DEPENDENCE OF THE SPACE CHARGE LIMIT ON THE CHOICE OF ν VALUES

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I. Introduction

This paper studies the dependence of the space charge limit on the choice of ν values ν_x, ν_y. The study finds there are valleys, places where the space charge limit is low, just above the location of the 1/4 resonances. For the AGS Booster, with a period of 6, the 1/4 resonances are located at $\nu = 1.5, 3, 4.5, 6 \ldots$ In between these valleys, peaks in the space charge limit are found. These peaks may be at the optimum choice of ν value to obtain the highest space charge limit. One peak that may be of interest for the Booster is the peak at $\nu = 5.8$. The choice of ν value of $\nu = 5.8$ appears to increase the space charge limit by 1/3 above the space charge limit found for $\nu = 4.8$.

II. Space Charge Limit Dependence on ν Values

Figure 1 plots the space charge limit for the AGS Booster, $N_{b,L}$ protons/bunch, against the choice of ν value ν_x. ν_y is always related to ν_x by $\nu_y = \nu_x - .01$. One should remember that comparison with results of operating accelerators indicates that the results of the simulation program for the space charge limit , shown in Figure 1, should be reduced by about a factor of 2. Figure 1 shows the valleys, low points in $N_{b,L}$, just above the 1/4 resonances at $\nu_x = 1.5, 3, 4.5$ and 6. Two of these resonances, those at $\nu_x = 3, 6$ are also 1/2 resonances which may also be contributing.

The space charge limit plotted in Figure 1 is the intrinsic space charge limit, which is the limit due to forces generated by the beam itself. Magnetic field errors are assumed not to be present. The 1/4 resonances indicated in Figure 1 are driven by the space charge forces of the beam itself. The 1/2 resonances are also driven by the 6 Θ harmonic in the magnetic guide field. The strength of the 1/2 resonances driven by the magnet guide field is indicated in Figure 2 where β_x, β_y and X_p, the horizontal dispersion, are plotted versus $\nu_x = \nu_y - .01$.

The source of the 6 Θ harmonic in the beam forces is probably the $1/\rho^2$ focussing term in the dipole which has a periodicity of 6.

The justification for looking only as the intrinsic space limit, and ignoring the resonances driven by magnetic field errors, is given in reference 1, where it was found that the intrinsic space charge limit appears to play a dominant role.

The effect of the beam driven resonances on the beam growth is shown in Figure 3. Where x_{max} and y_{max}, the largest x and y attained by particles in the beam are plotted versus $\nu_x = \nu_y - .01$. The assumed horizontal and vertical aperture limits are also indicated by dashed lines. This plot was done with $N_b = 1 \times 10^{13}$ protons/bunch.

