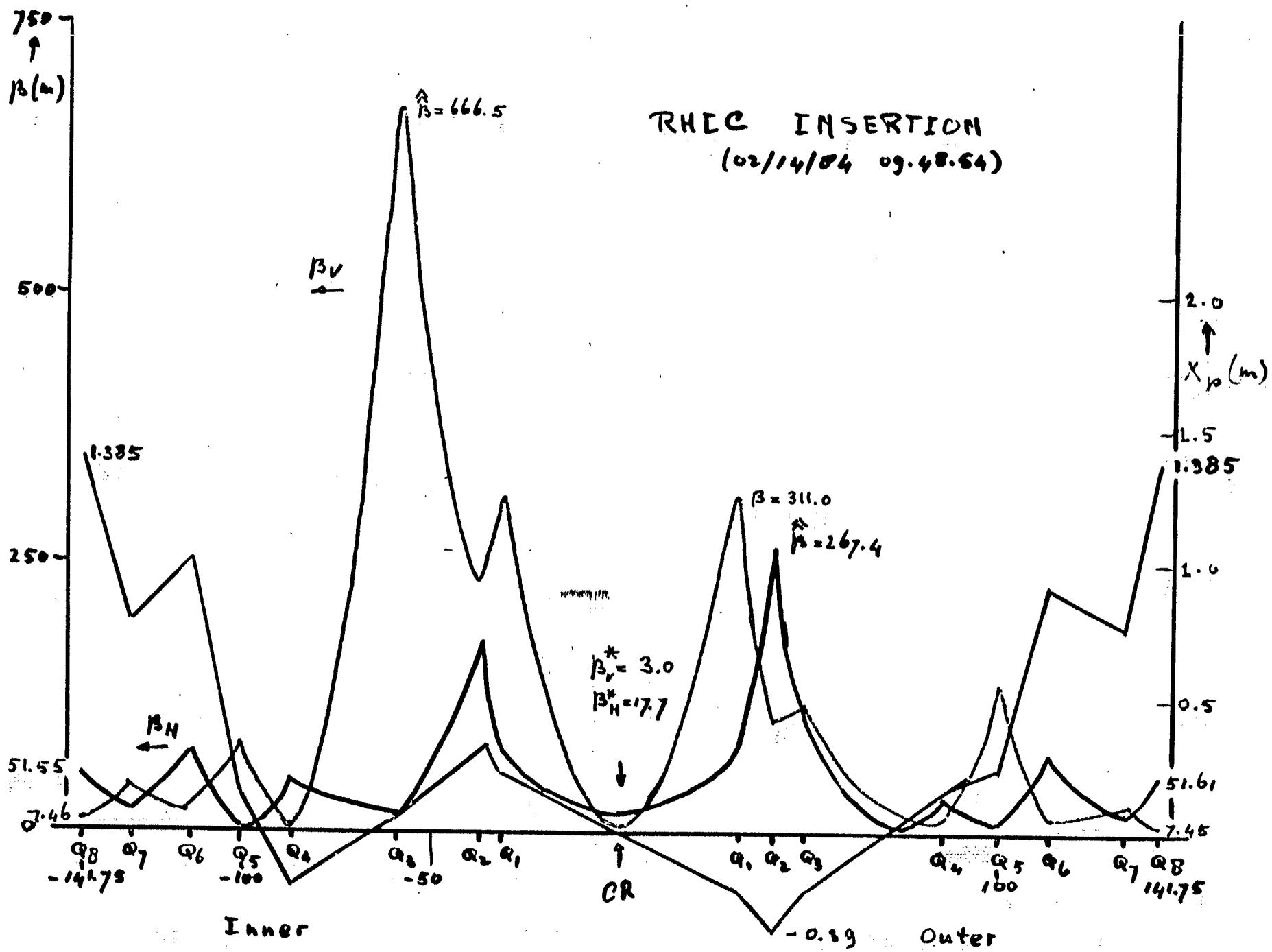
Quad Strengths ($\frac{\int B'dl}{B_p}$, m^{-1})

