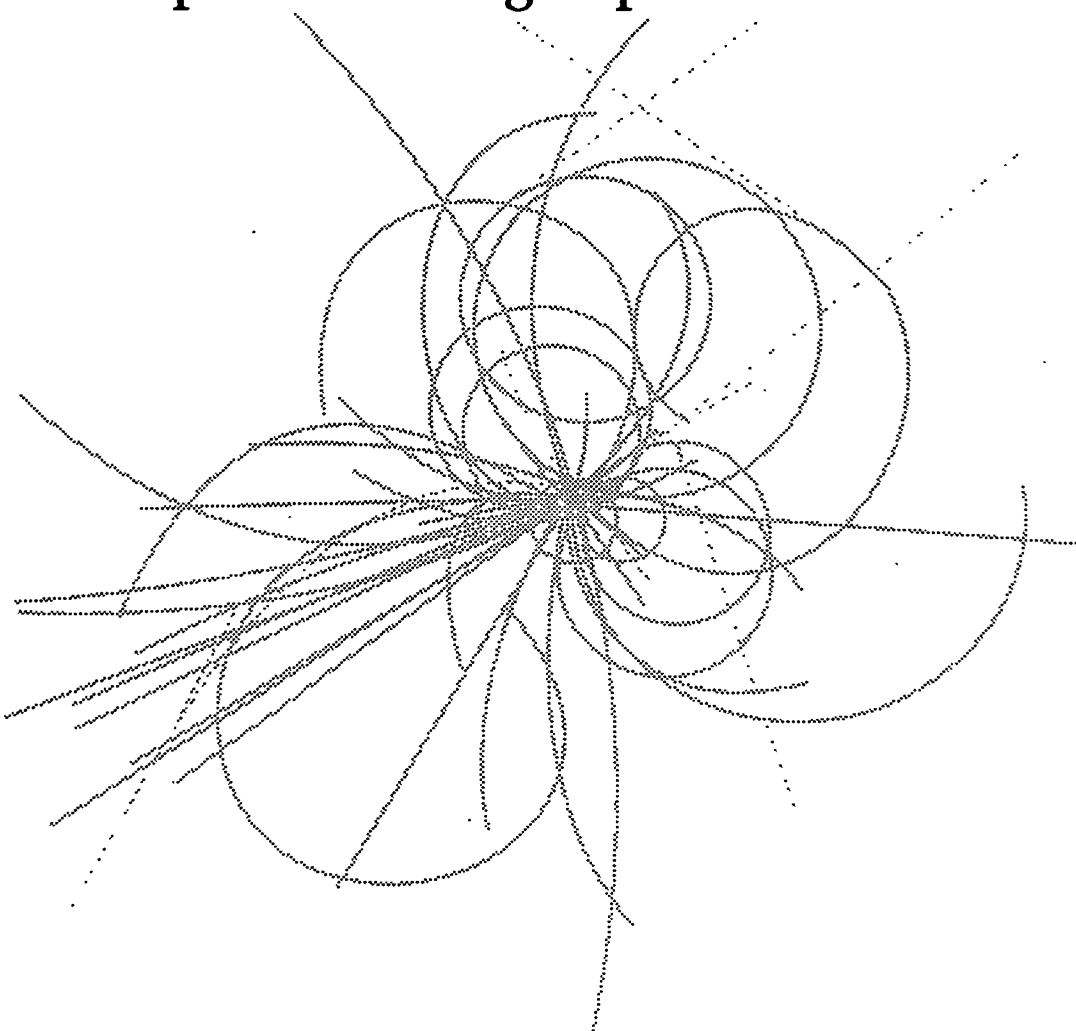
SSCL-260

Superconducting Super Collider Laboratory



The Effect of Magnetic Peaking on the Dynamic Aperture

T. Garavaglia and R. Stiening

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THE EFFECT OF MAGNETIC PEAKING ON THE DYNAMIC APERTURE

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* Operated by Universities Research Association, Inc., for the U.S. Department of Energy under Contract No. DE-AC02-89ER40486.

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1. Introduction

It has been suggested that the dynamic aperture of the SSC can be increased by a suitable choice of the dipole systematic allowed multipole moments so as to extend the uniform field region of the magnet. In this note the the effect of combinations of B_4 and B_6 are considered on the tune shifts. These tune shifts have been calculated using the methods of Refs. [1] and [2]. The results of these calculations are given in Figures 2 through 13.