SPACE CHARGE LIMIT VERSUS ν_x

AGS BOOOSTER

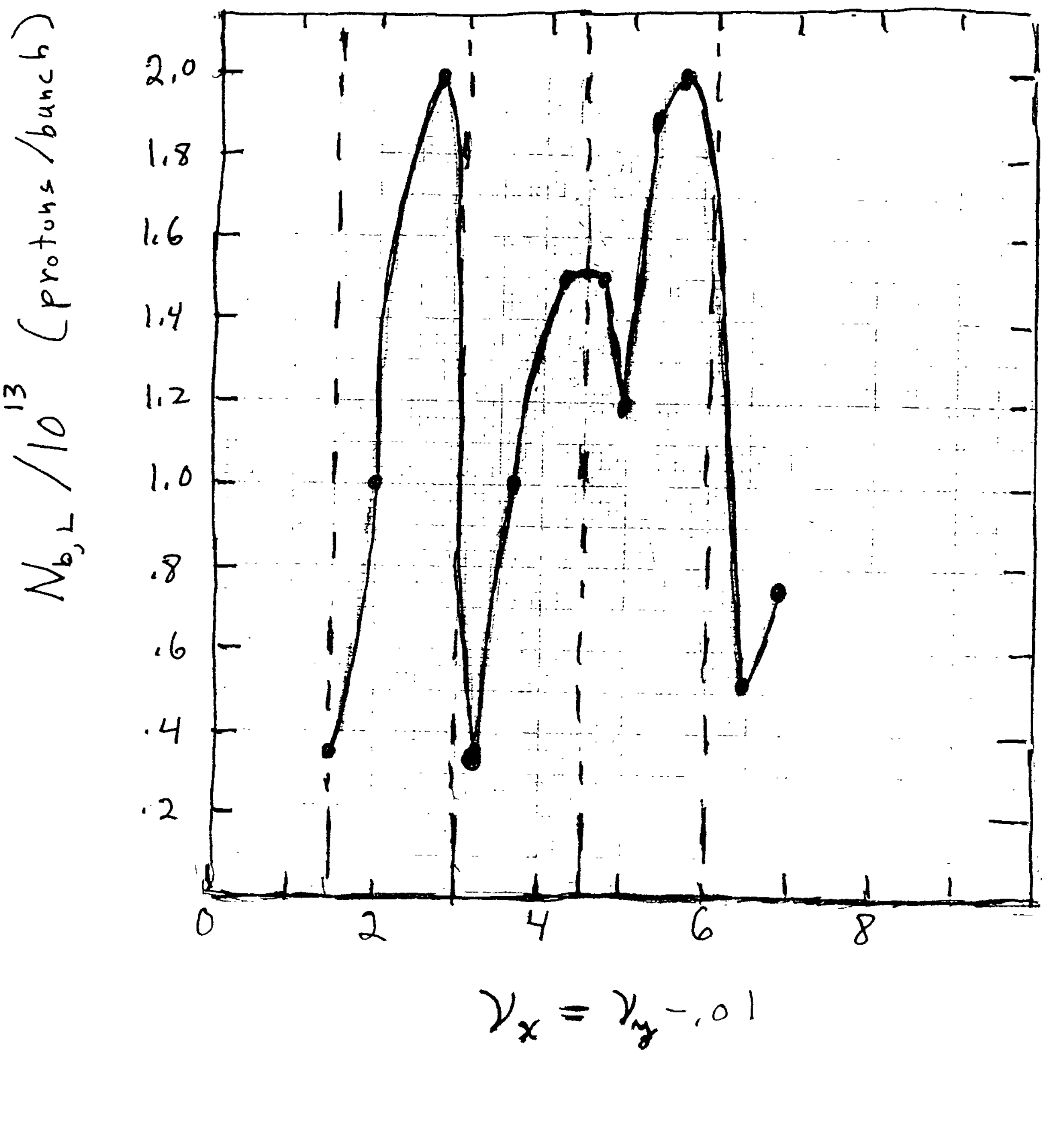

Figure 1

β_x, β_y and X_p versus ν_x

AGS Booster

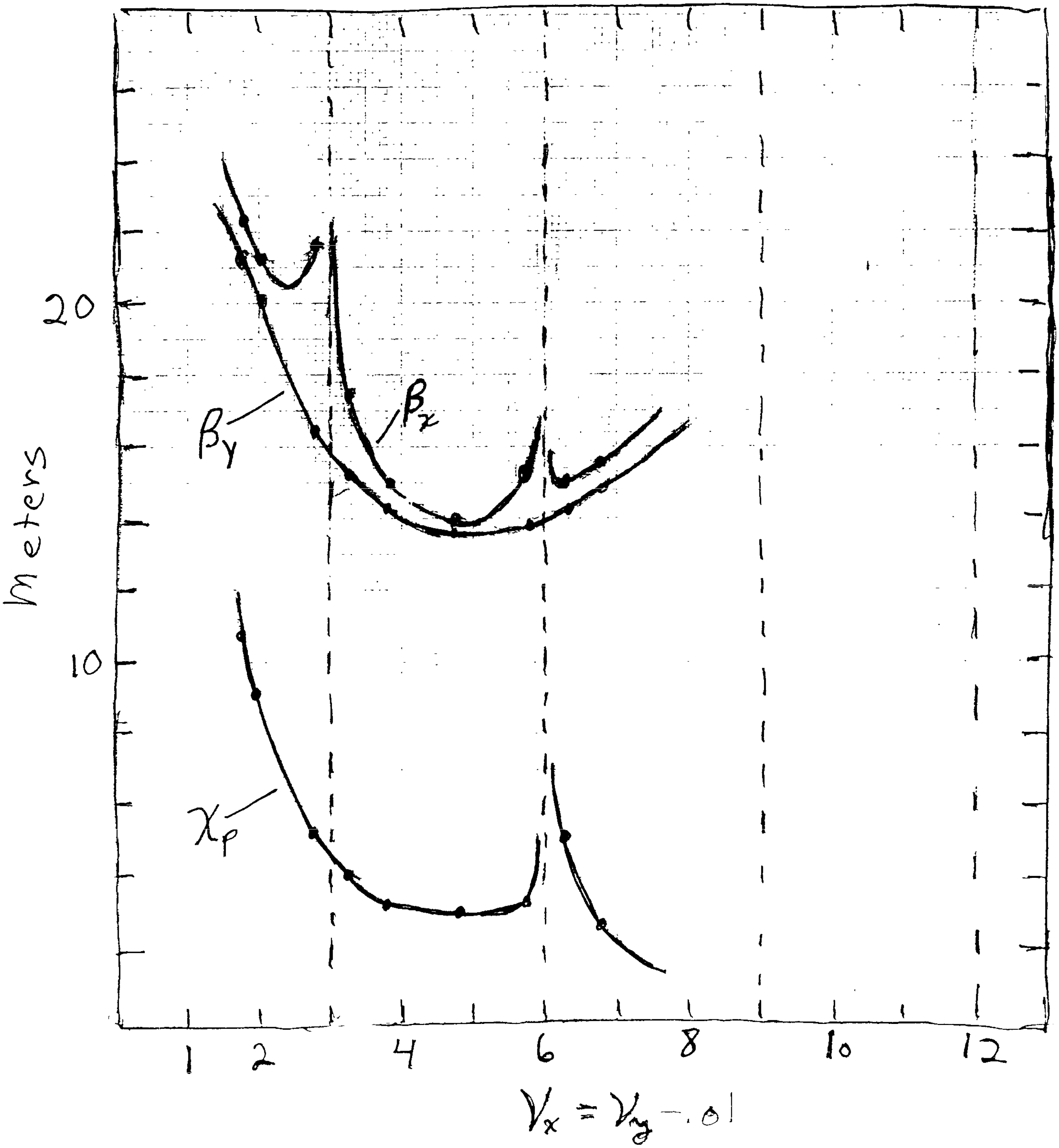

Figure 2