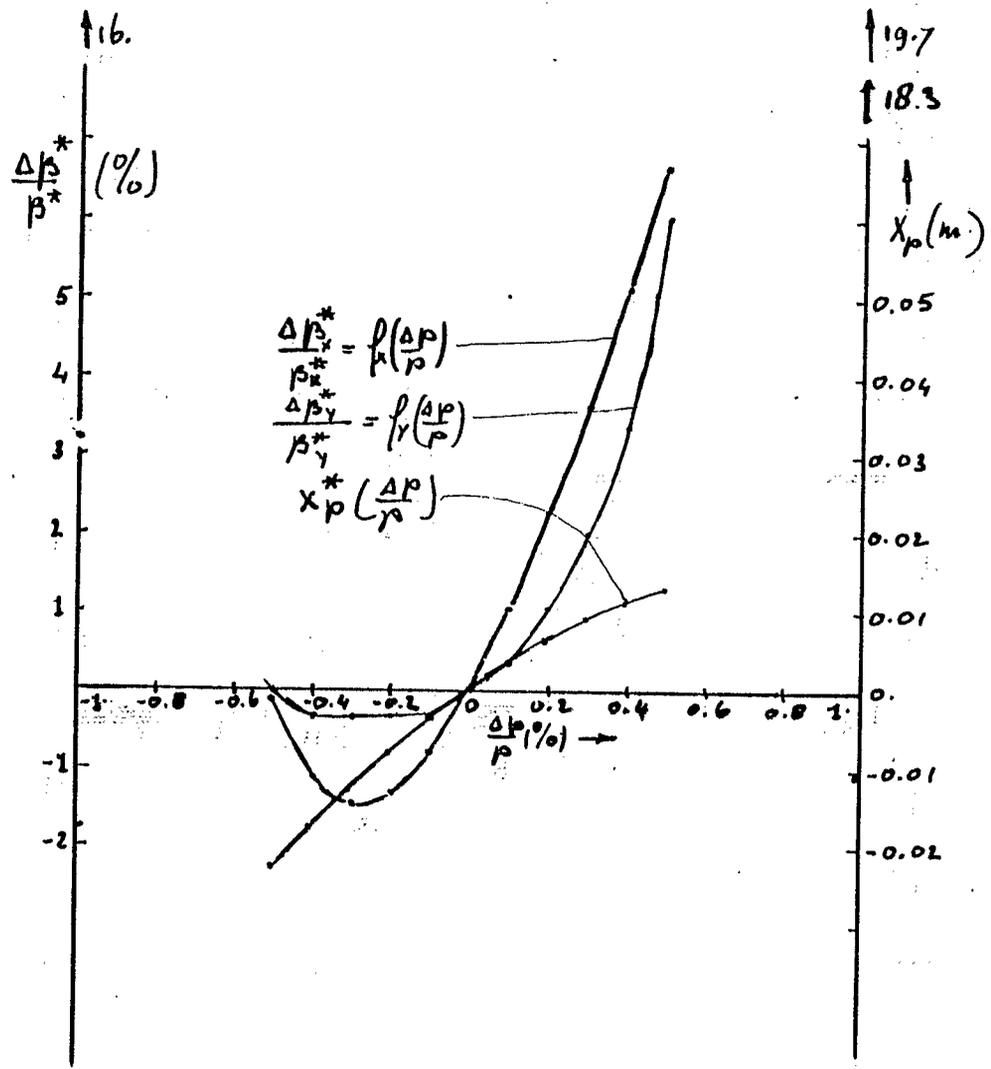
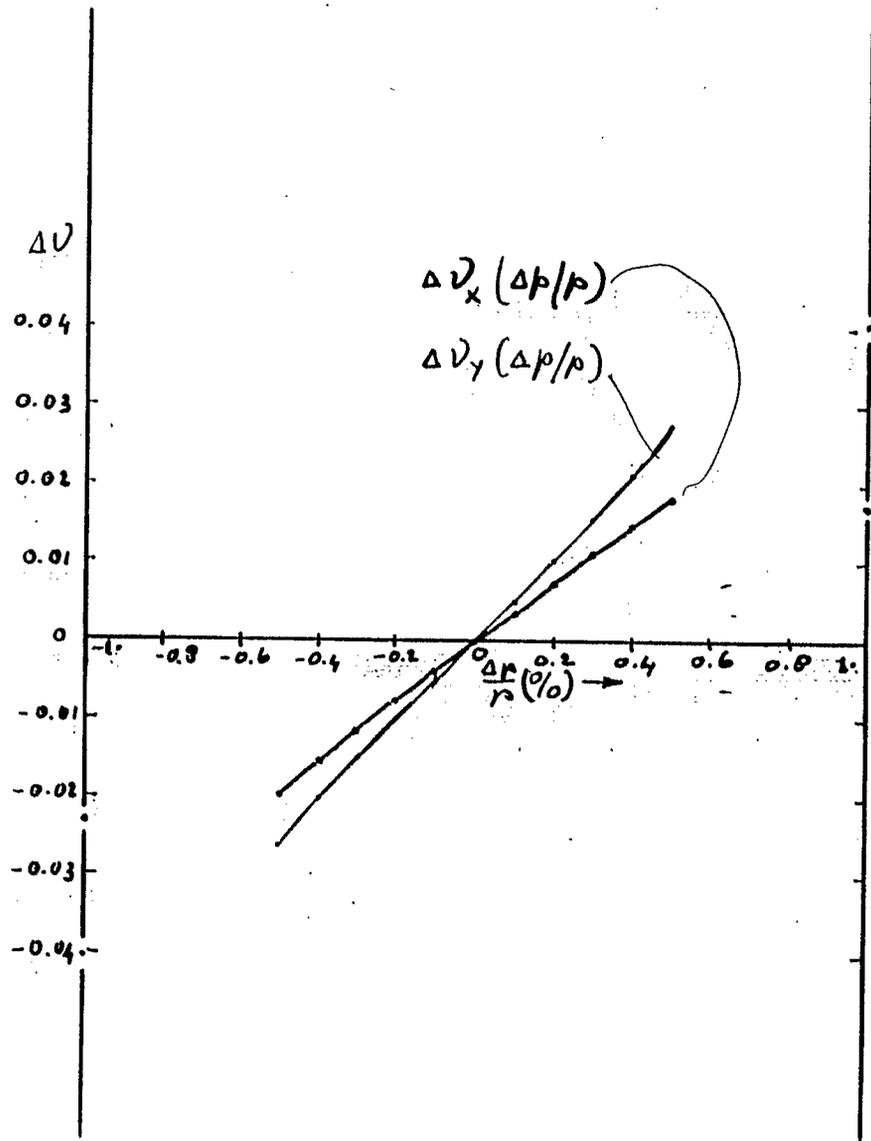
Q1	0.09070	0.09273
Q2	0.11593	0.11919
Q3	0.05906	0.04531
Q4	0.11367	0.12628
Q5	0.13379	0.10985
Q6	0.10440	0.09167
Q7	0.09040	0.12905
Q8/QF	0.08884	0.11272