The magnetic multipole field that results in peaking is found from

$$B_y(x,y) = B_o Real[B_4(x+iy)^4 + B_6(x+iy)^6] \tag{1}$$

which produces

$$\begin{aligned} B_y(x,y)/B_o = {} & B_4(x^4 - 6x^2y^2 + y^4) \\ & + B_6(x^6 - 15x^4y^2 + 15x^2y^4 - y^6)\,. \end{aligned} \tag{2}$$

One can illustrate the peaking effect using Eq. (2) with a suitable choice of the parameters. For $y = 0$, $B_4 = 1$, and $B_6 = 0$ the field $B_y(x,0)/B_o$ is positive

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and increasing with x; however, with $B_4 = 1$, and $B_6 = -4$, $B_y(x,0)/B_o$ rises to a maximum positive value—peaking—and then decreases to negative values for increasing x values. These two cases are shown in Figure 1 where it is seen that the second combination of parameters has the effect of extending the uniform field region in the horizontal plane of the magnet.

2. Tune Shift Plots

An indication of the change in the dynamic aperture can be found from an inspection of the figures indicating the tune shifts associated with injection at different points (x, y) for different choices of the values of B_4 and B_6. In these figures, particles are injected on a grid from $x = y = 0$ to $x = y = x_{\max}$ with momentum dispersion values of $+\delta p/p$, 0, and $-\delta p/p$. In all of these examples the nominal betatron fractional tune values are $\nu_x = 0.425$ and $\nu_y = 0.410$, and all multipole coefficients B_i, except B_4 and B_6, are zero. In each case the values used for B_4, B_6, $x_{\max}$, and $\delta p/p$ are given in Table 1.

Table 1. Input Values For Tune Shift Graphs

Case	B_4	B_6	$X_{\max}$ mm	$\delta p/p$
20	1.0	0.0	5.0	10^{-4}
21	1.0	0.0	4.0	10^{-4}
22	1.0	0.0	3.0	10^{-4}
23	1.0	-4.0	5.0	10^{-4}
24	1.0	-4.0	4.0	10^{-4}
25	1.0	-4.0	3.0	10^{-4}
26	0.1	-0.4	5.0	10^{-3}
27	0.1	-0.4	4.0	10^{-3}
28	0.1	-0.4	3.0	10^{-3}
29	0.1	0.0	5.0	10^{-3}
30	0.1	0.0	4.0	10^{-3}
31	0.1	0.0	3.0	10^{-3}

3. Conclusion

It is clear from the figures, which give a spread in the values of the tune shifts, that there is a marginal improvement in the dynamic aperture for cases 26, 27, and 28 (Figures 8, 9 and 10, respectively) where both B_4 and B_6 are small. These are to be compared with cases 29, 30 and 31 (Figures 11, 12 and 13, respectively) where B_6 is zero. However, for the case with $B_4 = 1$ and $B_6 = -4$ where Figure 1 shows an extension of the region of uniformity of the magnetic field to nearly 5 mm, the dynamic aperture is actually worse than the case with $B_4 = 1$ and $B_6 = 0$. This can be seen when the tune shift plots Figure 2 and Figure 3 for injection out to 5 mm and 4 mm, respectively, are compared with the corresponding plots case 23 and case 24 (Figures 5 and 6, respectively) which represent the case with extended field uniformity. We conclude from this study that the peaking effect would not produce a substantial increase in the dynamic aperture. Figures 4 and 7 are provided for continuity, but do not provide significant data.