Beam Growth versus ν_x

AGS Booster

for $N_b = 1 \times 10^{13}$ Protons/bunch

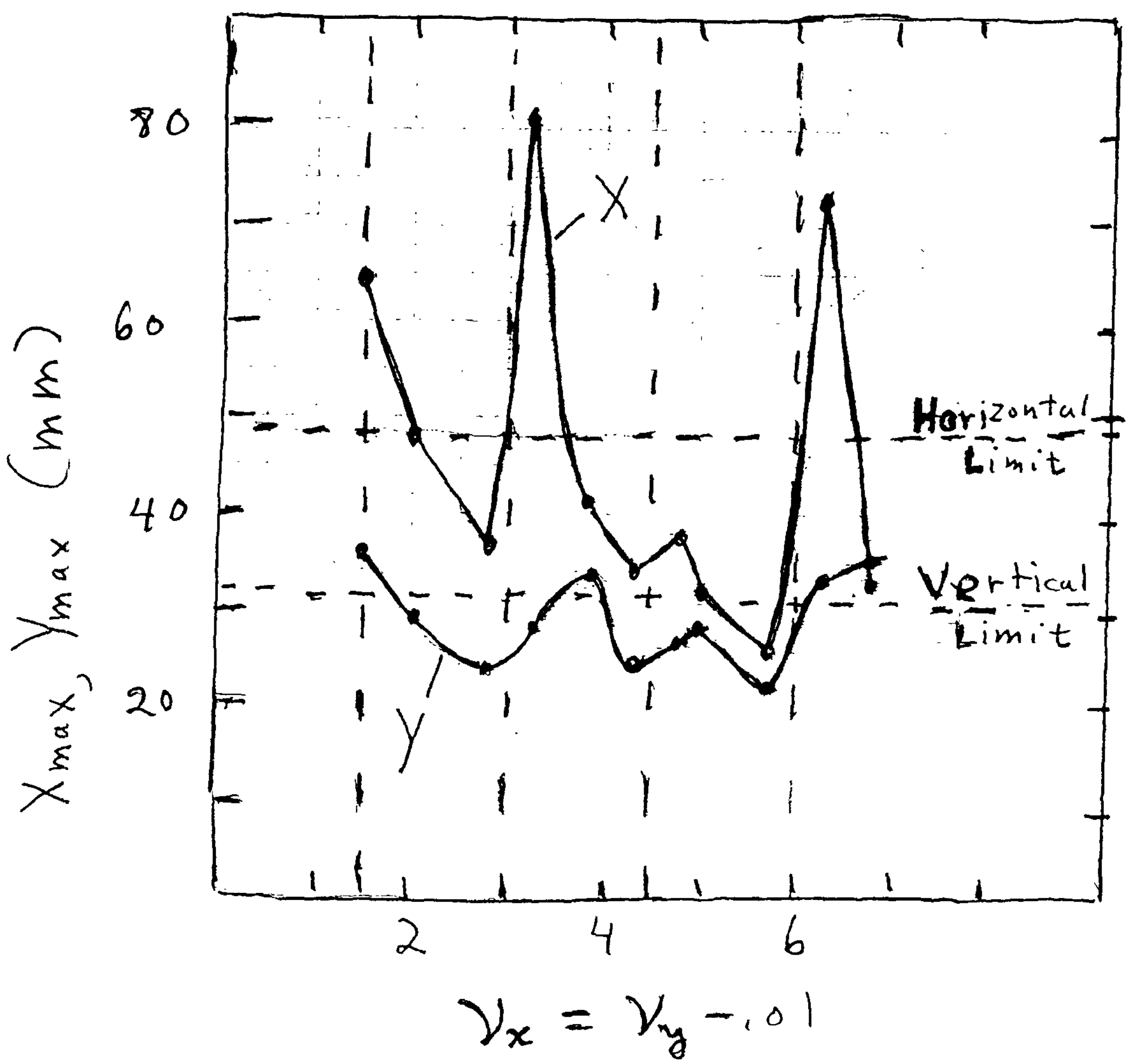

Figure 3

References:

1. G. Parzen, BNL Report # BNL-42653, (1988), to be published.