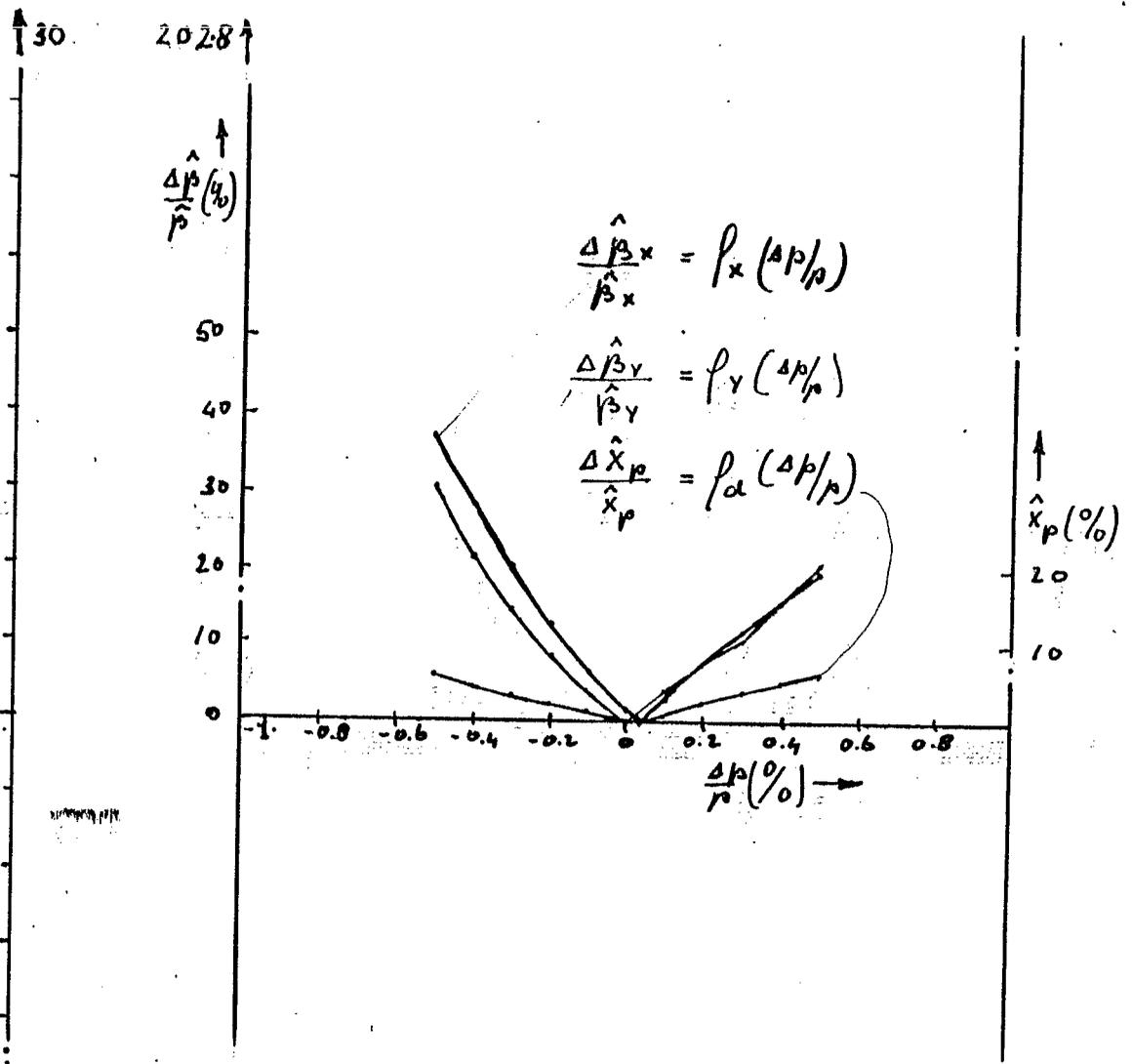
