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INJECTION MATCHING IN THE AGS EMITTANCE GROWTH

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ABSTRACT

Twiss parameters and dispersion of the AGS as a function of the current in the high field quadrupoles have been calculated with the model MAD, Ref.[1], at the location of the injection kicker AK5. The effects of a possible mismatch between AGS and injected beam from the BTA (Booster-to-AGS transfer line) on the circulating beam emittance are evaluated using the classical formulas of Ref.[2].

This note is a contribution to the ongoing discussions with Ed Bleser on the subject of AGS injection optimization. Ed has suggested to use the handy formulas on emittance growth.

INTRODUCTION

To optimize the injection into the AGS, the beam from the BTA should be matched in phase space to the AGS. This means that the final twiss parameters and the dispersion of the BTA line should match the twiss parameters and the dispersion of the AGS at the point of injection. We define as the point of injection, coincident with the end of the BTA, the mid point of the injection kicker AK5.

Now, when the tune and chromaticity of the AGS are varied as a function of the current in the high field tune quadrupoles (see Ref. [3]), also the values of the twiss parameters change considerably. Then, if the conditions for injection are chosen in the BTA, and thereafter the tune in the AGS is readjusted by means of the tuning quads, the matching will not be satisfied any more. This will result in a considerable increase of the emittance of the circulating beam, unless one retune sthe BTA every time that the tune in the AGS is changed during injection.

The procedure is complicated by the fact that the injected beam, even before reaching the AK5 kicker, is already traversing some of the elements of the AGS lattice, in particular a vertical high field quadrupole, QDV(7) located between A3 and A4. In the matching, vs. AGS quadrupole currents, the effect of this quadrupole must be considered, using values of twiss functions and dispersion at QDV(7).

RESULTS

In the case of emittance mismatch between injected beam and circulating beam, the resulting emittance growth can be calculated with the formula (3.4.5) of Ref. [2]

$$\frac{\delta\varepsilon}{\varepsilon}=\frac{S_3}{S}=D+\sqrt{D^2-1} \quad , \qquad D=\tfrac{1}{2}(\beta_2\gamma_1+\gamma_2\beta_1-2\alpha_1\alpha_2) \tag{1}$$

where S is the area of each ellipse in phase space, and for the twiss parameters it is

$$\alpha=-\tfrac{1}{2}\beta', \quad \gamma=\frac{1+\alpha^2}{\beta} . \tag{2}$$

The indices 1, 2, 3 have the following meaning: "1" is the injected mismatched ellipse, "2" belongs to an injected ellipse, matched to the acceptance ellipse "3" (i.e. "2" and "3" have the same aspect ratio and tilt) . The area S is common to "1" and "2": $S=S_1=S_2$.

Figure 1 shows a map of the tunes in the AGS, vs. tune quadrupole currents between ±80 A, at the injection momentum of 2.25 GeV/c (proton) and for zero B-dot.

Figure 2 is a map of the twiss parameter α, emittance ellipse tilt angle, calculated at the injection kicker, for the same beam conditions.

Figure 3 is a map of the twiss parameter β, at the injection kicker.

Figure 4 shows the emittance growth due to mismatch, referred to a match obtained for zero current in the tune quads. Values calculated with Eq. (1). The figure shows that currents of 40 A in the tune quads, that can produce a tune shift $\delta Q\approx 0.2$, may induce an emittance growth of 36%.

Figure 5 shows the dispersion variation at the injection kicker vs. tune quad current. An increase of dispersion respect to the value at matching, as obtained with negative currents in the horizontal quads, will result in a further emittance growth for a beam of sizable energy spread. On the other hand, a smaller dispersion, as obtained with positive IQx, is <u>not</u> expected to decrease the emittance.

Figures 6, 7, and 8 show maps of twiss parameters, horizontal dispersion, and dispersion derivative at the vertical quadrupole QDV(7) vs. tune quad current. This maps is needed for the matching process, as explained earlier.

