COMPARISON OF CLUSTERS WITH 2 AND 3 INTERACTION POINTS*

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For both types of cluster the following sextupole arrangements were compared with respect to dynamical aperture and variation of tunes (Q_x, Q_z) and interaction beta values (β^*_x, β^*_z) with momentum:

- global correction scheme, i.e. 2 families of sextupoles with equal strengths for each family
- local interleaved correction
- local noninterleaved correction

For the two local correction schemes the sextupoles in the regular arcs were tuned to compensate the local cell chromaticity only. An optic with approximately n + 1/4 tune variation between two interaction points was used.

I. 3-IR Cluster (2 per Ring)

Figures 1 and 2 show the variation of tune with momentum for the sextupole distributions C3.G (global), C3.LI (local interleaved) and C3.LN (local noninterleaved).

For the two local correction schemes only sextupoles between the two outer interaction points were used (6 1/2 cells). Since the tune advance between 2 IP's is n + 1/4, the linear beta variation with momentum produced by sextupoles is locally compensated within the cluster.

To avoid large sextupole strenghts, for the local interleaved compensation both drift spaces left and right from a cell quadrupole were equipped with sextupoles.

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* SSC-N-39
+ Operated by the Universities Research Association for the Department of Energy

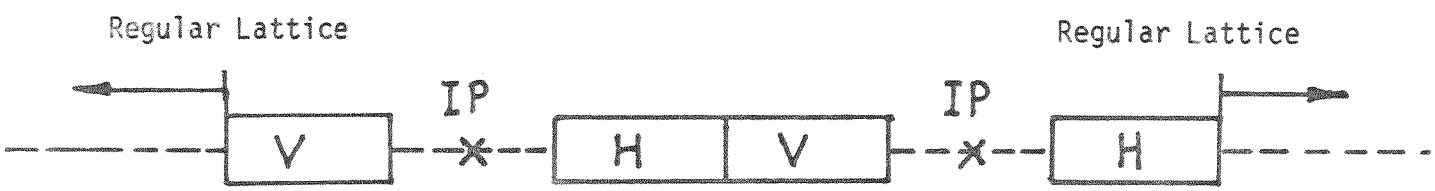
The variation of horizontal and vertical interaction beta with momentum for the inner and outer interaction points of the cluster are shown in Figures 3 to 6.

Figure 7 shows the variation of dynamical aperture (i.e. maximum horizontal amplitude for 100% emittance coupling) with momentum.

The tracking was performed for 4 different initial conditions $(x, x', z, z') = (\hat{x}, 0, \hat{z}, 0)$, $(-\hat{x}, 0, \hat{z}, 0)$, $(\hat{x}, 0, 0, \hat{z}')$, and $(-\hat{x}, 0, 0, \hat{z}')$ over 50 revolutions.

II. <u>2-IR Cluster</u> (3 per Ring)

To achieve a cancellation of the linear beta beat produced by sextupoles, in the local correction schemes a corresponding number of cells outside the cluster was added for the local correction, so that the arrangement got the following structure:



For the local noninterleaved compensation one pair of sextupole was used in each section V and H.

Figures 8 and 9 show the variation of horizontal tune and β^* with momentum. Due to symmetry reasons both interaction points in the cluster show the same β-variation. Even tune and beta variation in both planes are equal, as shown in Figures 10 and 11. The slight difference between the two planes is a result of the difference in tune (Q_x=85.265/Q_z=85.285).

Figure 12 shows the variation of dynamical aperture with momentum. The symmetric behaviour of the global compensation (C2.G) is caused by a drastic increase of the $2Q_x-2Q_z$ driving term for positive momentum deviation.

Figure 13 shows the variation of 2 different tunes with momentum. For both cases the dynamical aperture is reduced for positive momentum deviation as shown in Figure 12. That means a change of the resonance driving term has caused the loss in stability and not a shift of the tune onto a resonance as a result of the momentum variation.

A motion of the tune away from the coupling resonance $2Q_x-2Q_z$, should bring an increase in stable amplitude for positive momentum deviation.

Comparison of Different Aspects

1) Noninterleaved/Interleaved

For the noninterleaved distribution the dynamical aperture is extremely large for small energy deviations. Even for the tails of the energy distribution it is sufficiently large.

But orbit errors (i.e. focusing errors due to orbit displacements in the sextupoles), sextupole displacement errors and quadupole errors have not been taken into account yet. The noninterleaved distribution tend to be very sensitive to these errors.

On the other hand also the momentum dependence of tunes and interaction betas are intolerably large and it is difficult to compensate them (by introducing more sextupole families).

2) Global Compensation/Local Compensation

An acceptable sextupole distribution should provide

- large dynamical aperture
- small variation of tune with momentum
- small variation of β^* with momentum

All local compensations in the examples given above are clearly worse than the global distributions. For the specific examples there is no preference for the local sextupole compensation

3) <u>3-IR Cluster/2-IR Cluster</u>

Structures with 2-IR cluster are clearly preferable compared to 3-IR clusters. The dynamical aperture is significantly larger and momentum dependence of tune and β* are considerably weaker.

The maximum deviations of tune and $(\frac{\Delta\beta}{\beta} / \frac{\Delta\rho}{\rho})$ over the momentum range of ± 0.001, and the minimum stable amplitude are compared in the following table for 2-IR and 3-IR clusters:

Parameters for the Range $-0.001 < \frac{\Delta\rho}{\rho} < .001$	3-IR	2-IR	
$\lvert \Delta Q_x \rvert$ max	2.8×10^{-3}	1.8×10^{-3}	
$\lvert \Delta Q_z \rvert$ max	2.9 x 10	1.7x10	
$\left\lvert \frac{\Delta\beta^*_x}{\beta_x} \Big/ \frac{\Delta\rho}{\rho} \right\rvert$ max	10.2	2.8	[%]
$\left\lvert \frac{\Delta\beta^*_z}{\beta_z} \Big/ \frac{\Delta\rho}{\rho} \right\rvert$ max	9.6	2.9	[%]
(A_x) min	3.47	6.35	[mm]

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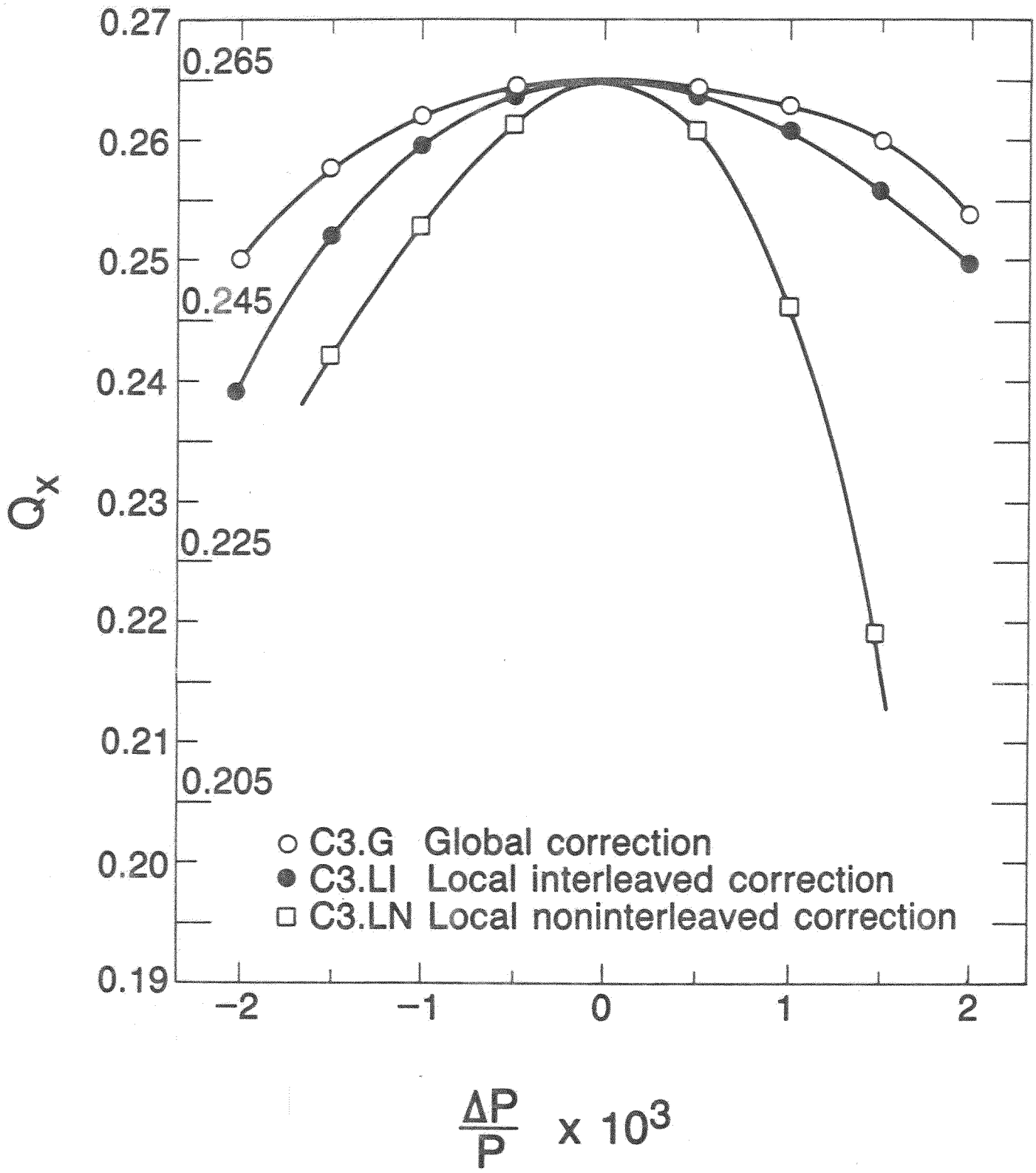
Figure 1. (3IR) Horizontal Tune vs. Momentum



XBL 859-11291

Figure 2. (3IR) Verticle Tune vs. Momentum

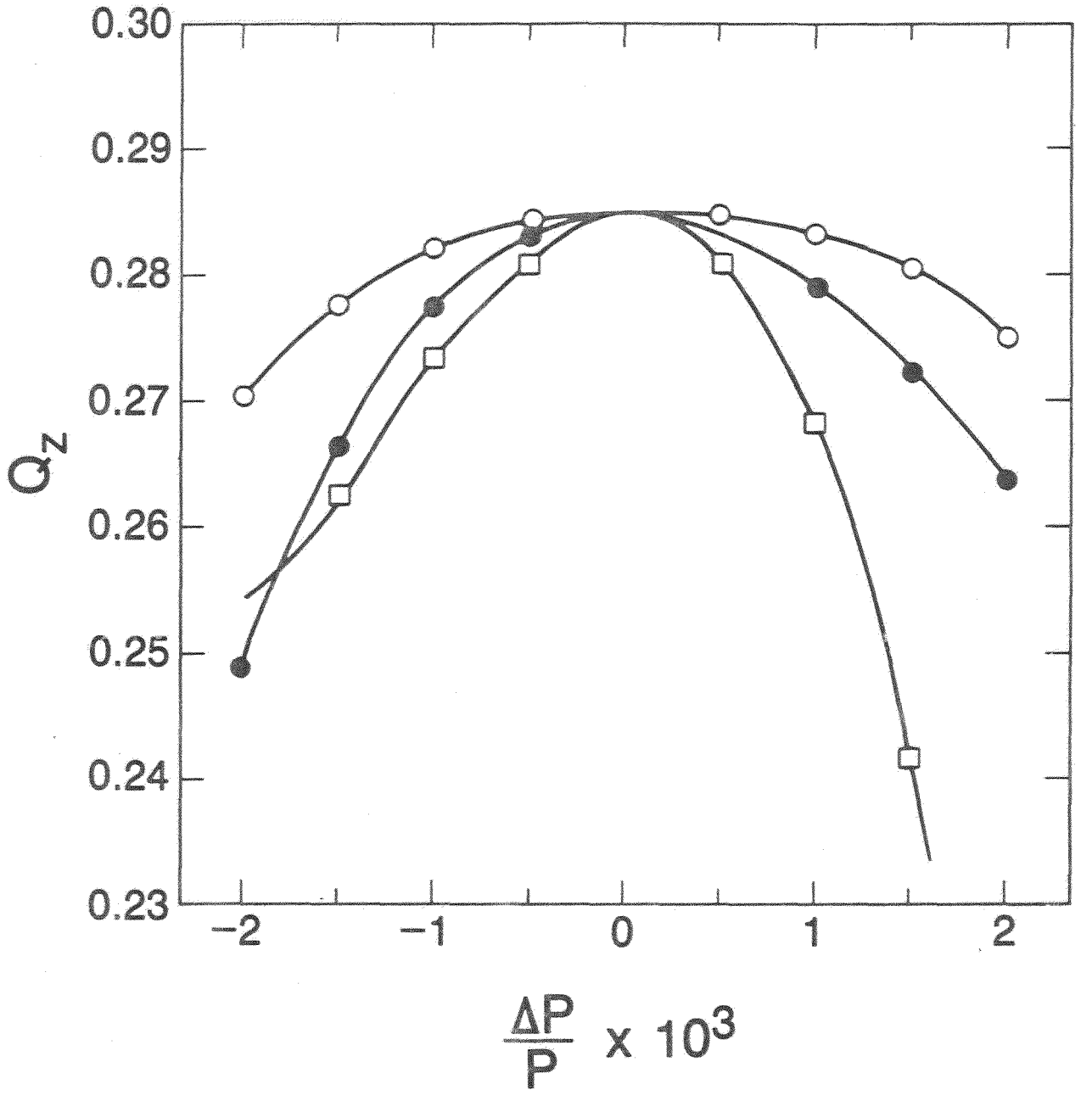


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Figure 3. (3IR) β_x^* vs Momentum