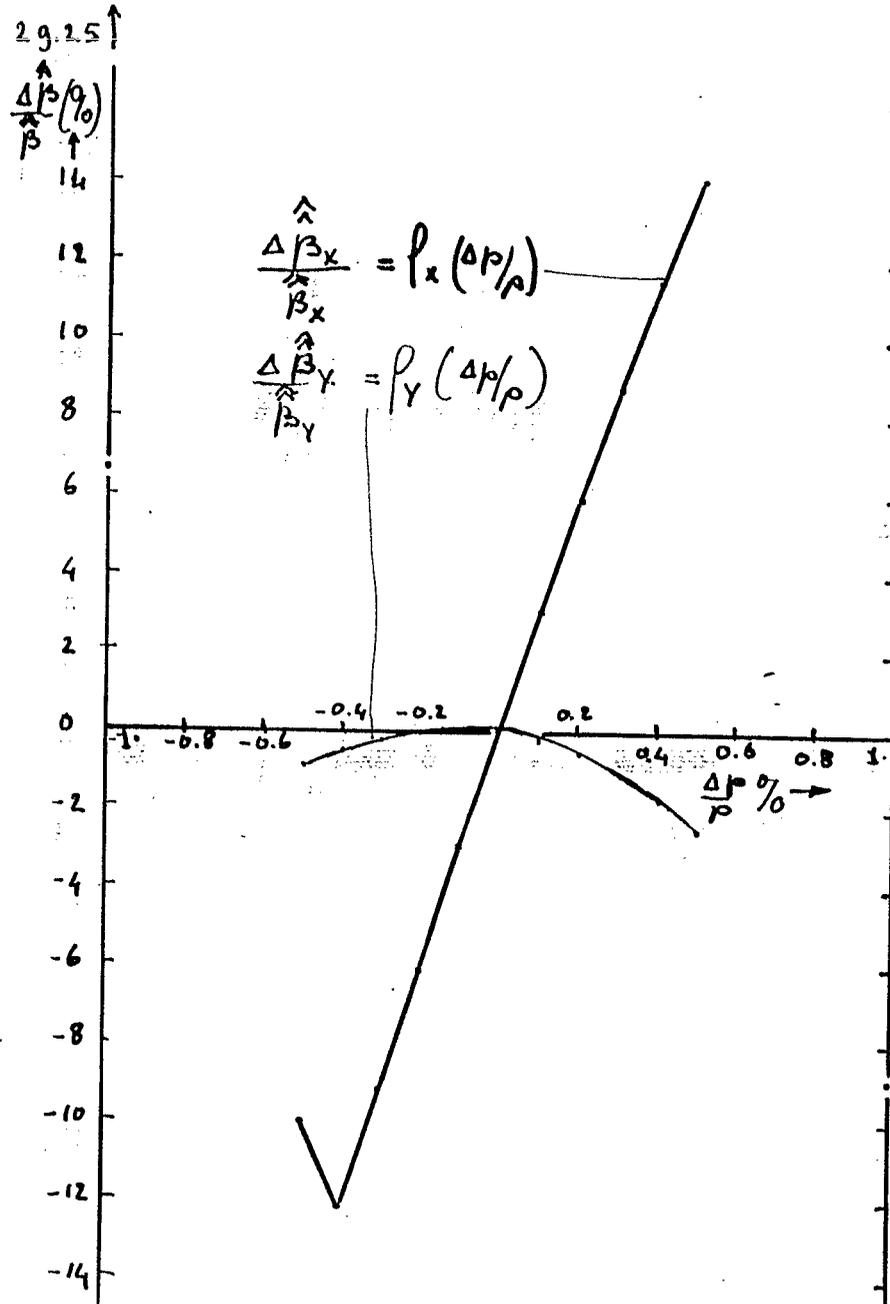
Center at 590.515m