REFERENCES

1. A. Jackson, "Tune Shifts and Compensation From Systematic Field Components," SSC-107, (1987).

2. E. Forest, "Computation of First Order Tune Shifts," SSC-N-322, (1987).

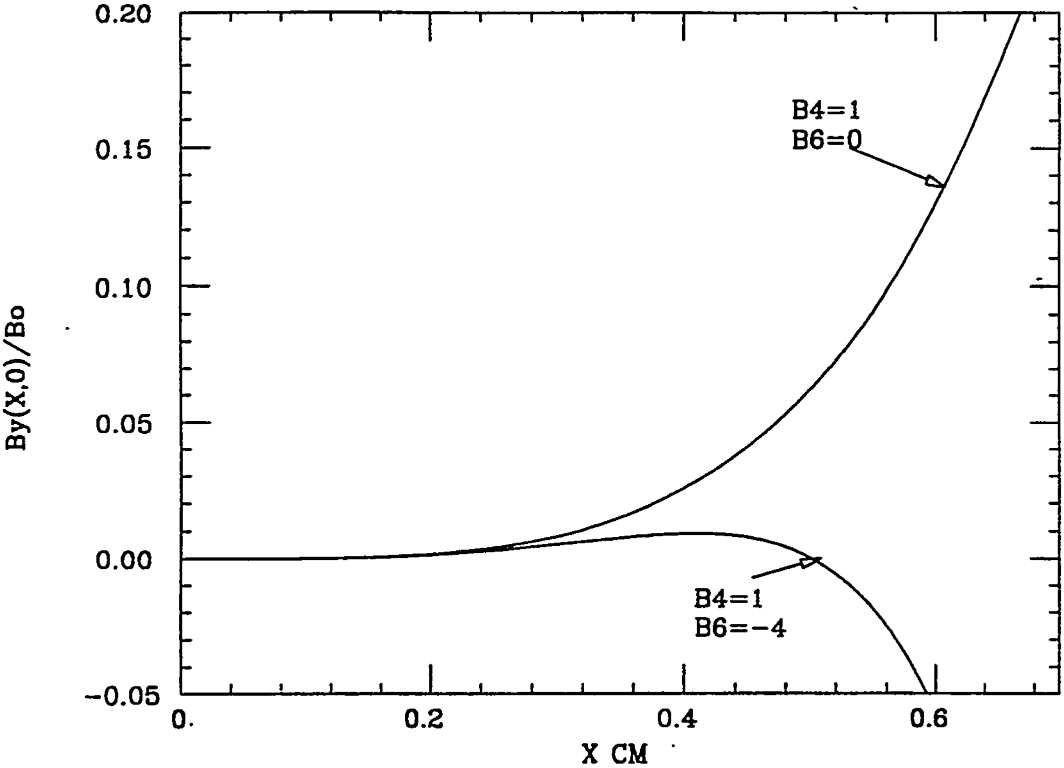

Figure 1: Magnetic field peaking.

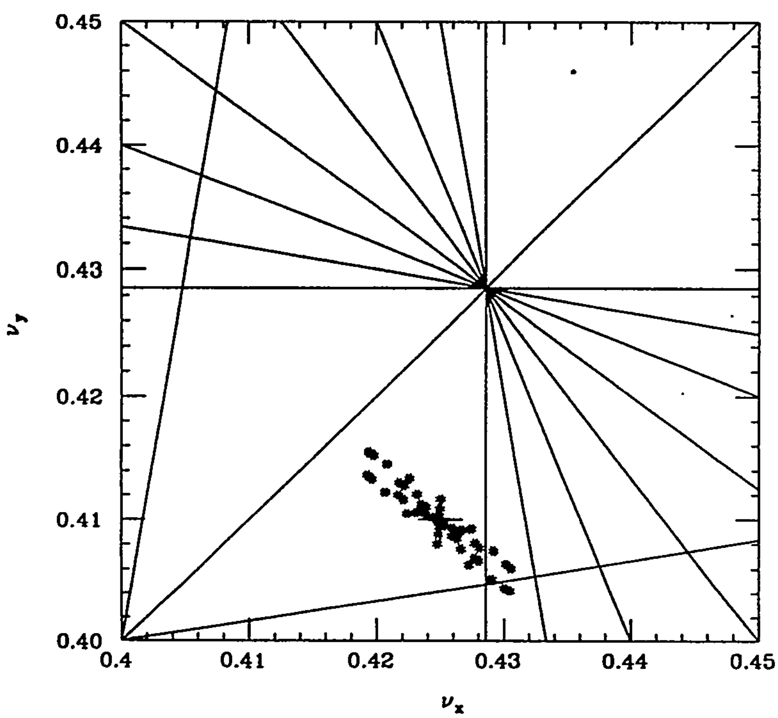

Figure 2: Tune shift 20, 4 cm magnet $x = y = 0.500$ cm.

