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The effect of sextupole fields on the space charge limit

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I. INTRODUCTION

The presence of sextupole fields in the AGS Booster appears to have a considerable effect on the intrinsic space charge limit. The sextupole fields can lower the space charge limit by about a factor of 2.5. Overall, sextupole arrangements with a periodicity of 6 and a periodicity of 24 have about the same effect and reduce the intrinsic space charge limit by about a factor of 2.5. The optimum space charge limit is reduced by the sextupoles from 4×10^{13} protons/bunch ts 1.5×10^{13} protons/bunch.

II. RESULTS OF SIMULATION STUDIES OF THE SPACE CHARGE LIMIT

The simulation studies reported here compute the beam growth and the space charge limit in the absence of external resonances, which is called the intrinsic space charge limit.

Figure 1 shows the computed space charge limit for various arrangements of sextupole fields. In Figure 1, the space charge limit $N_{b,L}$ protons/bunch, is plotted against the initial horizontal half-size of the beam, XBM, when the beam is injected using only a horizontal bump. The largest space charge limit is found when no sextupole fields are present. Results are shown for the following sextupole arrangements:

1) Sextupoles with Periodicity = 24, $C_x = C_y = -5$
2) Sextupoles with Periodicity = 6, $C_x = C_y = -5$
3) No sextupole fields.

Both sextupole distributions give about the same results for the space charge limit, and considerably reduce the optimum space charge limit from $N_{b,L} = 4.0 \times 10^{13}$ protons/bunch to $N_{b,L} = 1.5 \times 10^{13}$ protons/bunch.

In some respects the periodicity = 24 sextupole arrangement is better and this is shown in the beam growth plot in Figure 2.

Figure 2 shows the beam growth for various sextupole arrangements. In Figure 2, the maximum vertical emittance achieved by any particle in the beam is plotted against N_b, the number of protons/bunch, when the beam is injected as a flat beam with a maximum horizontal emittance if $\varepsilon_x = 53 \times 10^{-6}$ m Rad and an initial maximum vertical emittance of $\varepsilon_y = 5 \times 10^{-6}$ m Rad. One sees that the growth is smaller for the case of no sextupole fields. The results for the periodicity = 24 sextupole arrangement oscillate with N_b, with some values of N_b giving large beam growth, similar to that of the periodicity = 6 arrangement, and with some values of N_b giving less beam growth similar to that of the no sextupole field case. This seems to indicate that the beam may be unstable and strike the vacuum chamber at some lower value of N_b and become more stable and have less growth as some higher value of N_b. In computing $N_{b,L}$, the space charge limit the smallest N_b that makes the beam hit the vacuum chamber was used, even though some larger N_b appear to be stable.

The results for the space charge limit when the sextupoles are present may be considered uncomfortably low. The largest space charge limit found in this case is 1.5×10^{13} protons/bunch. These results do not include the effects of external resonances due to magnet field errors and there are other factors that add to the uncertainty in the results.

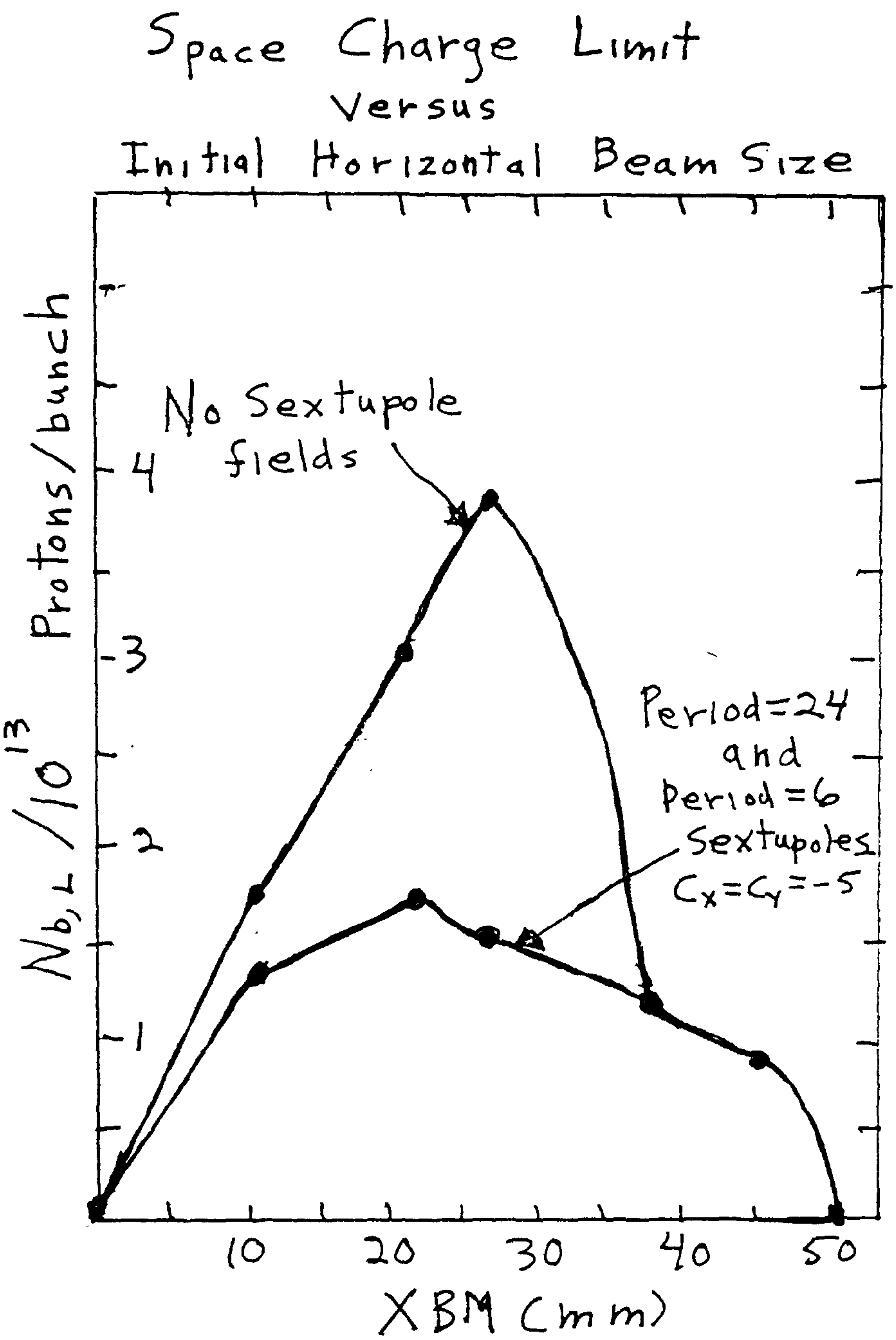
Space Charge Limit
Versus
Initial Horizontal Beam Size
$N_{b,L}/10^{13}$ Protons/bunch
No Sextupole fields
Period=24
and
Period=6
Sextupoles
$C_x=C_y=-5$
1
2
3
4
10
20
30
40
50
XBM (mm)