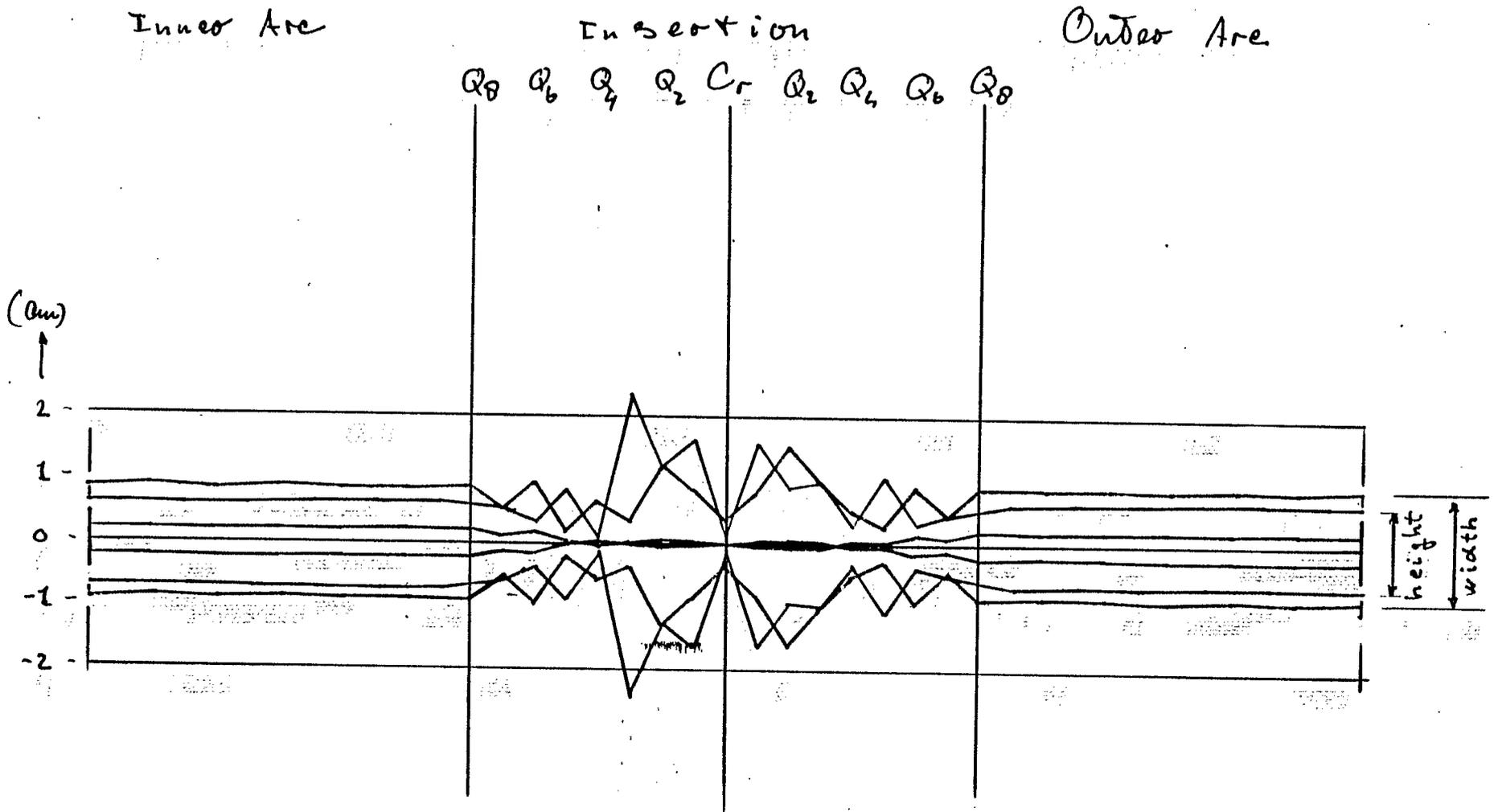


RHEC INSERTION (02/14/84 09.48.64)









Beam dimensions at injection