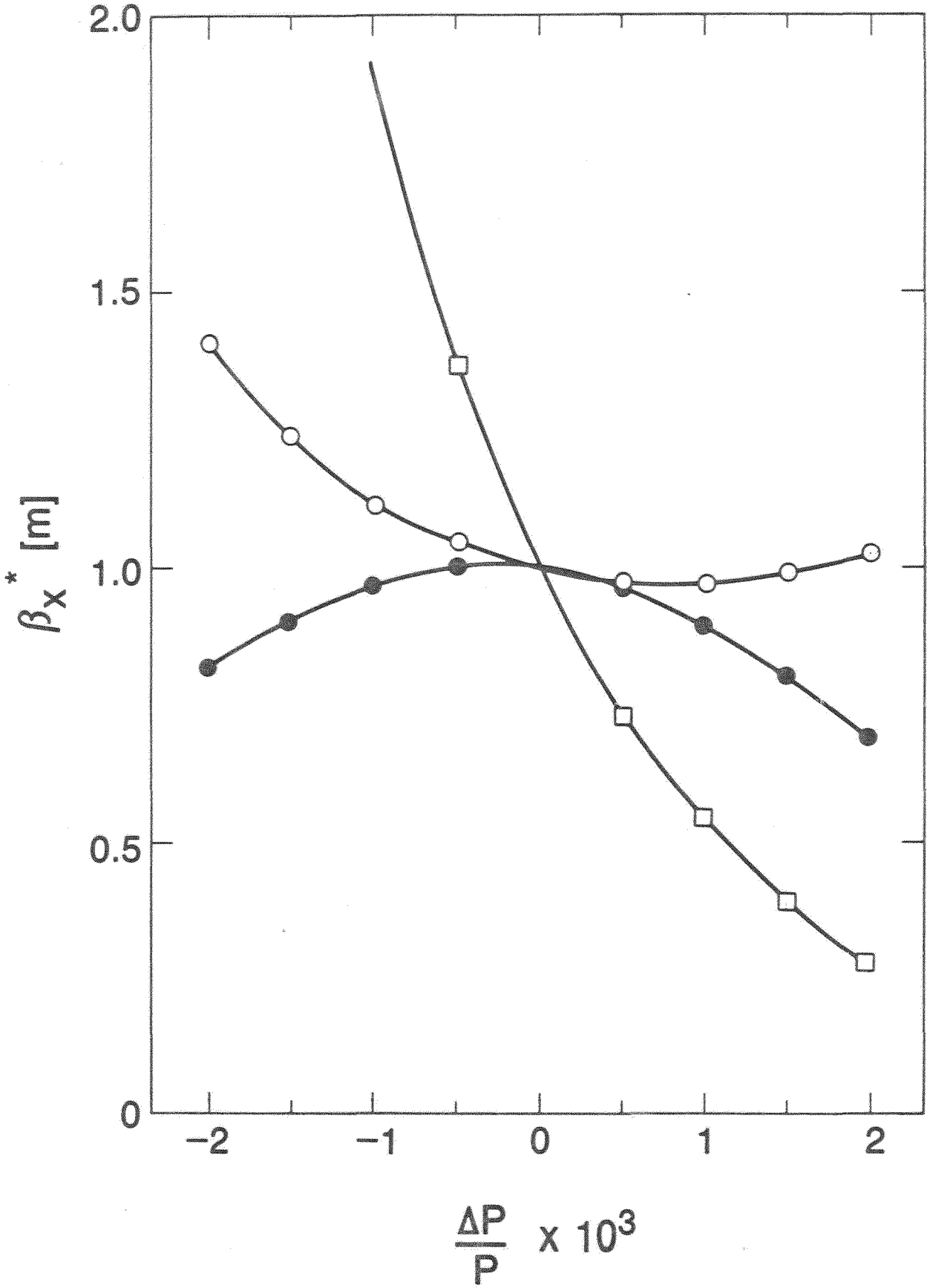

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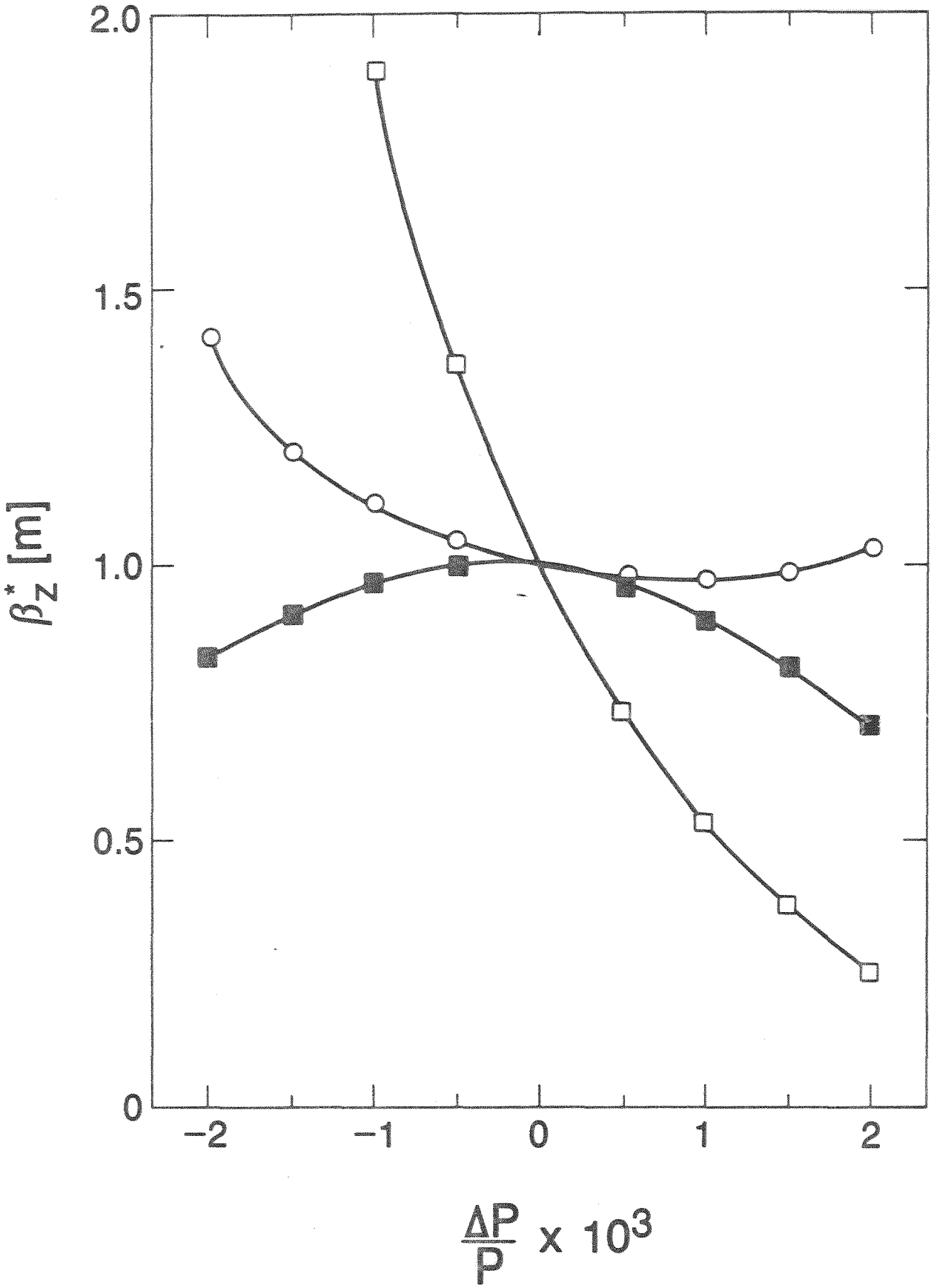
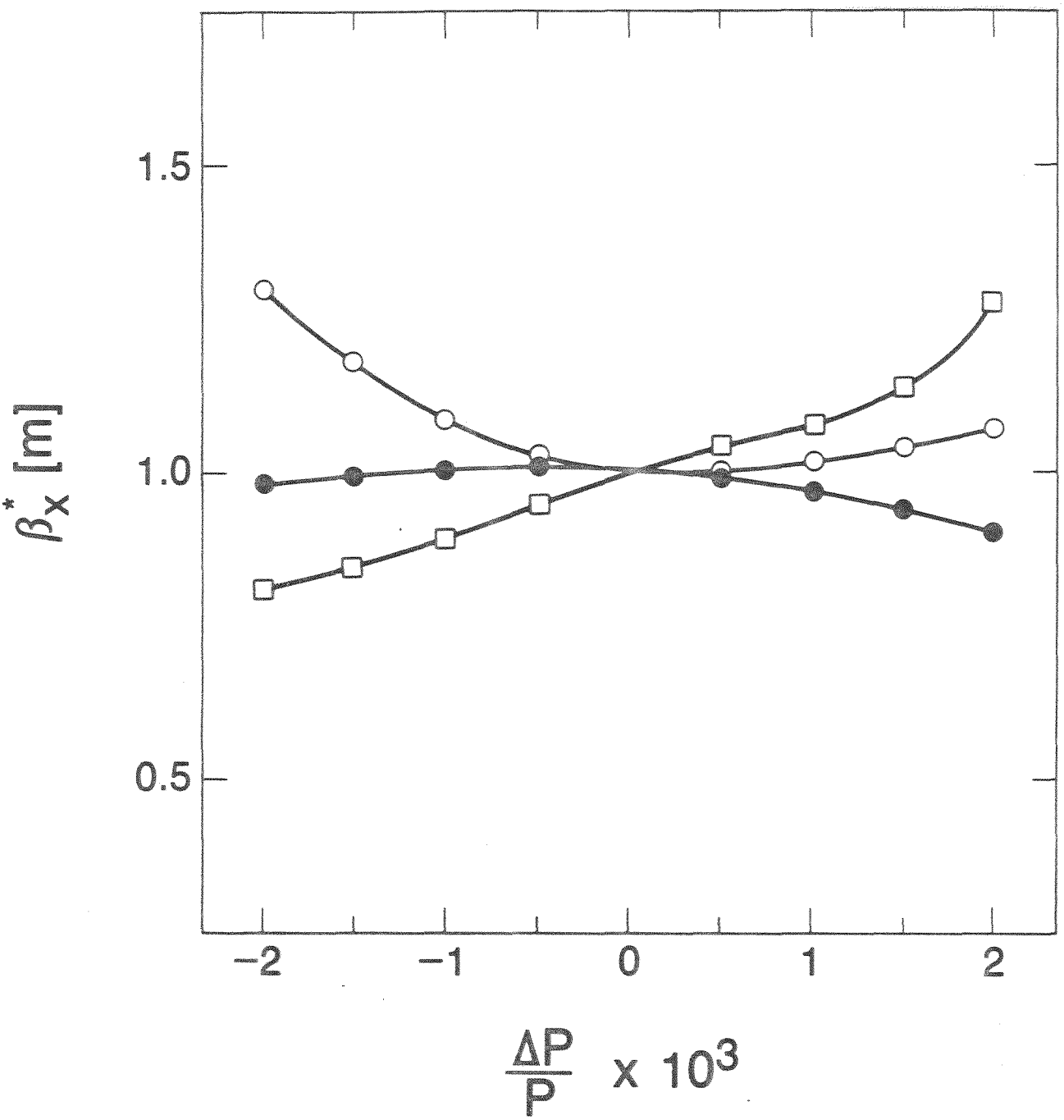
Figure 4. (3IR) β_z^* vs Momentum