REFERENCES

1. F.Ch.Iselin and J.Niederer, "The Mad Program Version 7.2" CERN/LEP-TH/88-38, Geneva, July 13, 1988.
2. A.Luccio "Tune and Chromaticity of the AGS v. Quad Currents. Calculated Plots and Fitting Coefficients,. Code QFIT" AGS/AD/ Tech. Note, March 31, 1994.
3. C.Bovet, R.Gouiran, I.Gumowski, and K.H.Reich "A Selection of Formulæ and Data Useful for the Design of A.G. Synchrotrons", CERN/MPS-SI/Int, DL/70/4, 23 April 1970.

Fig.1. Tunes vs. High field Quadrupole Currents. Protons 2.25 GeV/c.

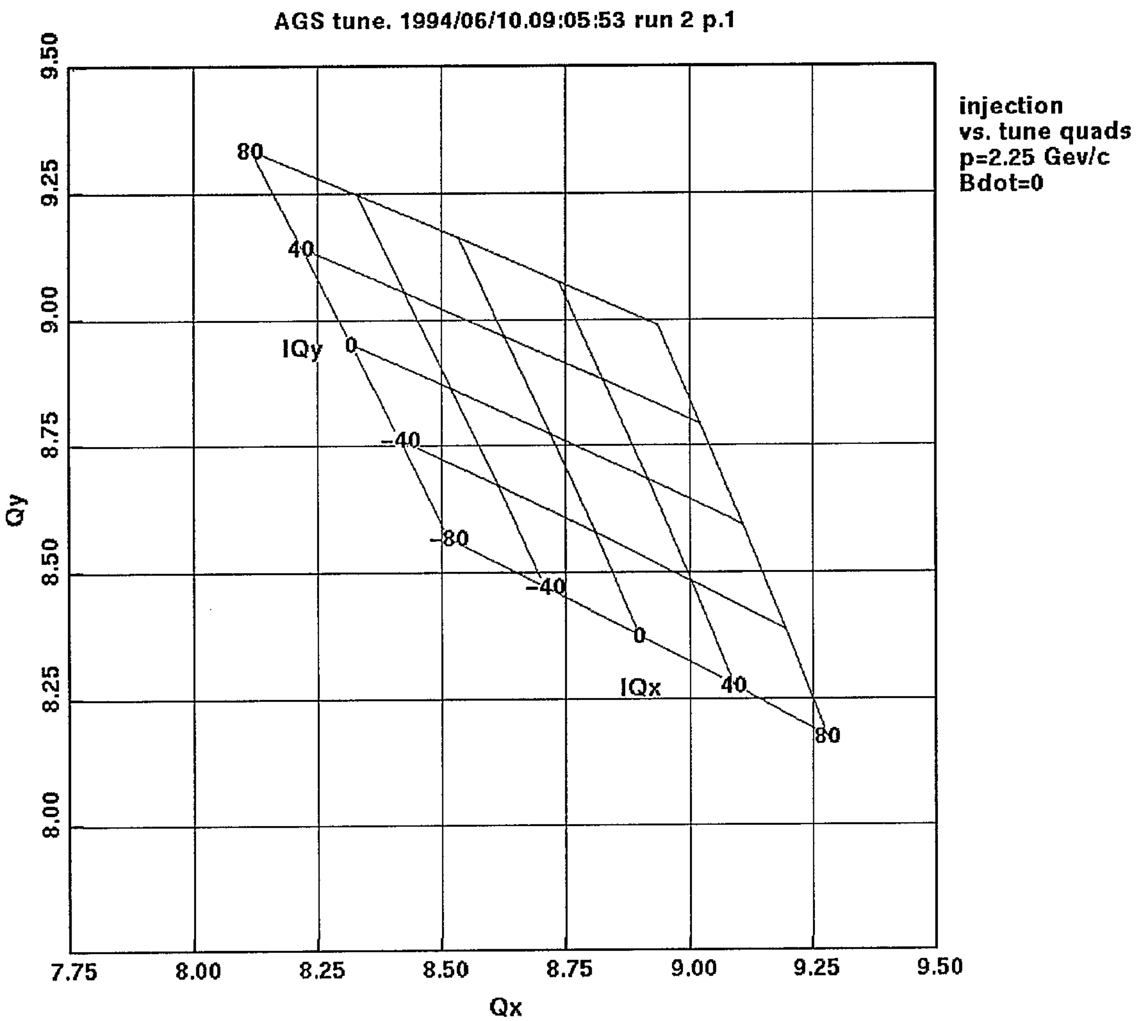

Fig.2. Twiss parameter α at the injection kicker vs. HF Quad Currents.