 $\gamma = 12$

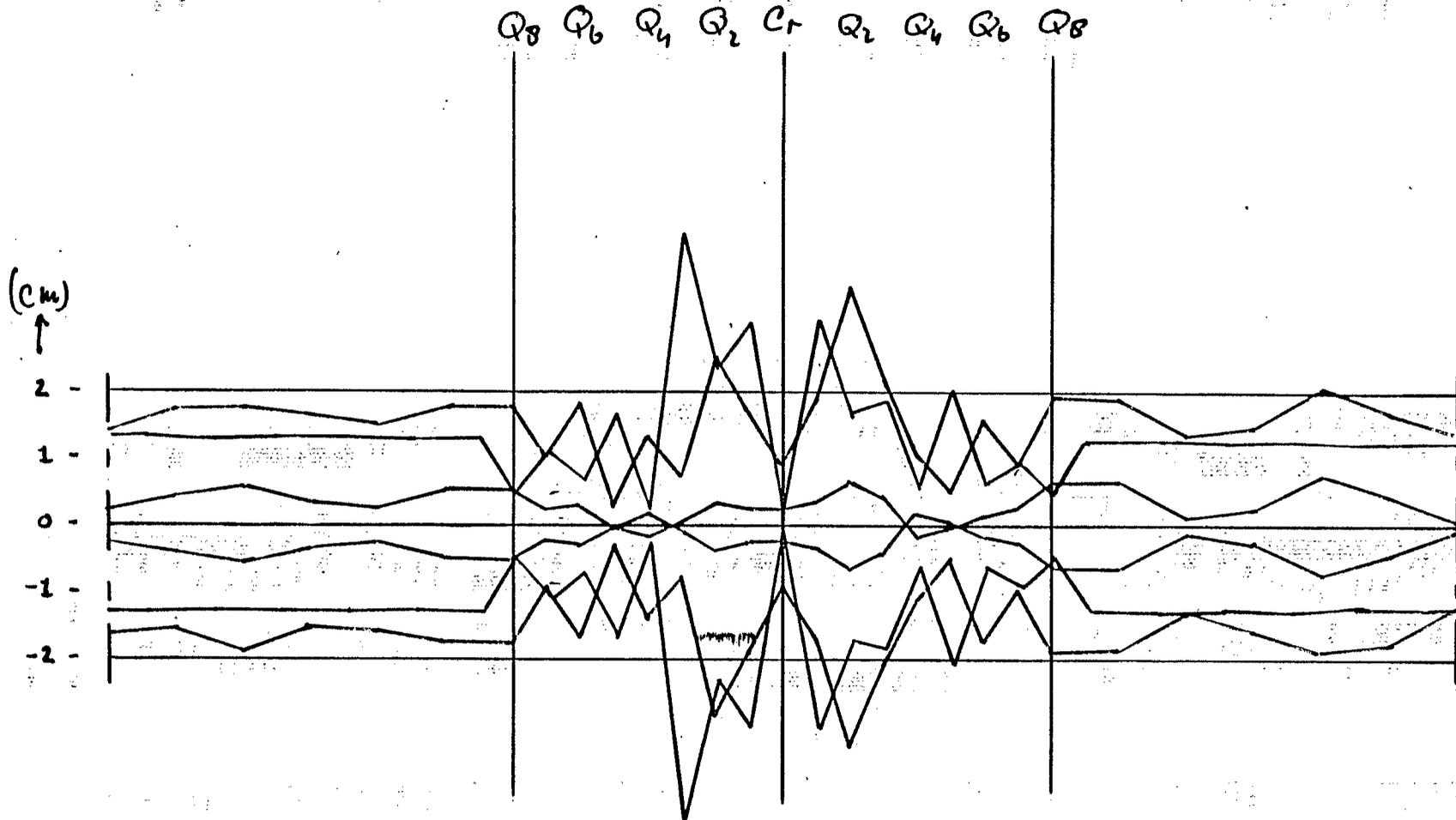
$$\Sigma = 10 \times 10^{-6} \text{ rad-m (2.5\%)}$$