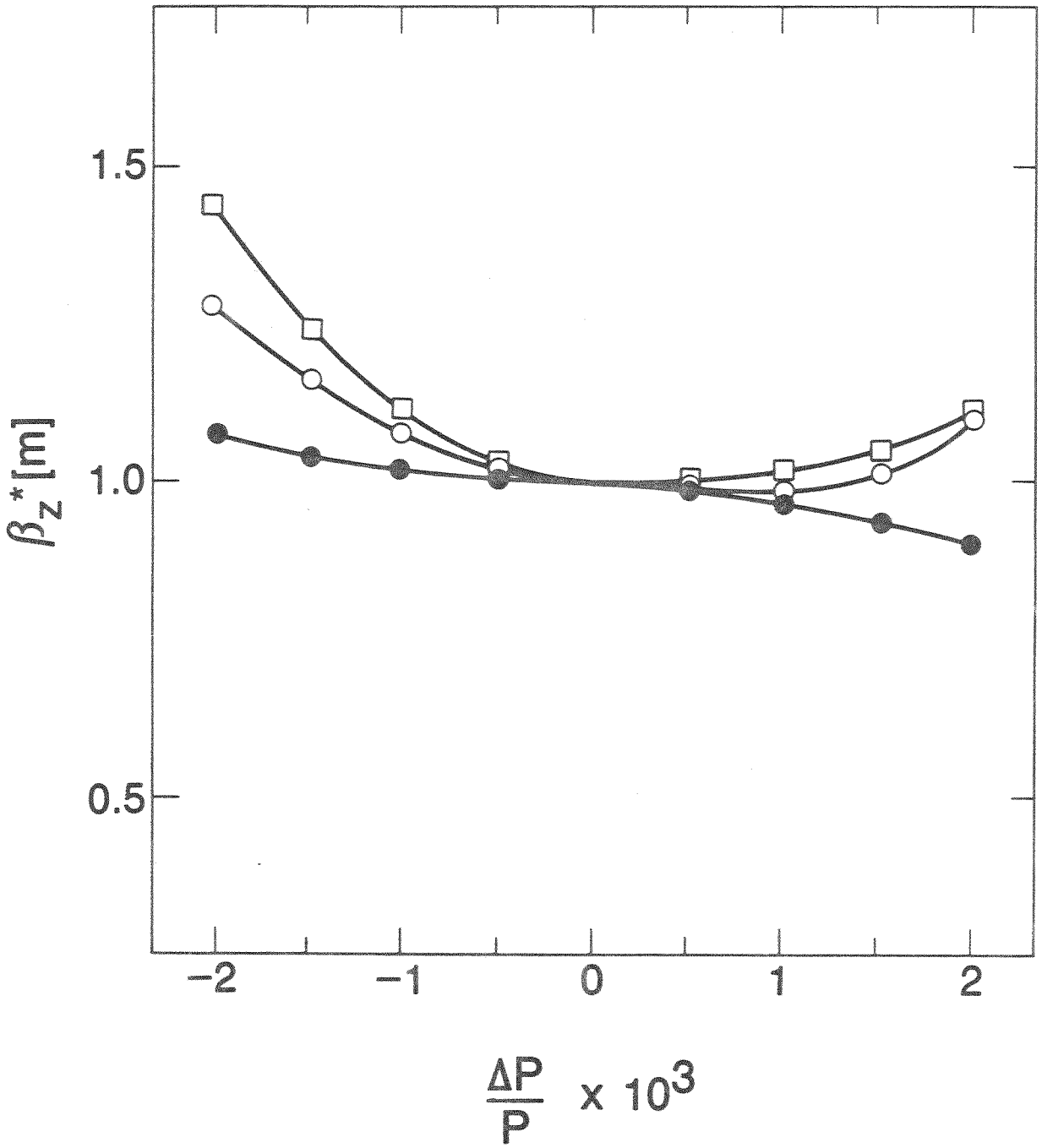
XBL 850-11295

Figure 5. (3IR) β_x^* vs Momentum



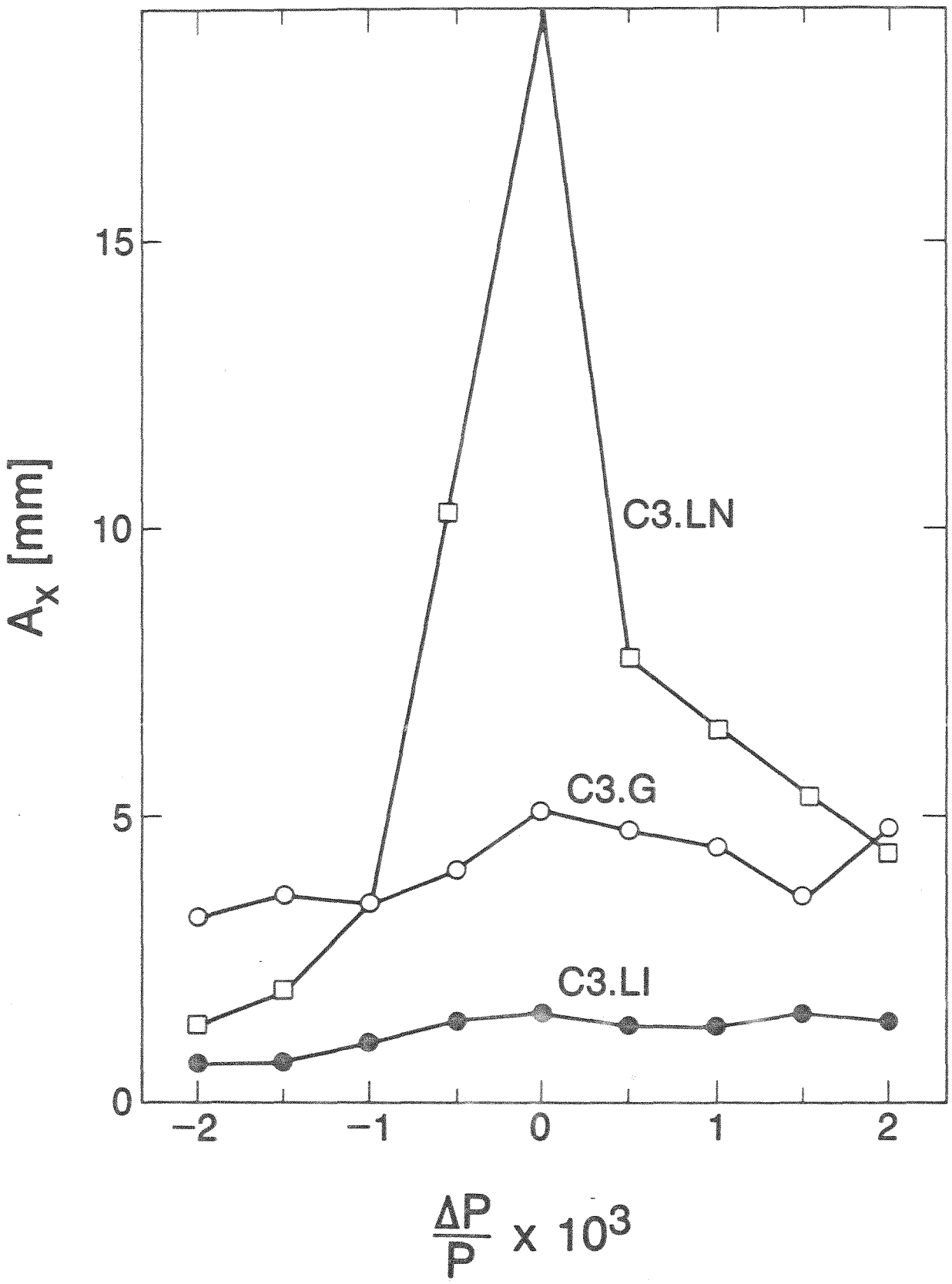
XBL 859-11296

Figure 6. (3IR) β_z^* vs Momentum



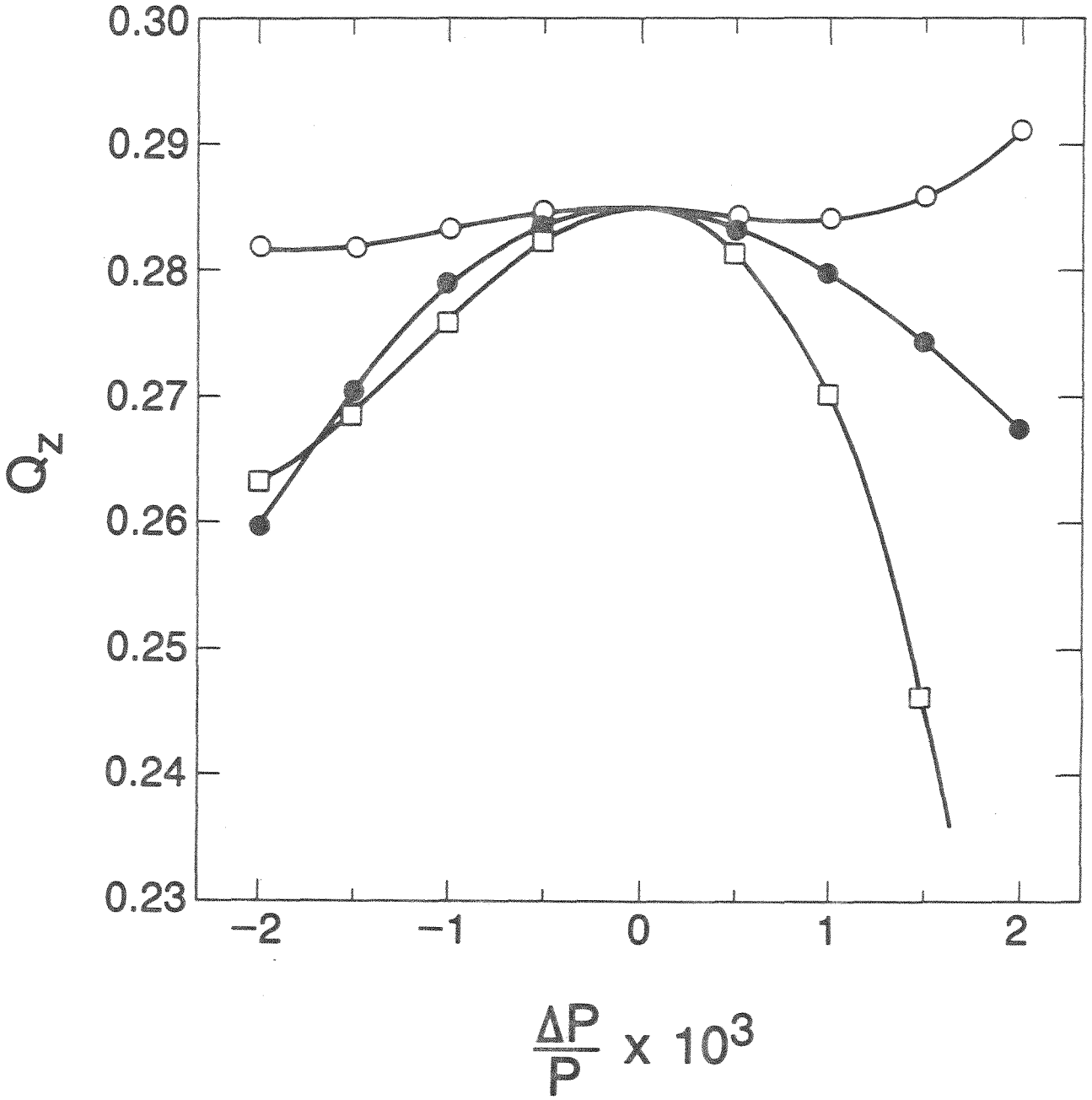
XBL 859-11305

Figure 7. (3IR) Maximum Stable Horizontal Aplitude vs Momentum



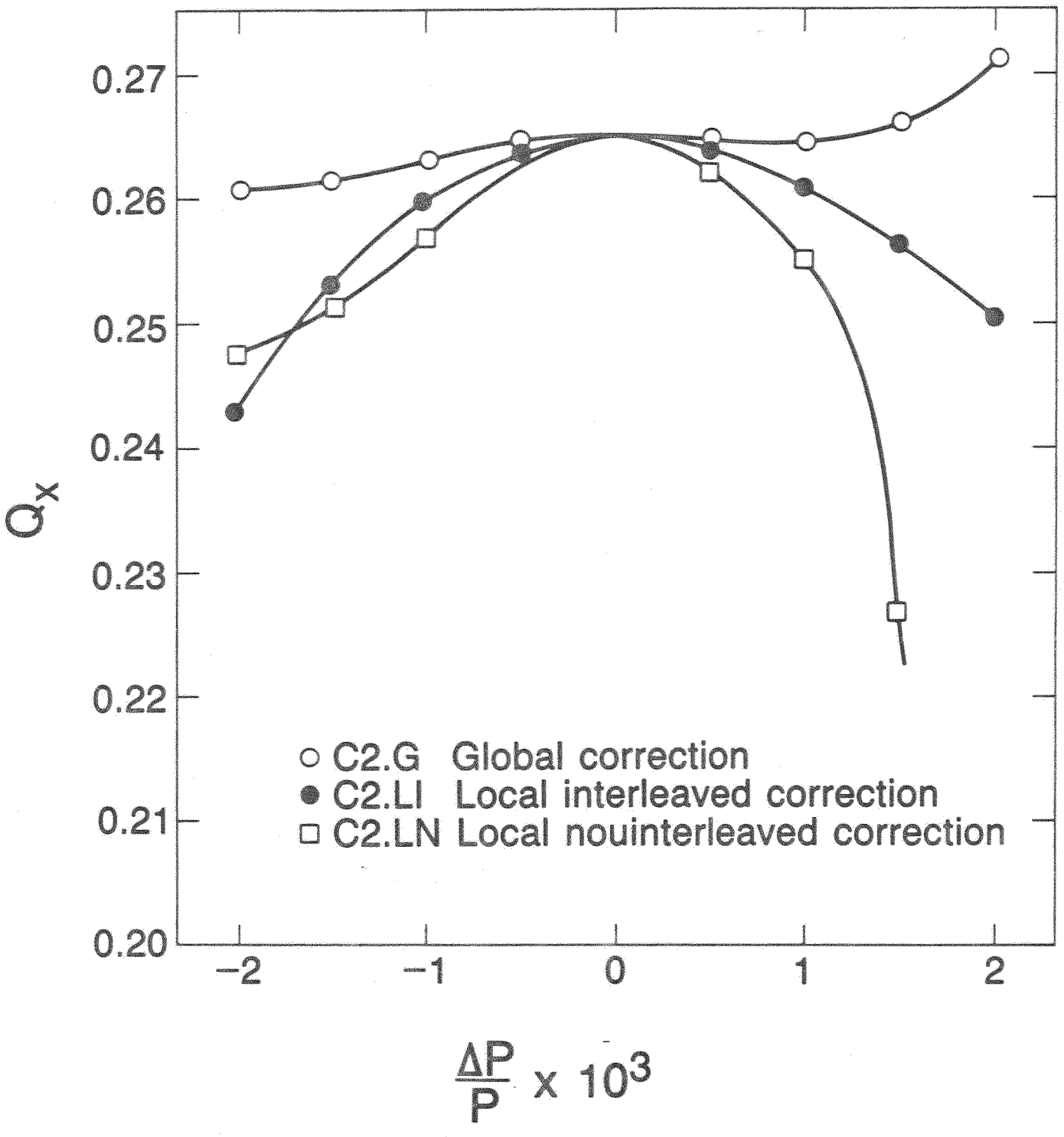
XBL 858-11298

Figure 8. (2IR) Horizontal Tune vs Momentum



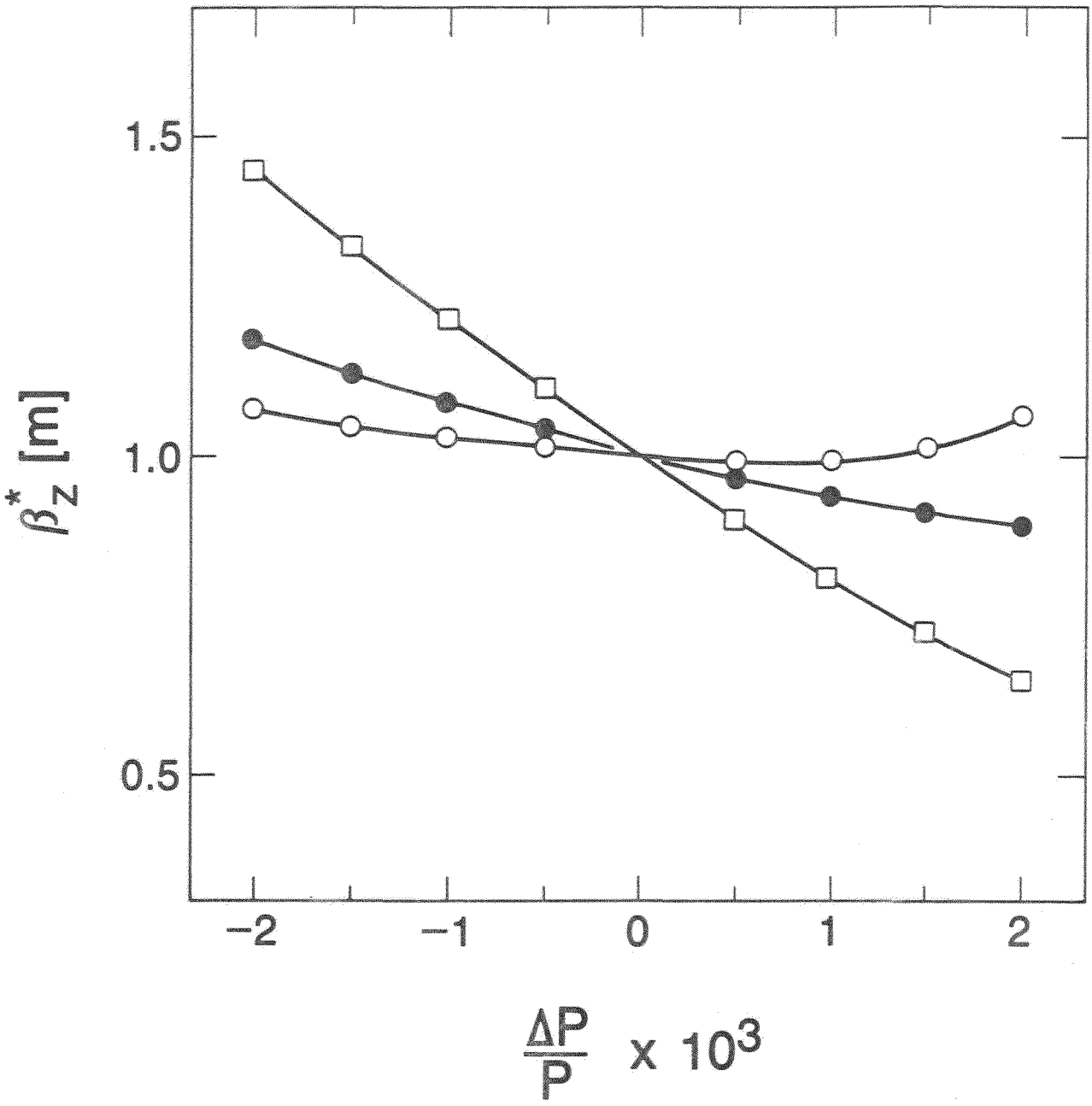
XBL 859-11290

Figure 10. (2IR) Verticle Tune vs Momentum



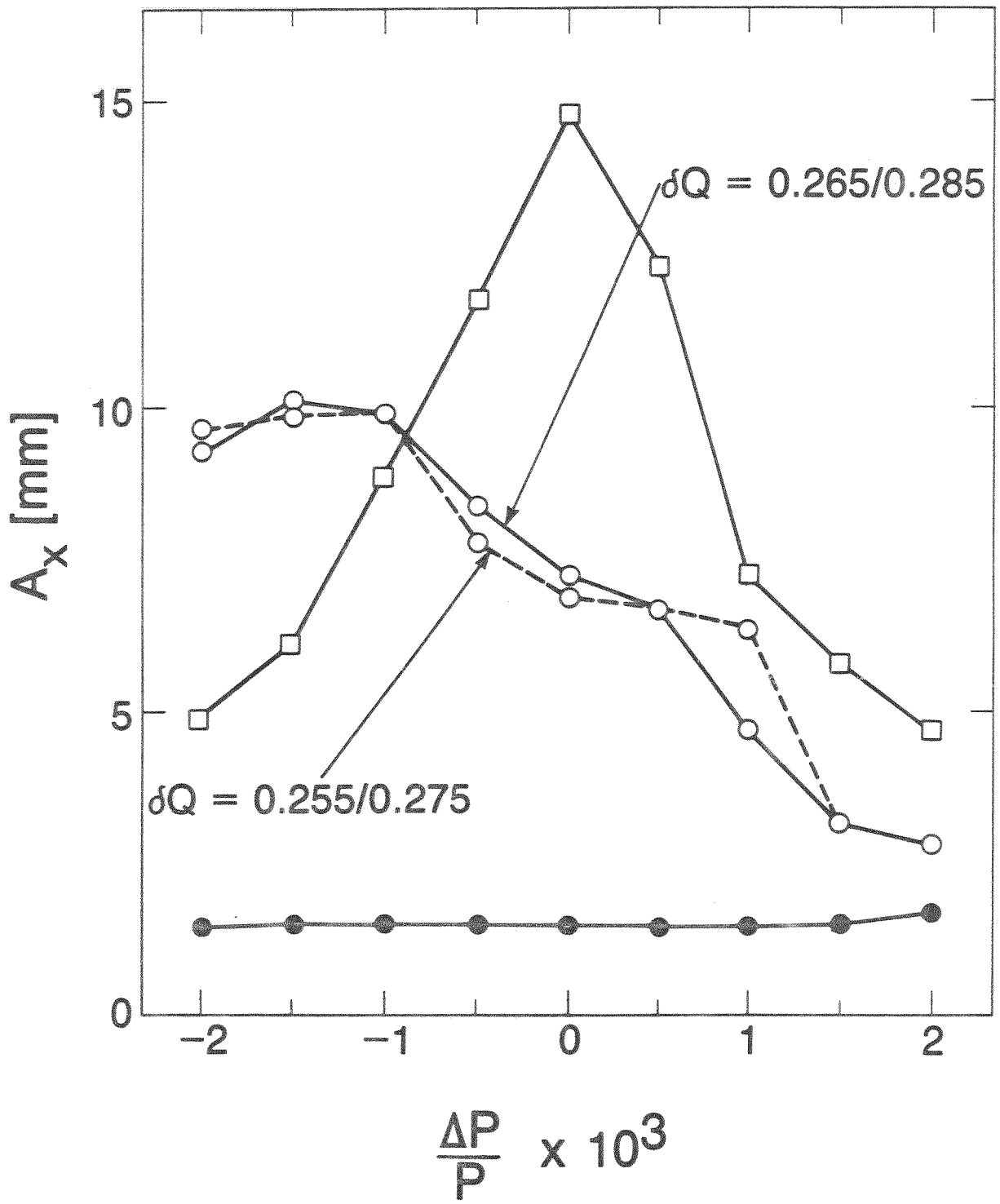