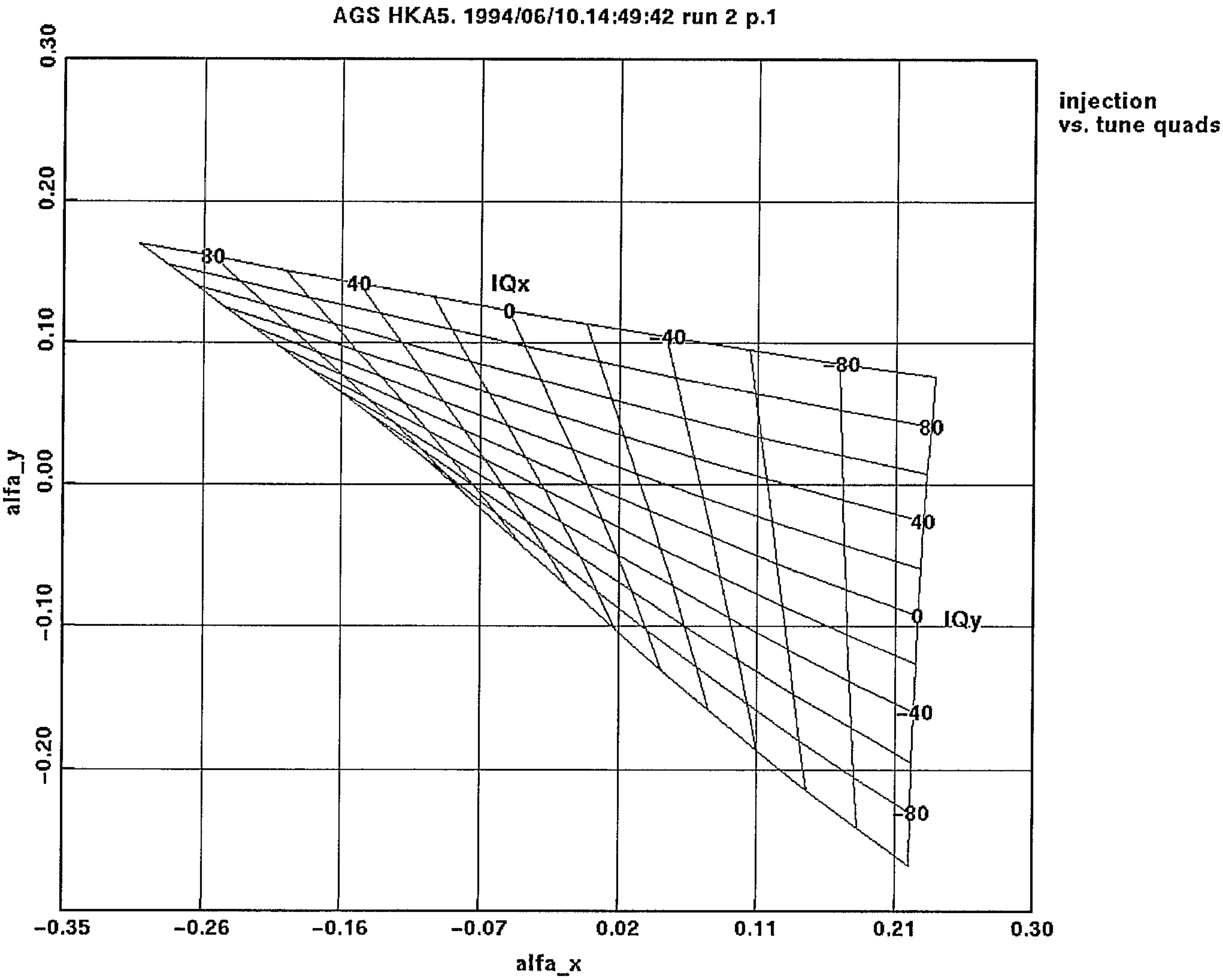

Fig.3. Twiss parameter β at the injection kicker vs. HF Quad Currents.