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

Inner Arc

Insertion

Outer Arc



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

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

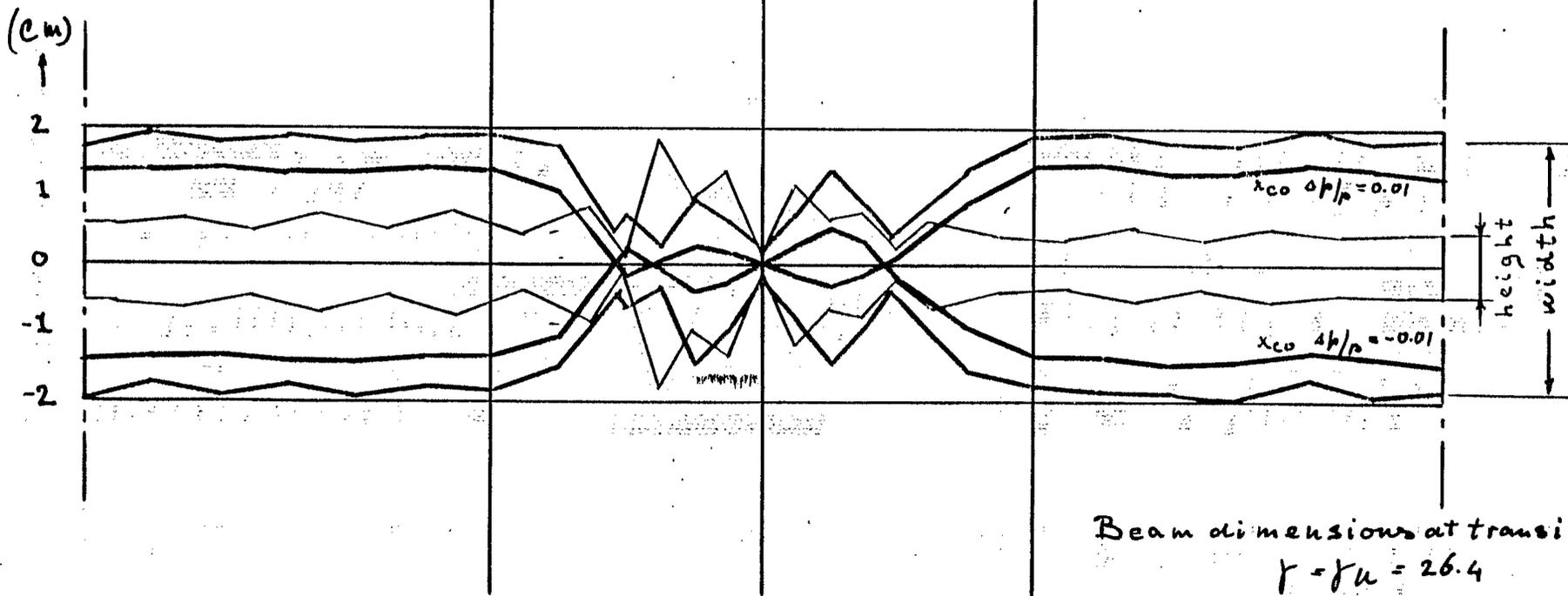
$$\frac{\Delta p}{p} = \pm 3 \times 10^{-3}$$