XBL 850-11297

Figure 11. (2IR) β_z^* vs Momentum



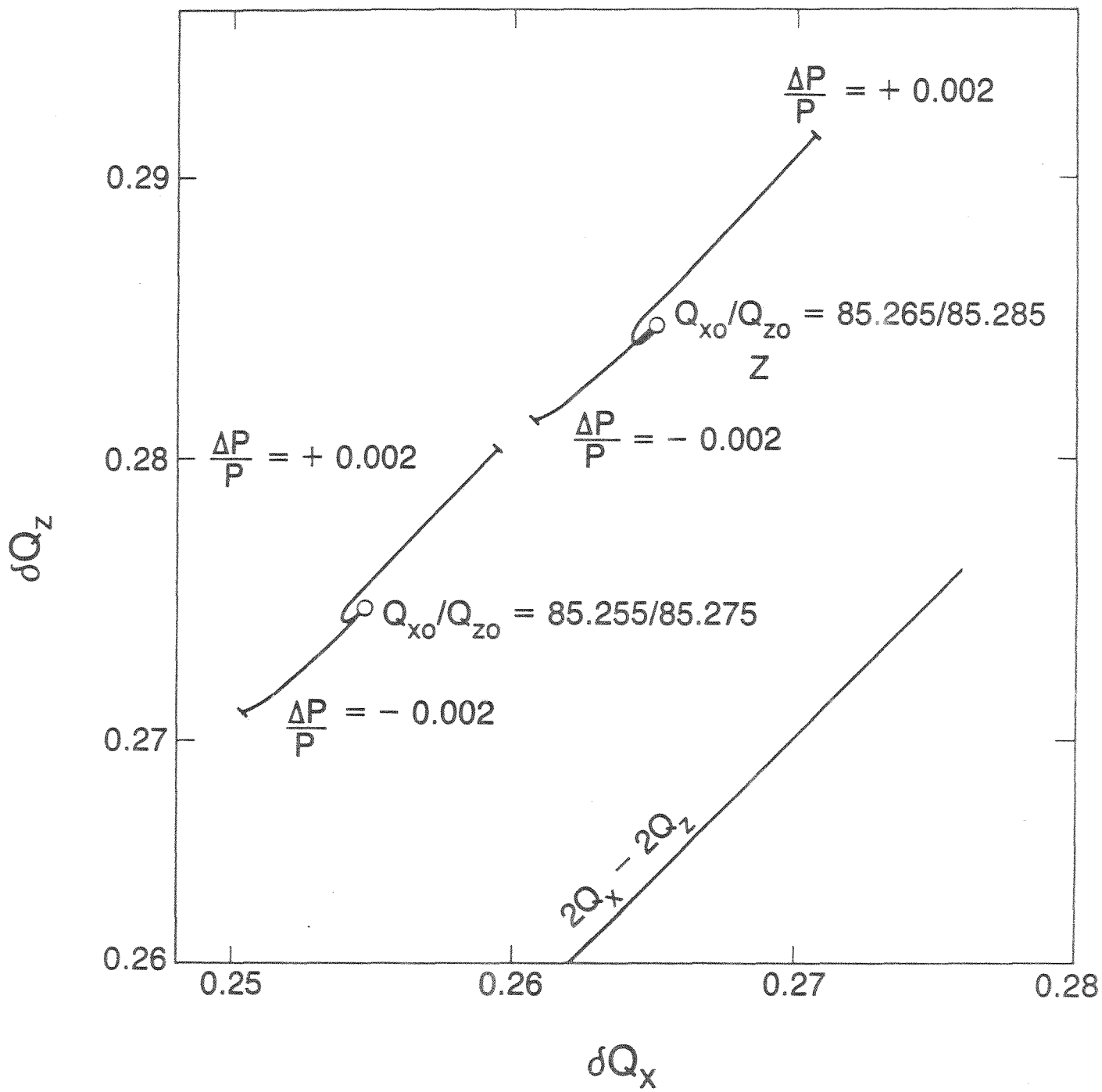
XBL 859-11301

Figure 12. (2IR) Maximum Stable Horizontal Amplitude vs Momentum



XBL 859-11292

Figure 13. (2IR) Variation of Tune with Momentum



XBL 859-11300

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SSC-N-39

A. Wrulich

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The variation of horizontal and vertical interaction beta with momentum for the inner and outer interaction points of the cluster are shown in Figures A3 to A6.