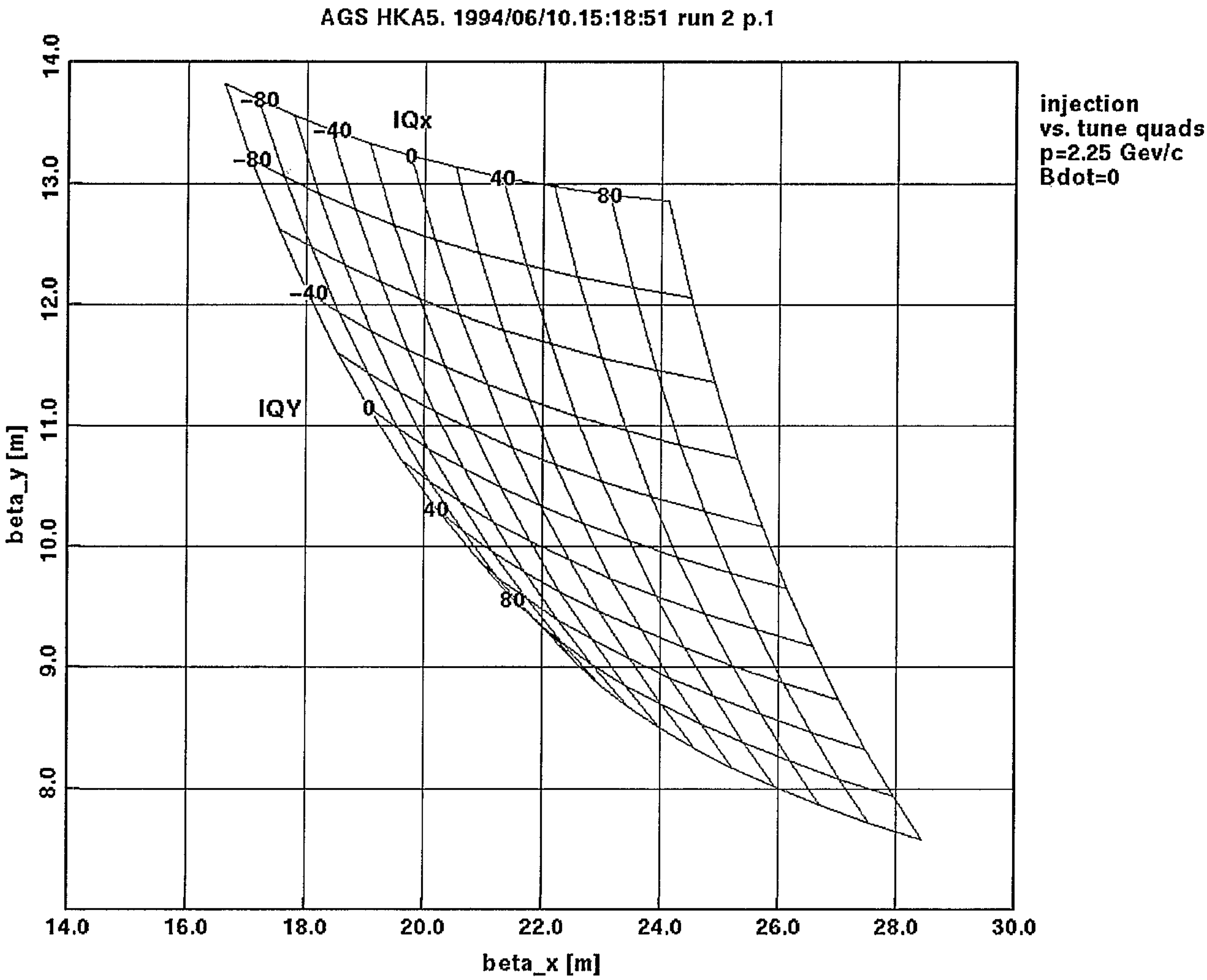

Fig.4. Emittance Growth vs. HF Quad Currents.