Fig. 1

Vertical Emittance Growth vs. N_b

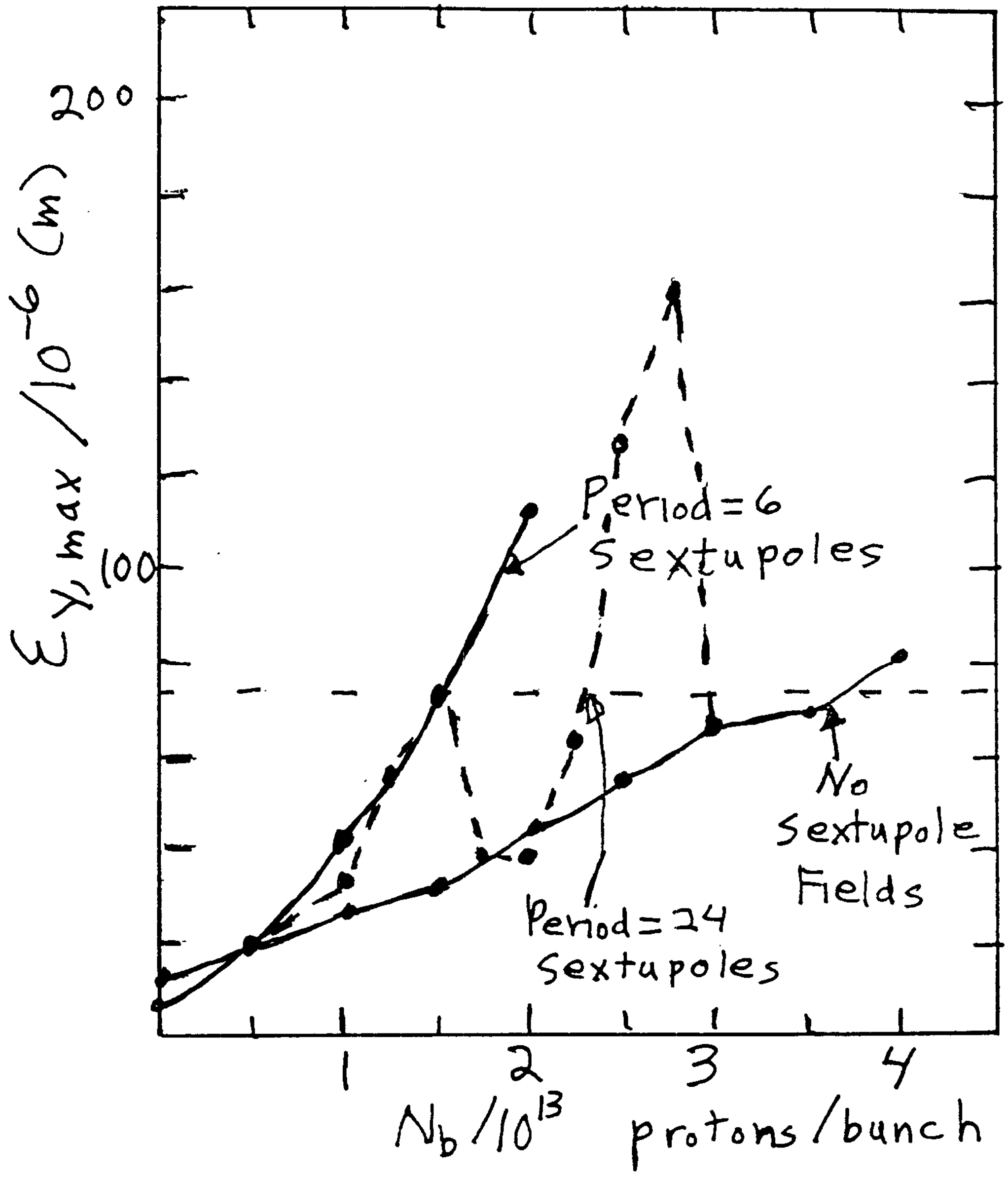

Fig. 2