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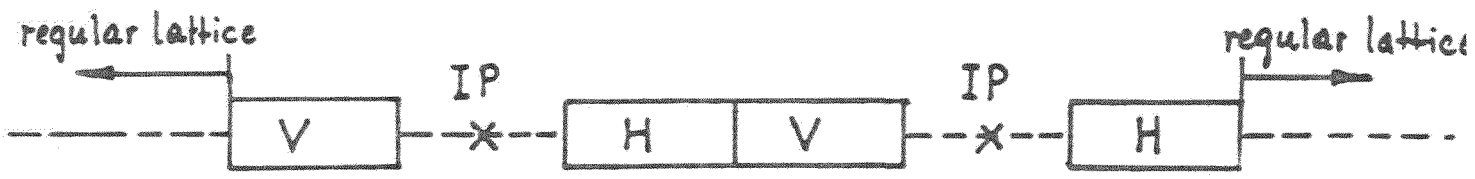

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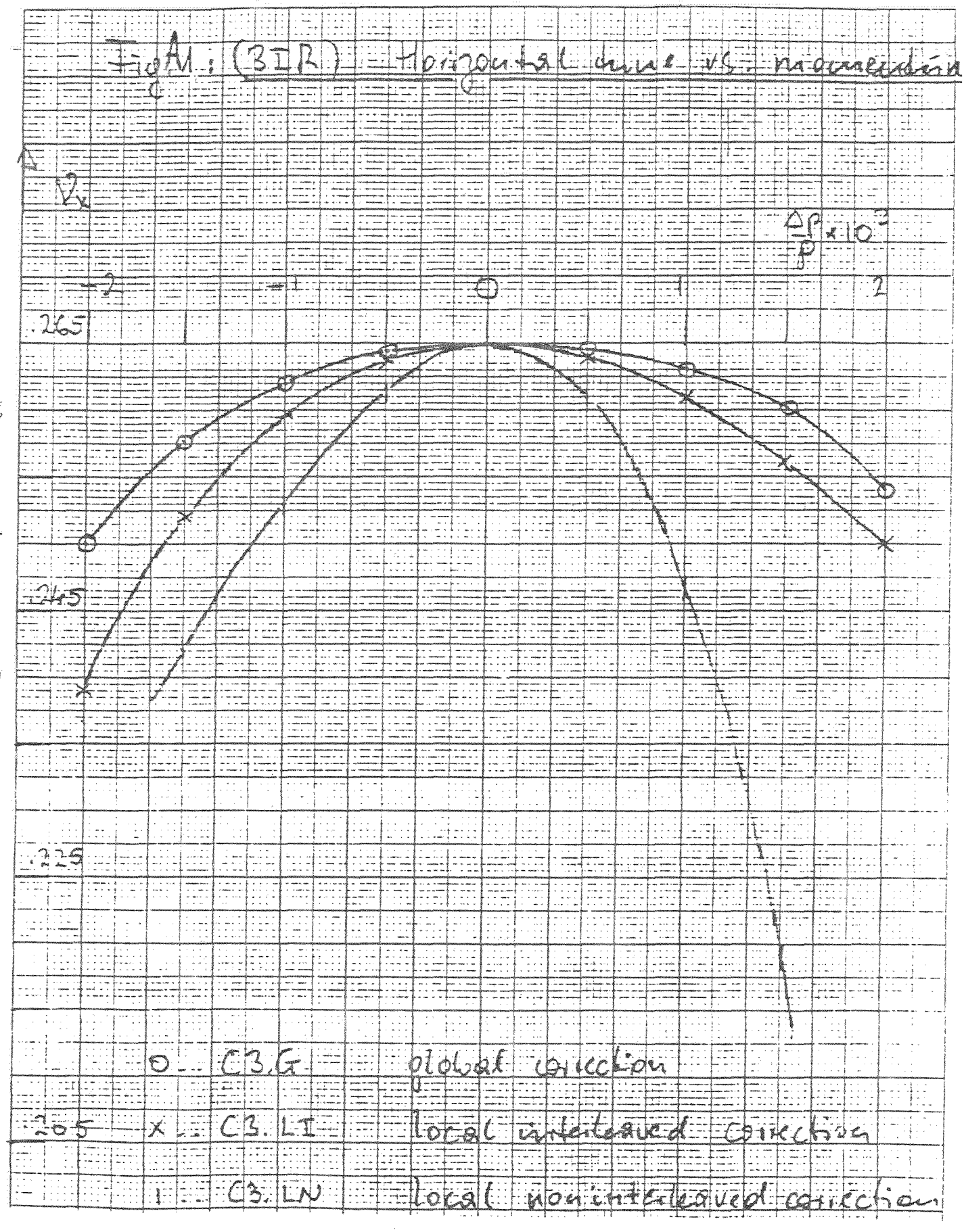

Fig. A1. (3IR) Horizontal Tune vs. Momentum

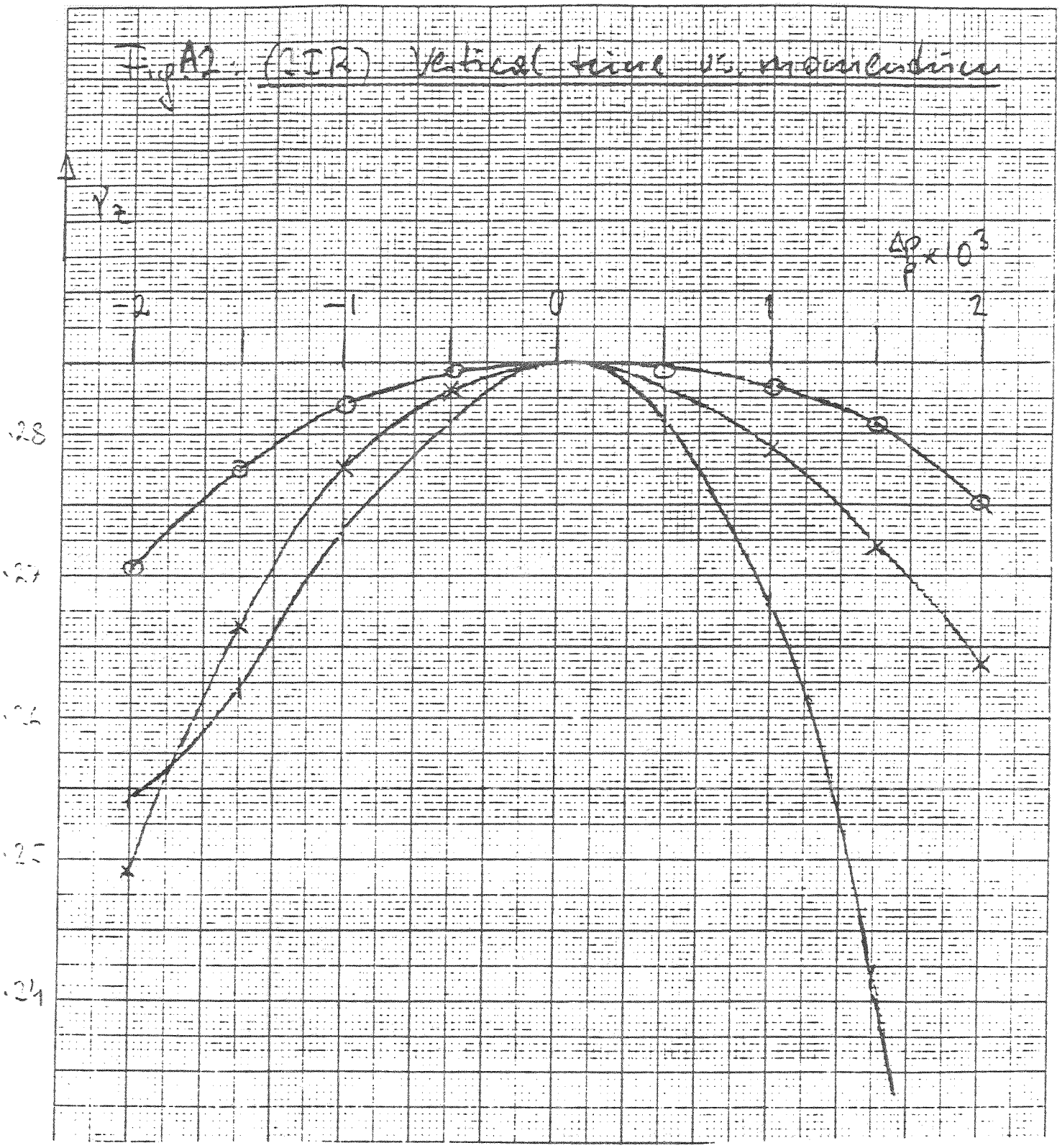

Fig. A2. (3IR) Vertical Tune vs. Momentum

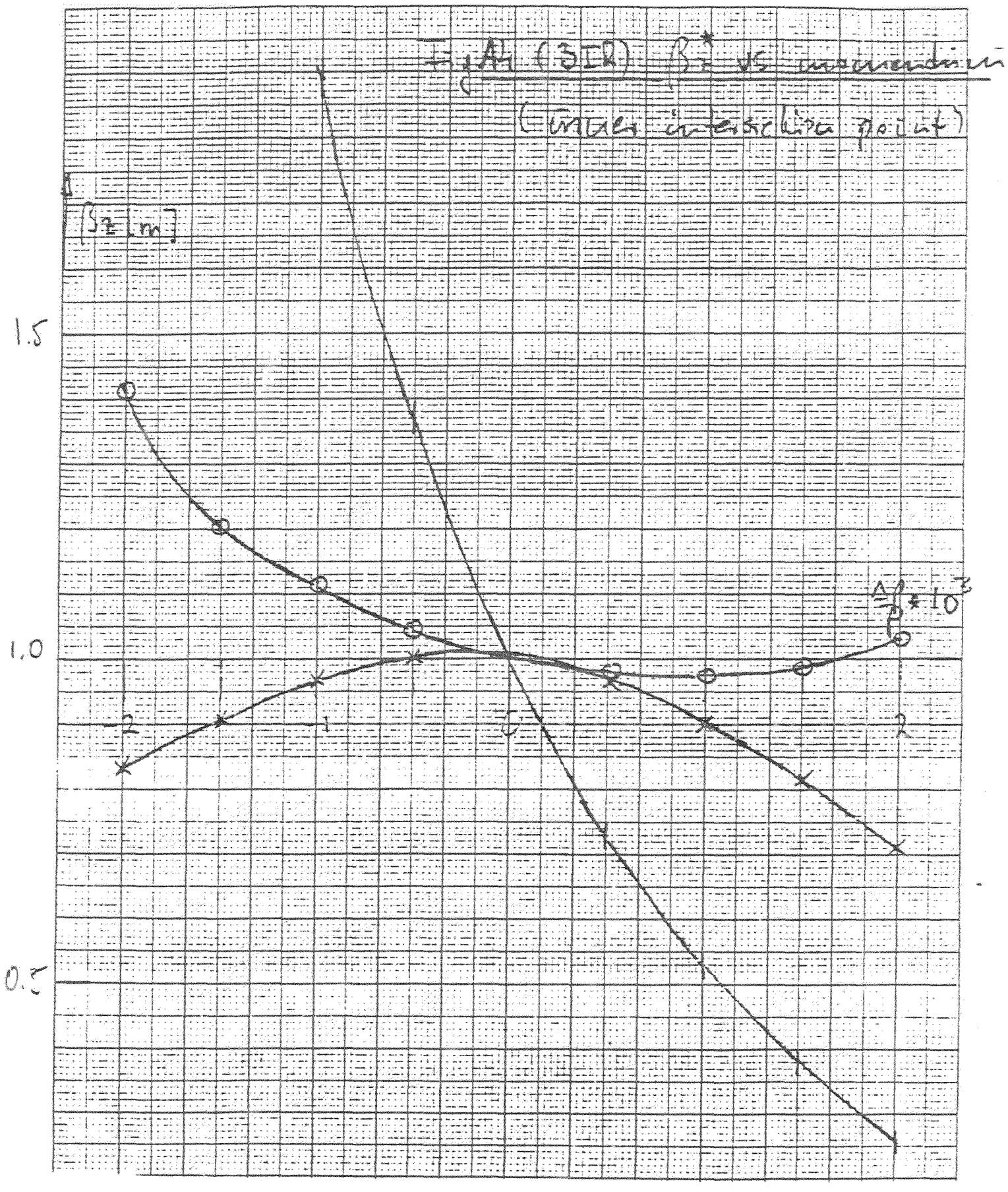

Fig. A4. (3IR) Bz* vs Momentum
(Inner Interaction Point)