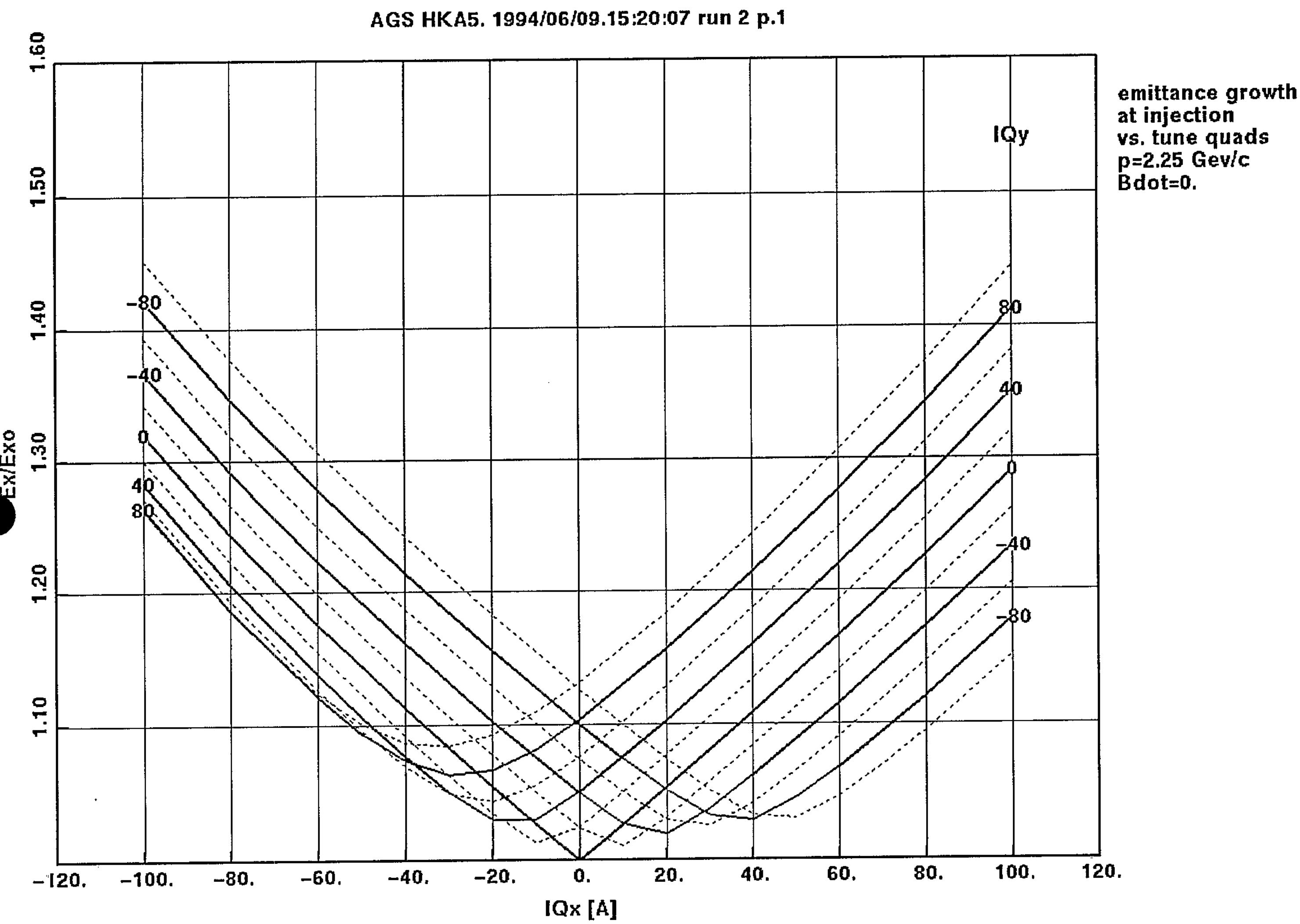

Fig.5. Dispersion variation at the injection kicker vs. HF Quad Currents.