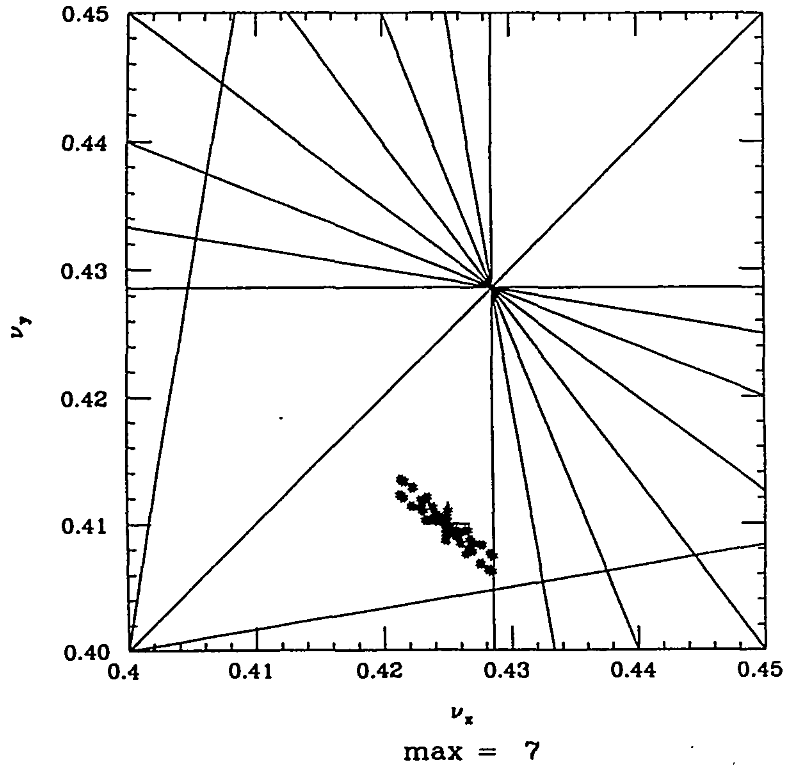

Figure 3: Tune shift 21, 4 cm magnet $x = y = 0.400$ cm.

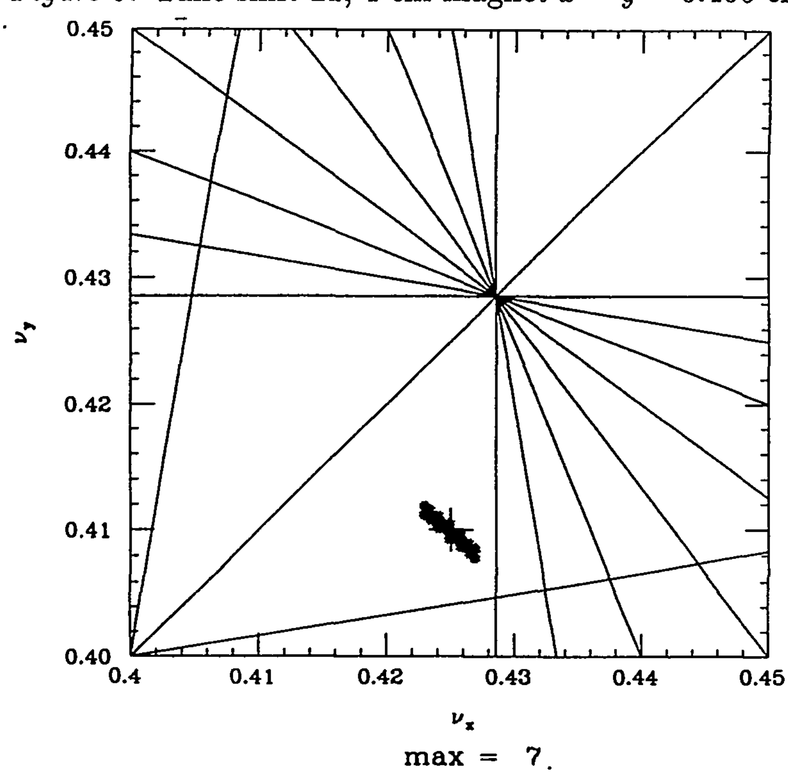

Figure 4: Tune shift 22, 4 cm magnet $x = y = 0.300$ cm.