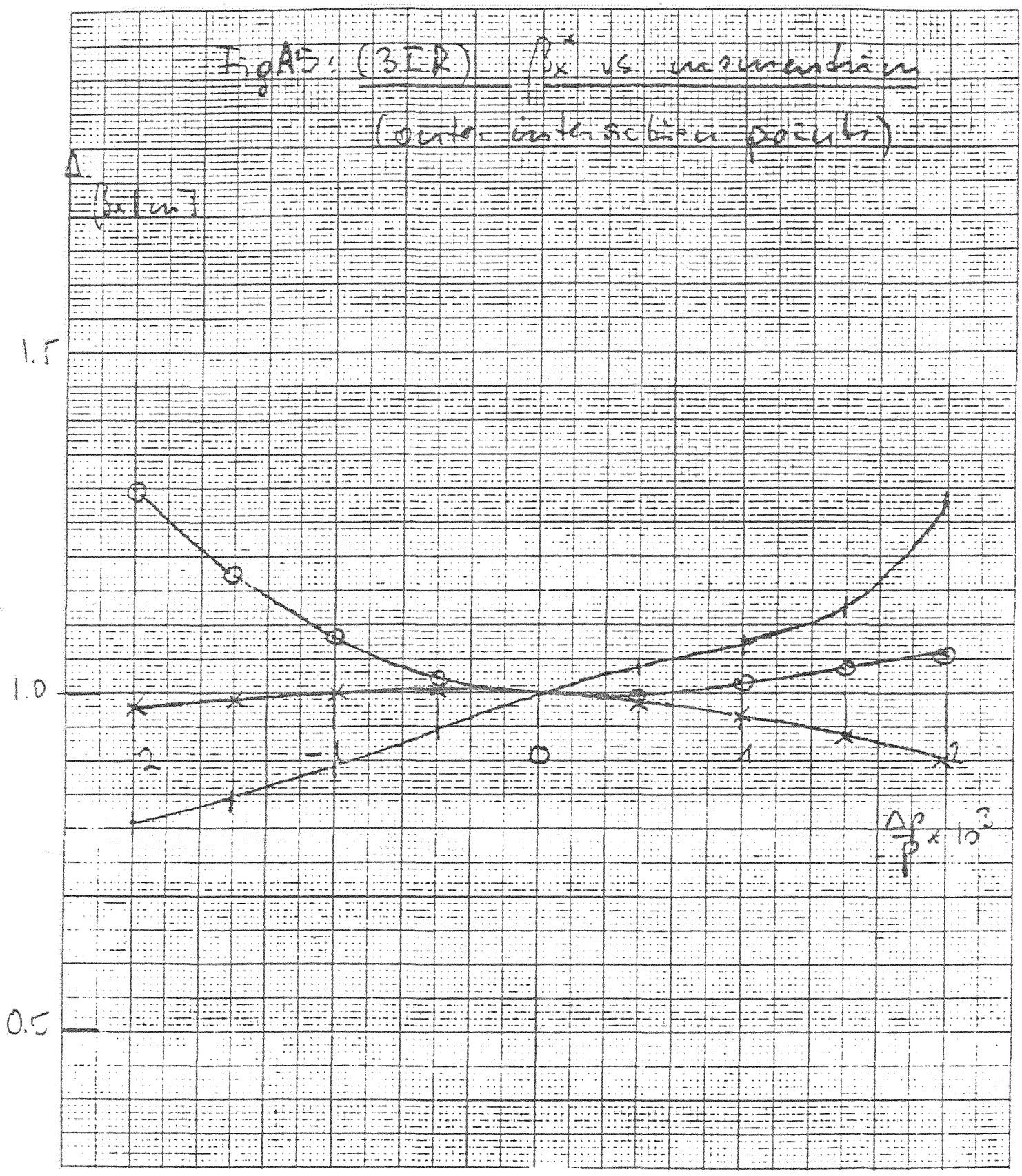

Fig. A5. (3IR) βx* vs Momentum
(Outer Interaction Points)

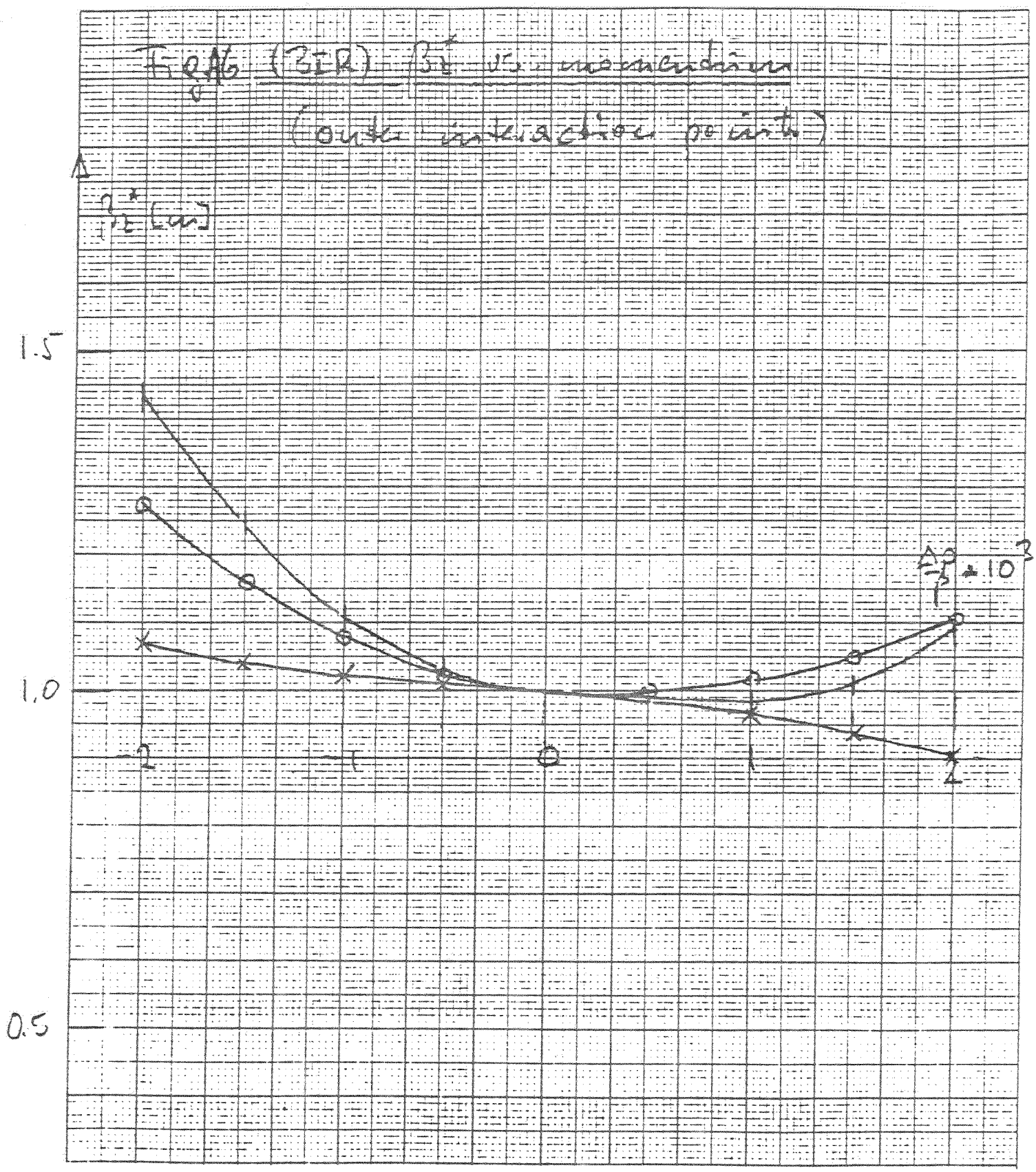

Fig. A6. (3IR) Bz* vs. momentum
(Outer Interaction Points)