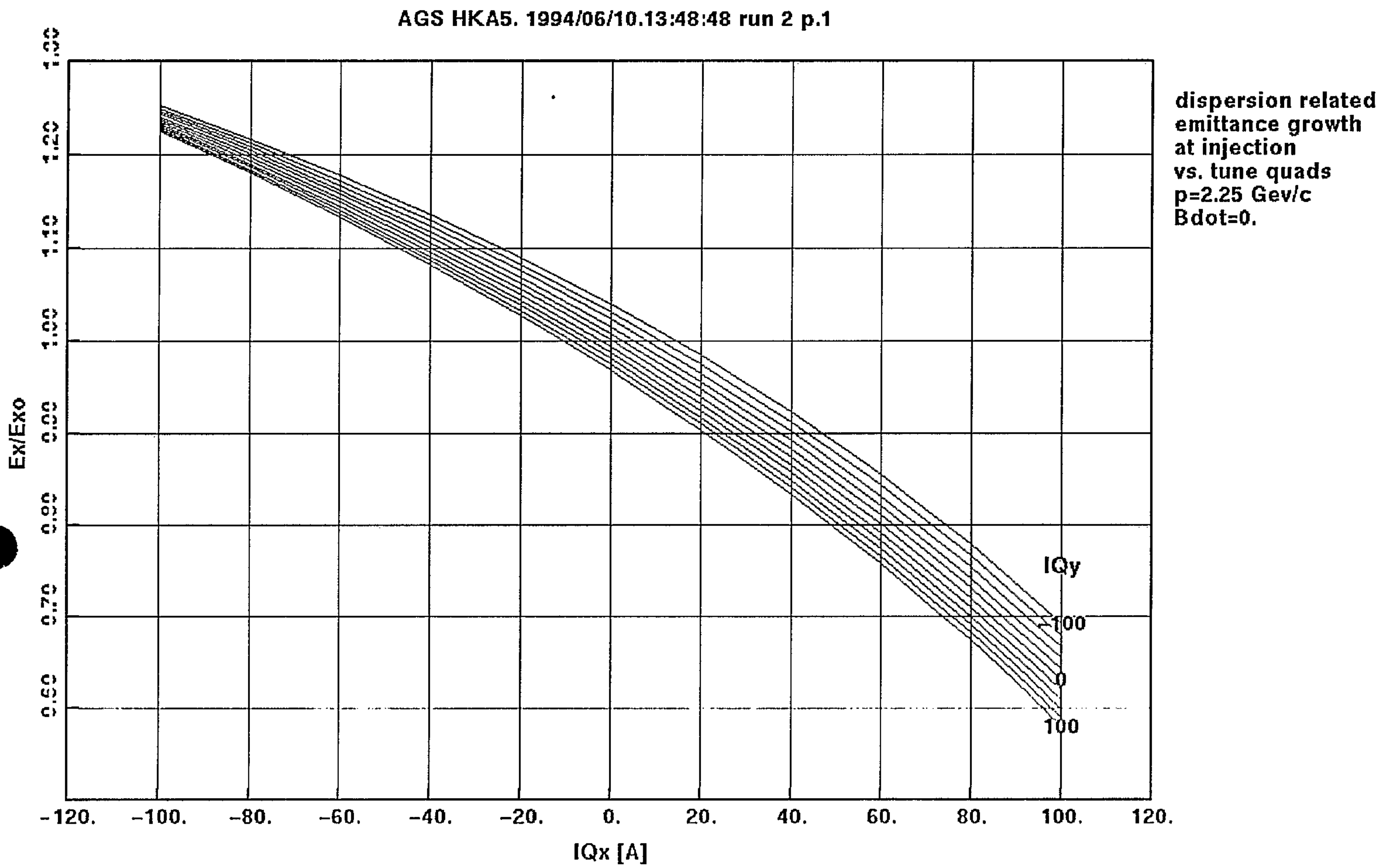

Fig.6. Twiss parameter α at the QV(6) quad vs. HF Quad Currents.