Inner Arc

Insertion

Outer Arc

Q₈ Q₆ Q₄ Q₂ CR Q₂ Q₄ Q₆ Q₈



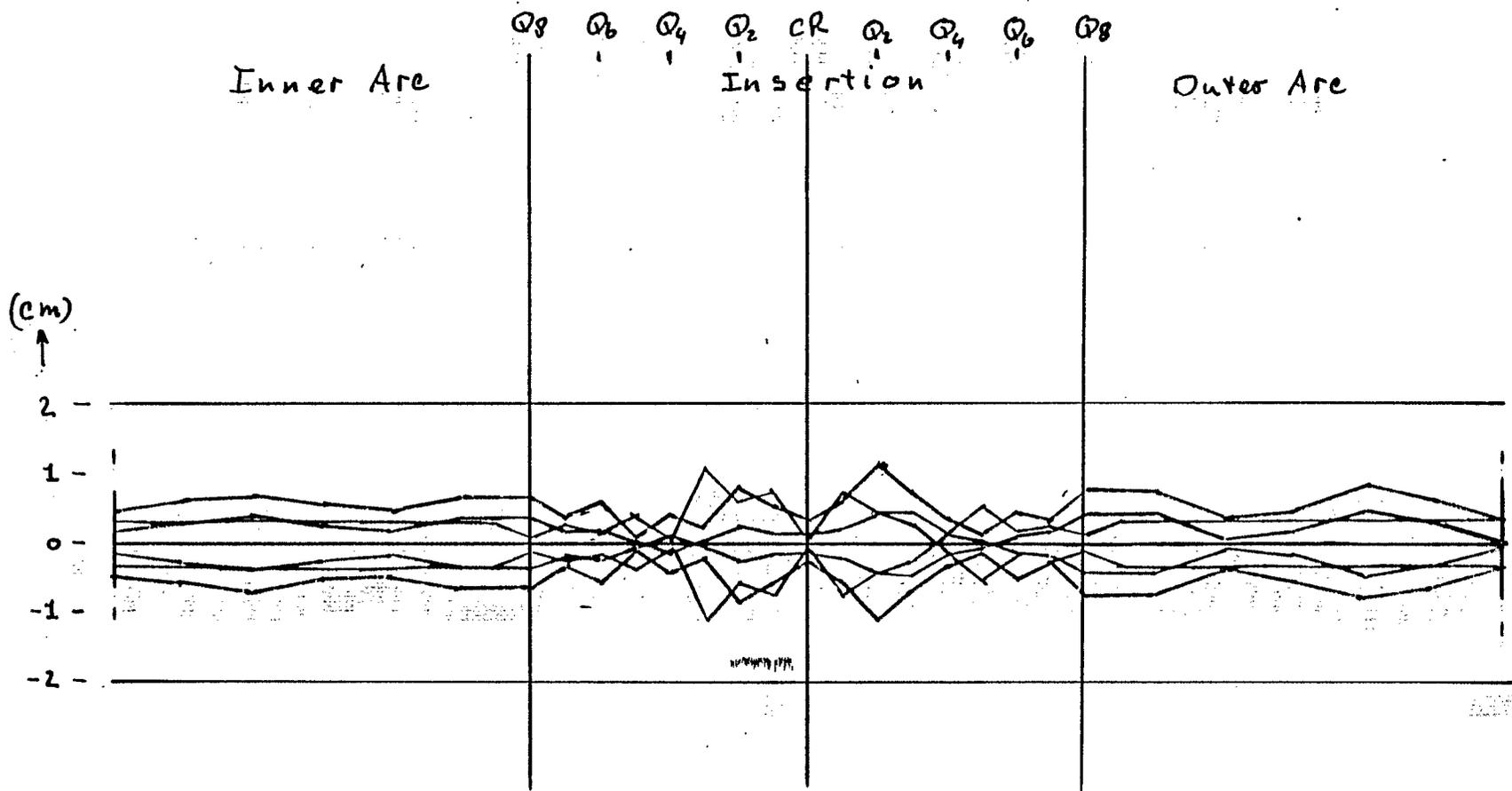
Beam dimensions at transition

$$\gamma = \gamma_u = 26.4$$

$$\epsilon = 10 \times 10^{-6} \text{ rad-m (2.55)}$$

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

02/06/84 16.34.47 JEL



Beam dimensions after 2 hrs
at $f = 100$

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

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