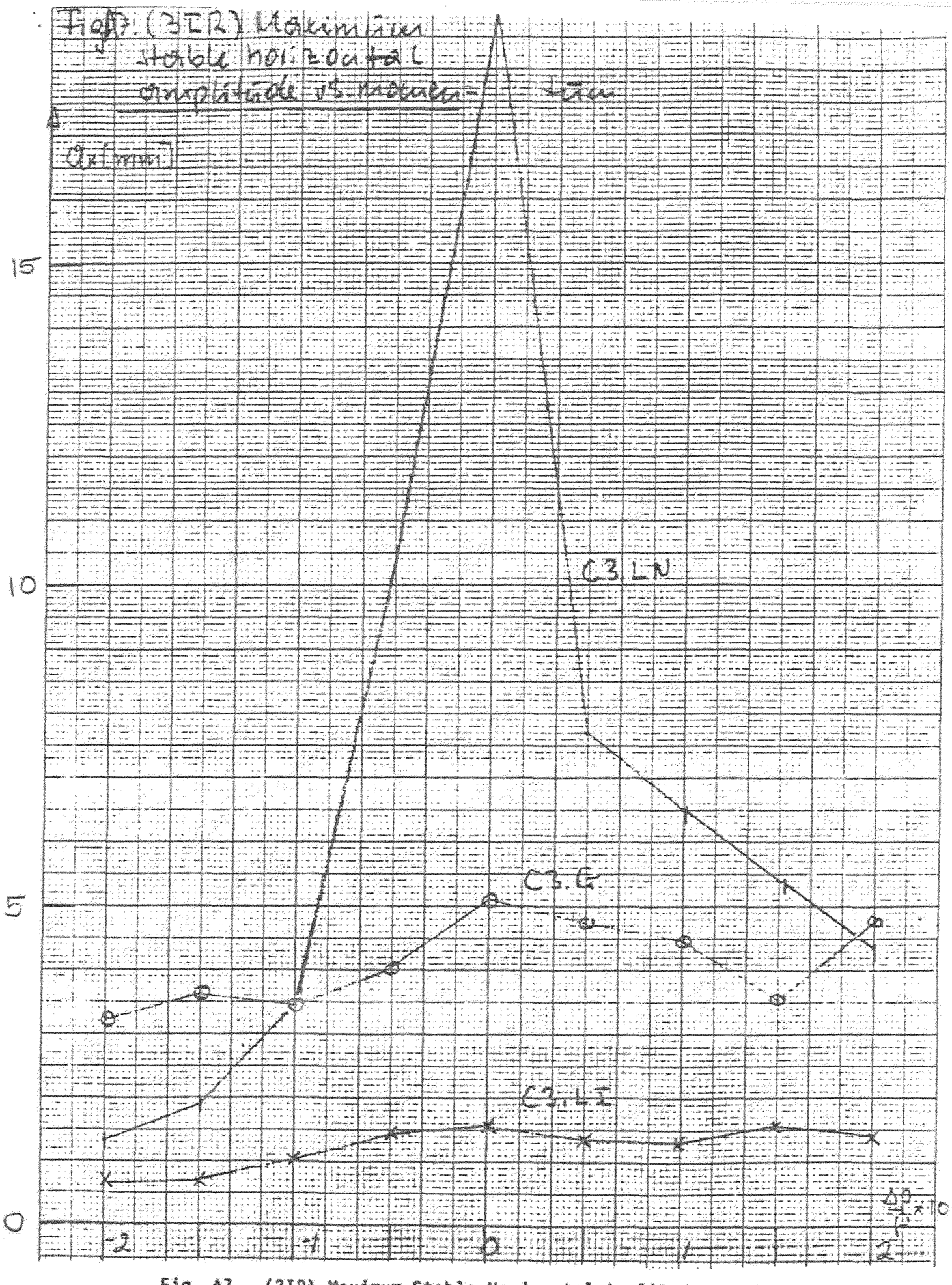

Fig. A7. (3IR) Maximum Stable Horizontal Amplitude vs. Momentum

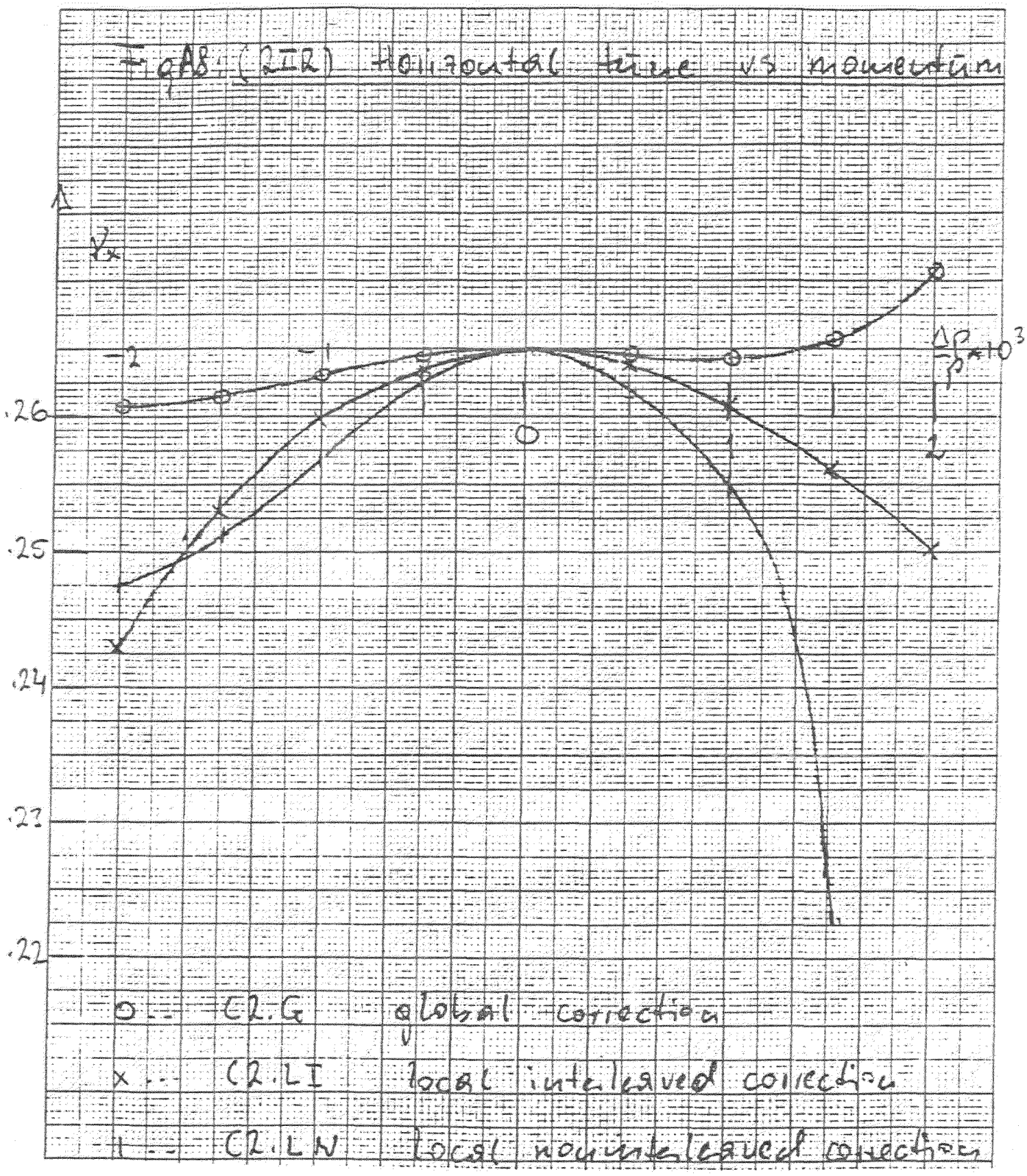

Fig. A8 (2IR) Horizontal Tune vs. Momentum

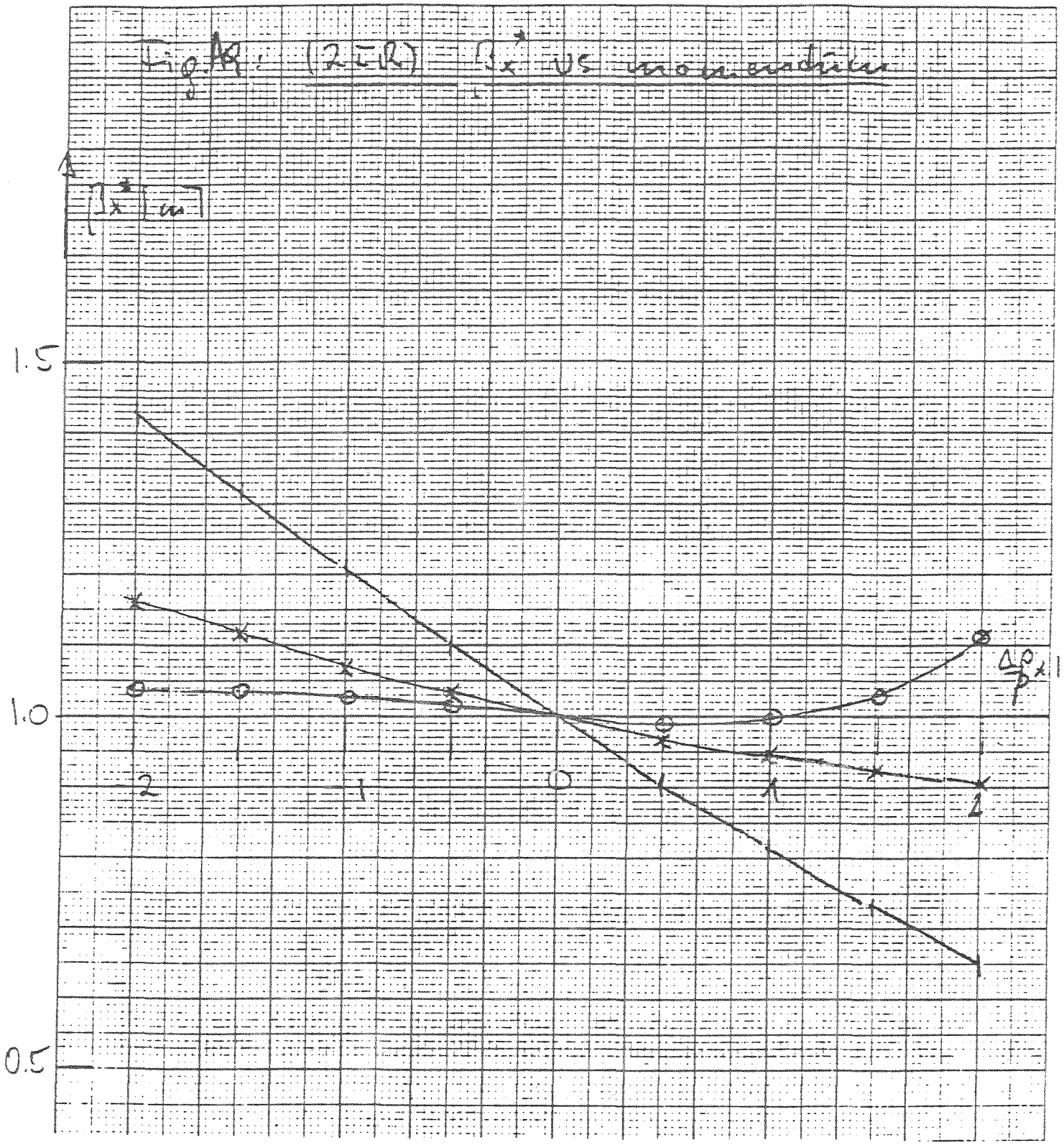

Fig. A-9 (2IR) Bx* vs. Momentum

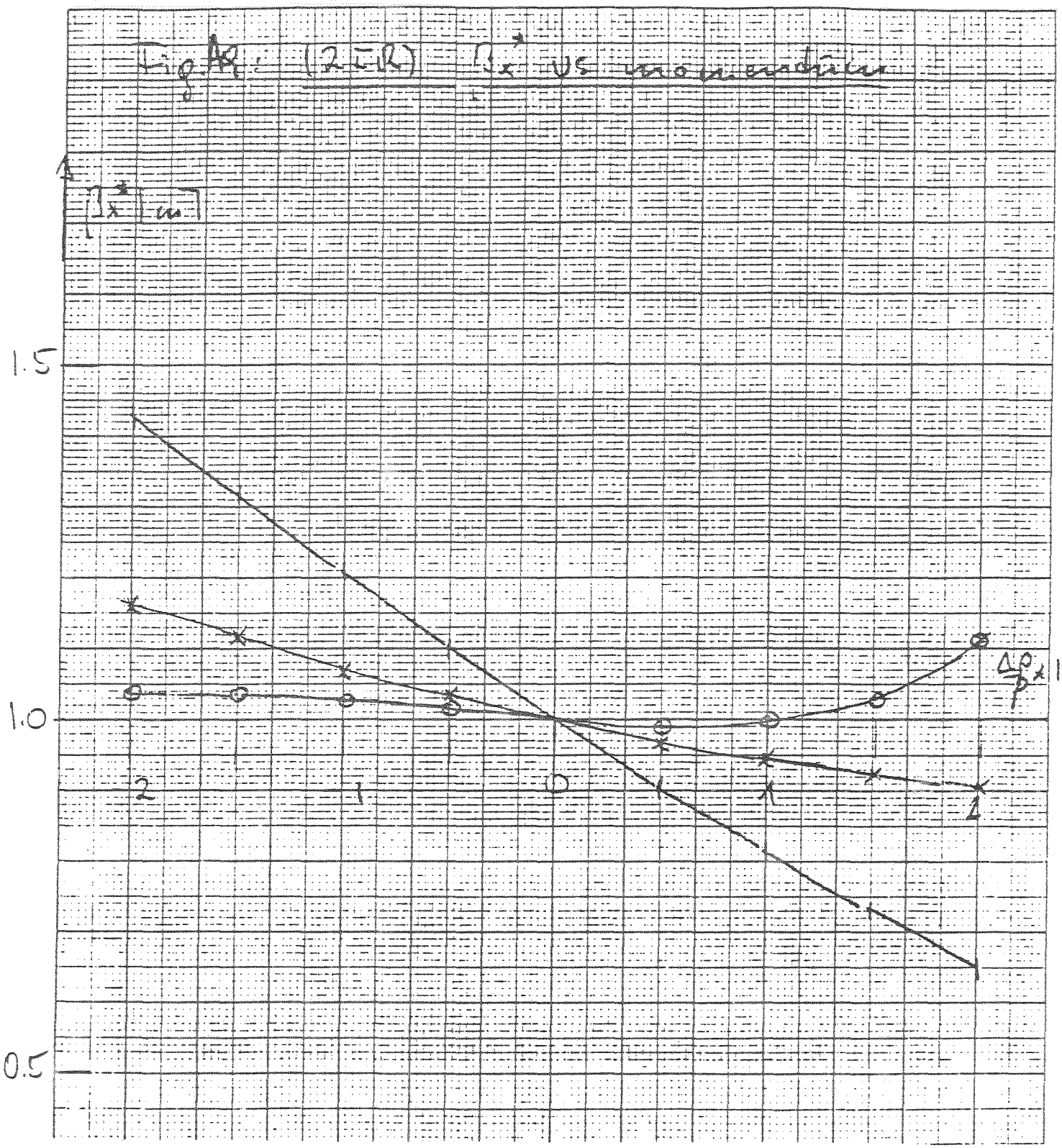

Fig. A-9 (2IR) βx* vs. Momentum