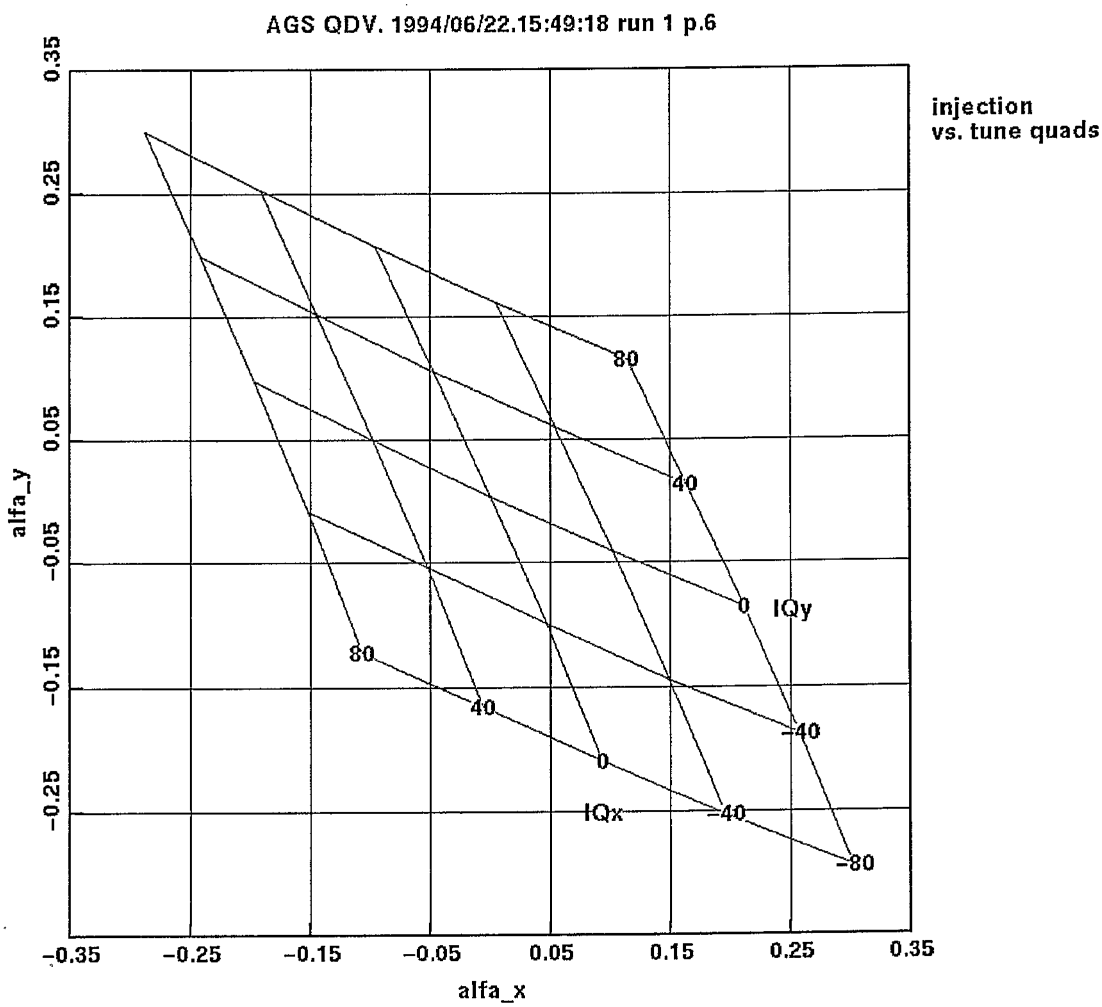

Fig.7. Twiss parameter β at the QV(6) quad vs. HF Quad Currents.

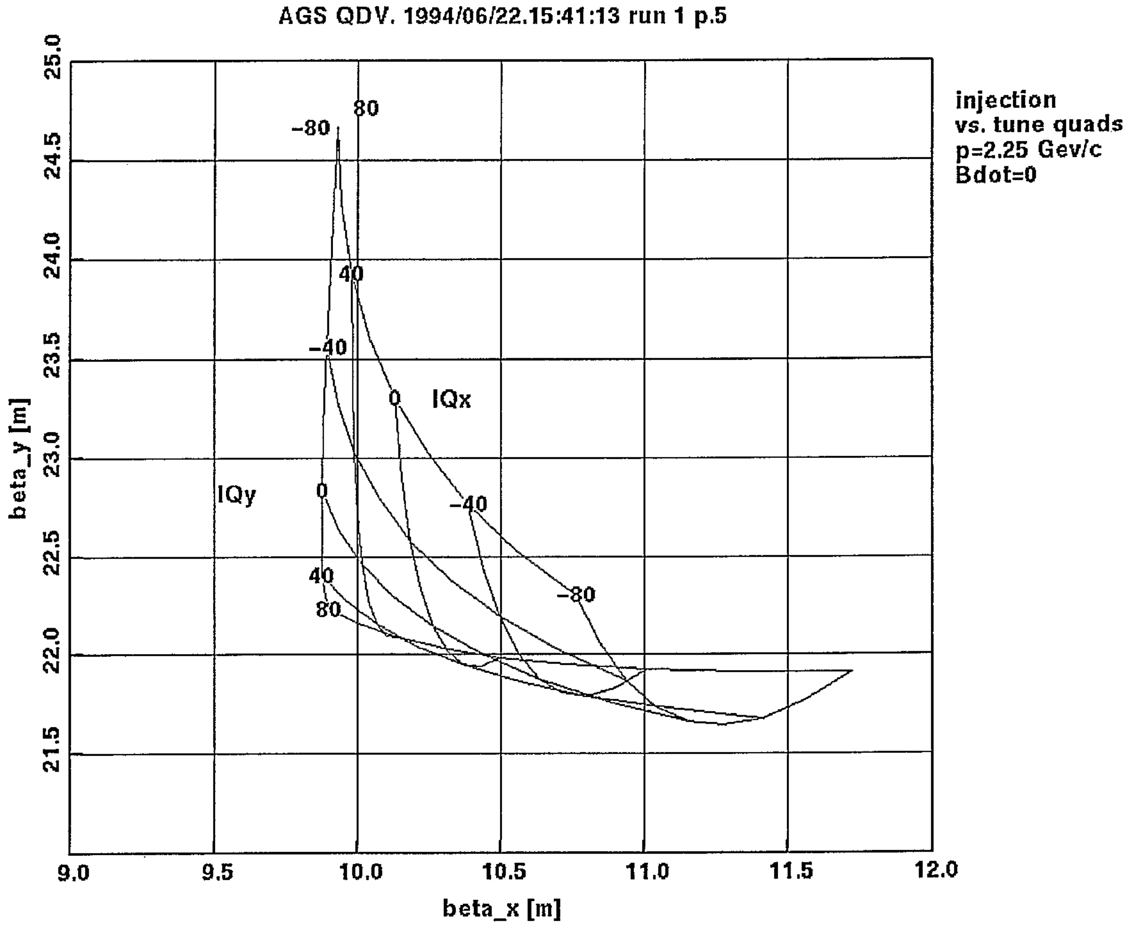

Fig.8. Horizontal Dispersion and its derivative at the QV(6) quad vs. HF Quad Currents.