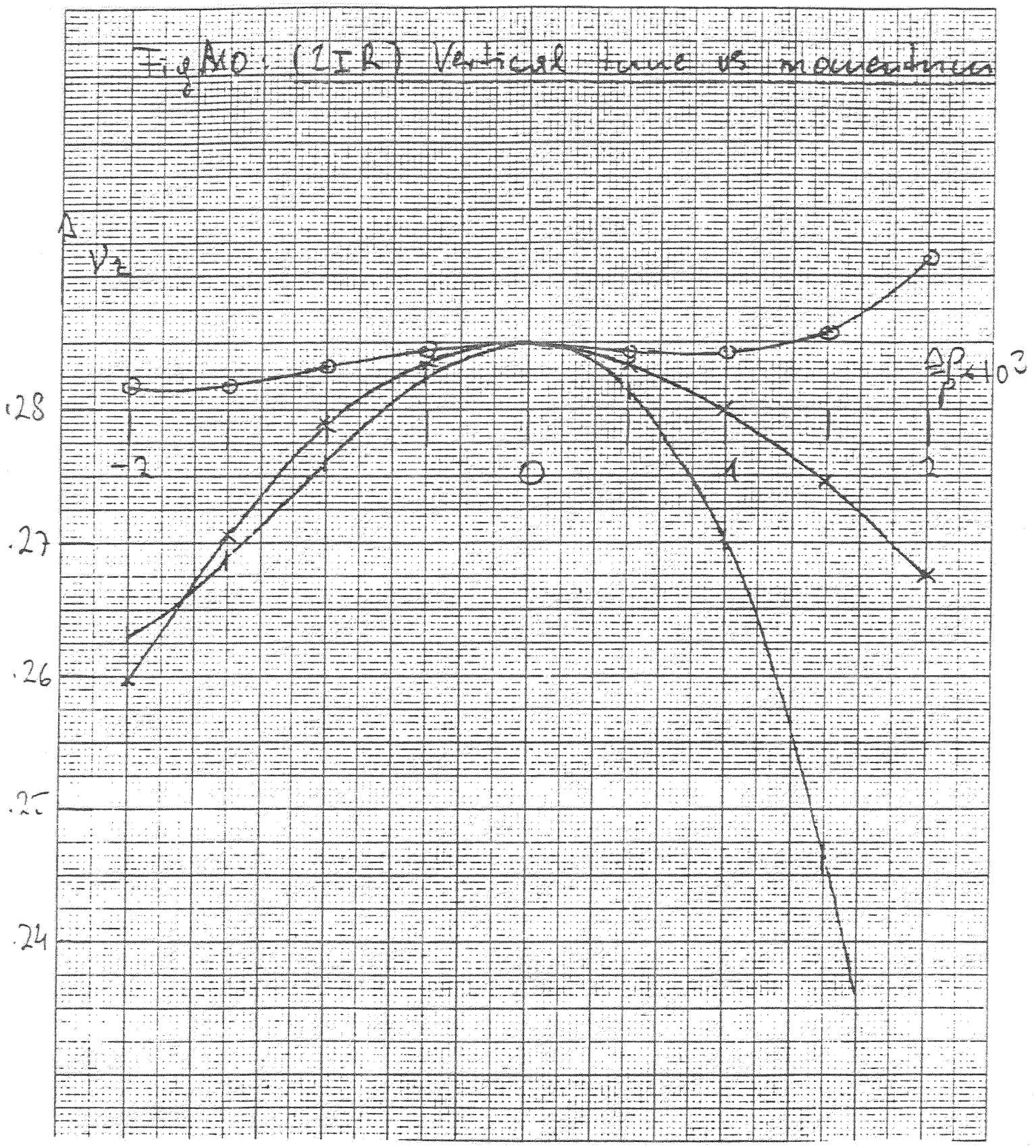

Fig. A10. (2IR) Vertical Tune vs. Momentum

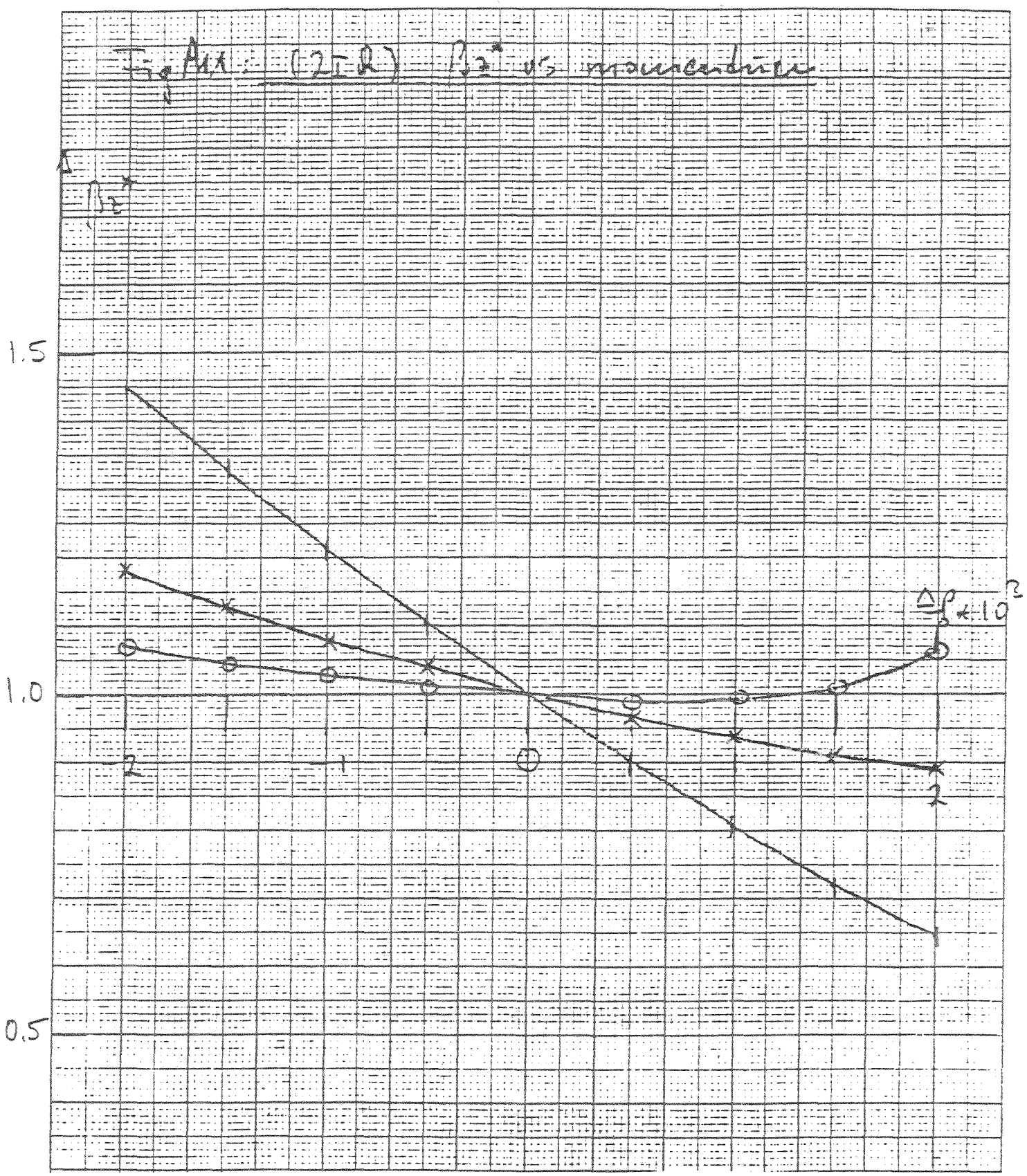

Fig. A11. (2IR) βx* vs. Momentum

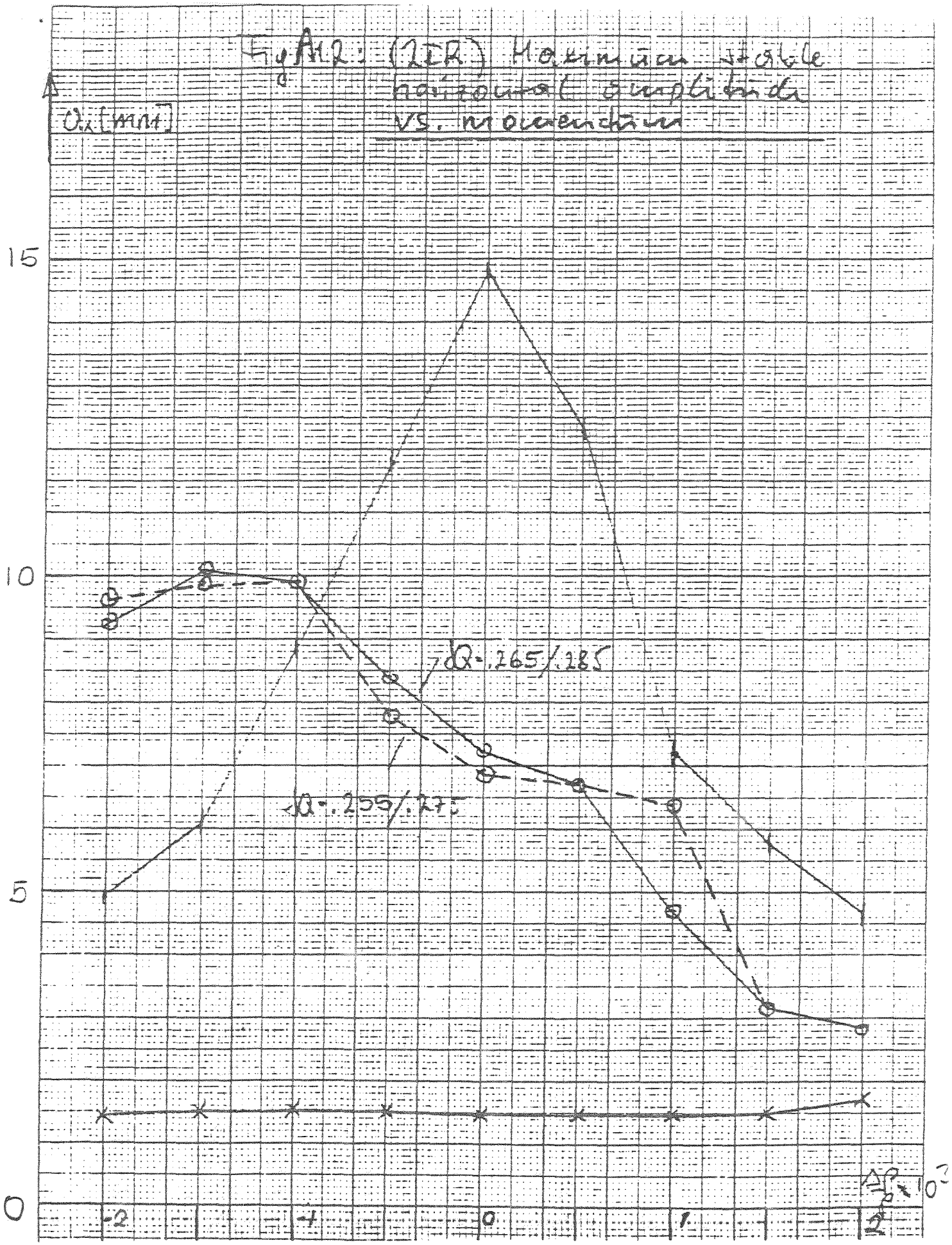

Fig. A12. (2IR) Maximum Stable Horizontal Amplitude vs. Momentum

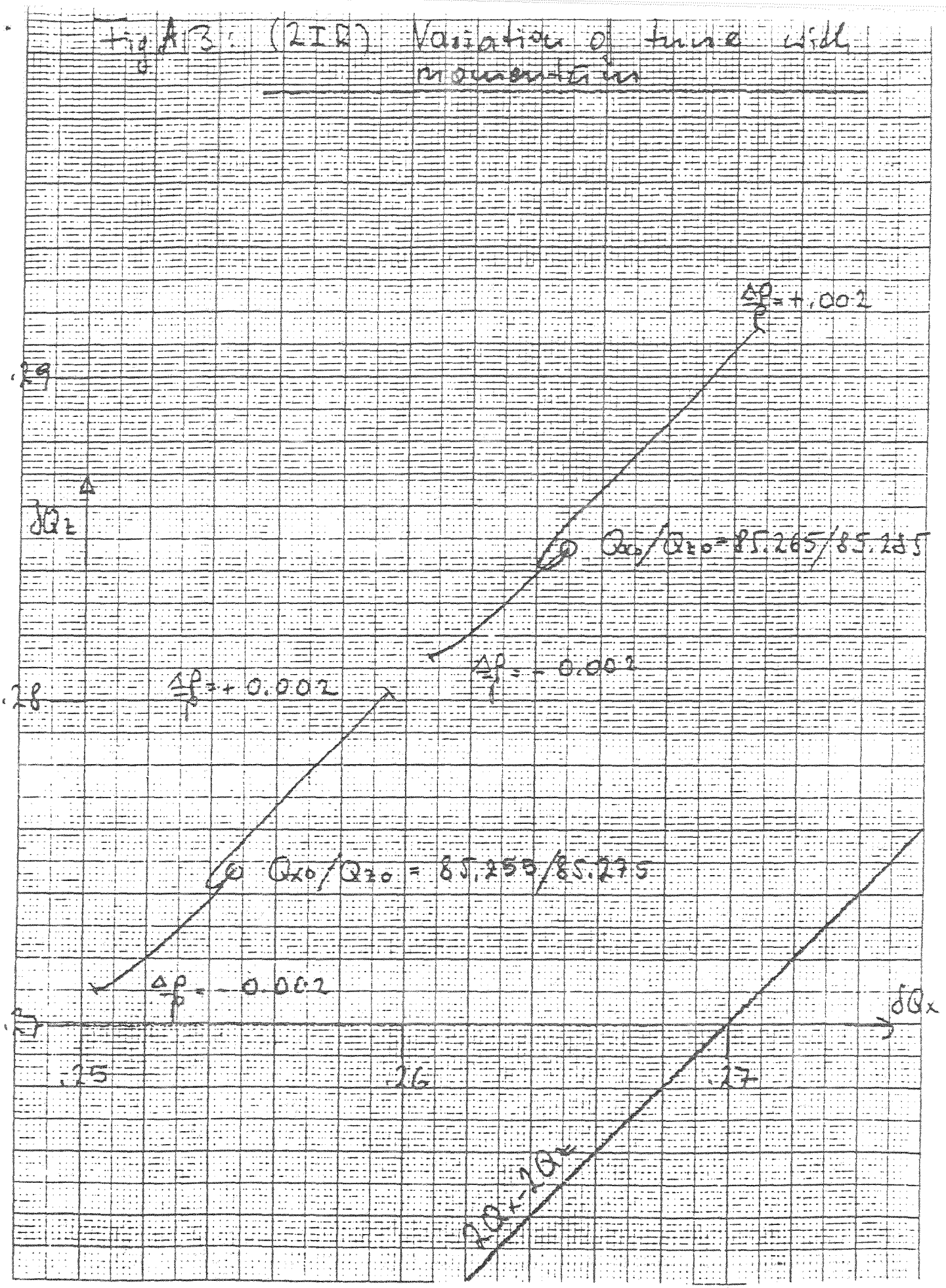

Fig. A13. (2IR) Variation of Tune with Momentum