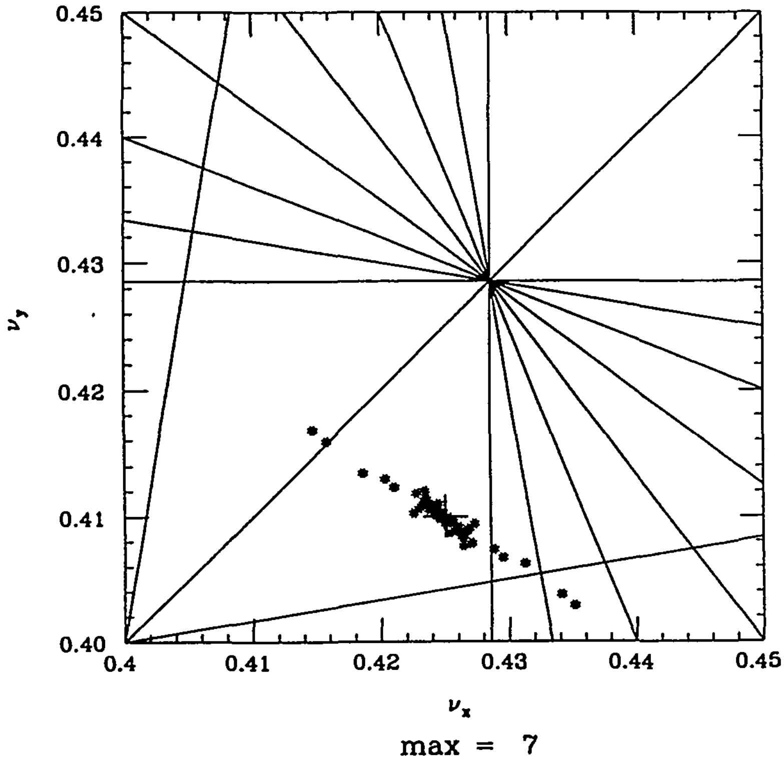

Figure 5: Tune shift 23, 4 cm magnet $x = y = 0.500$ cm.

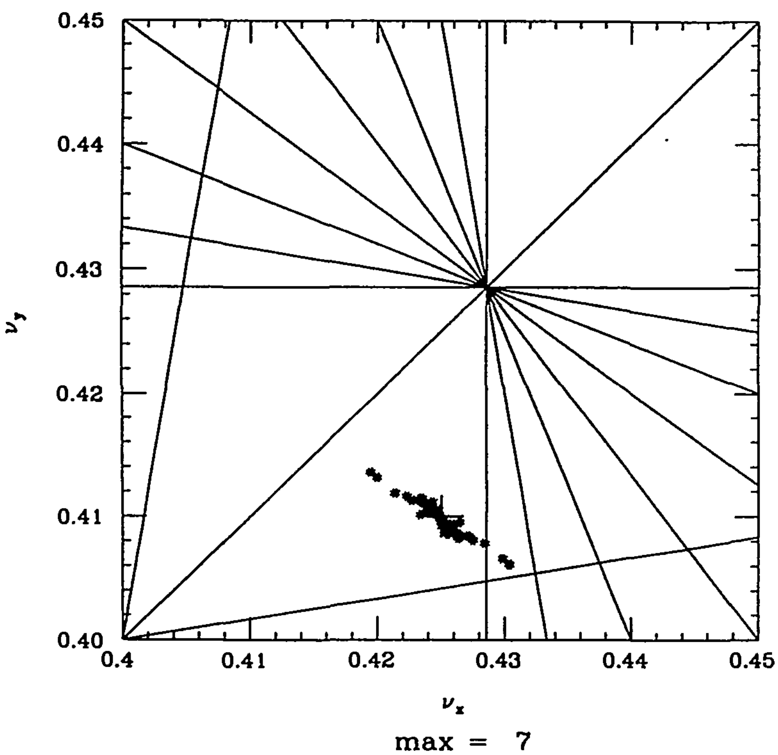

Figure 6: Tune shift 24, 4 cm magnet $x = y = 0.400$ cm.

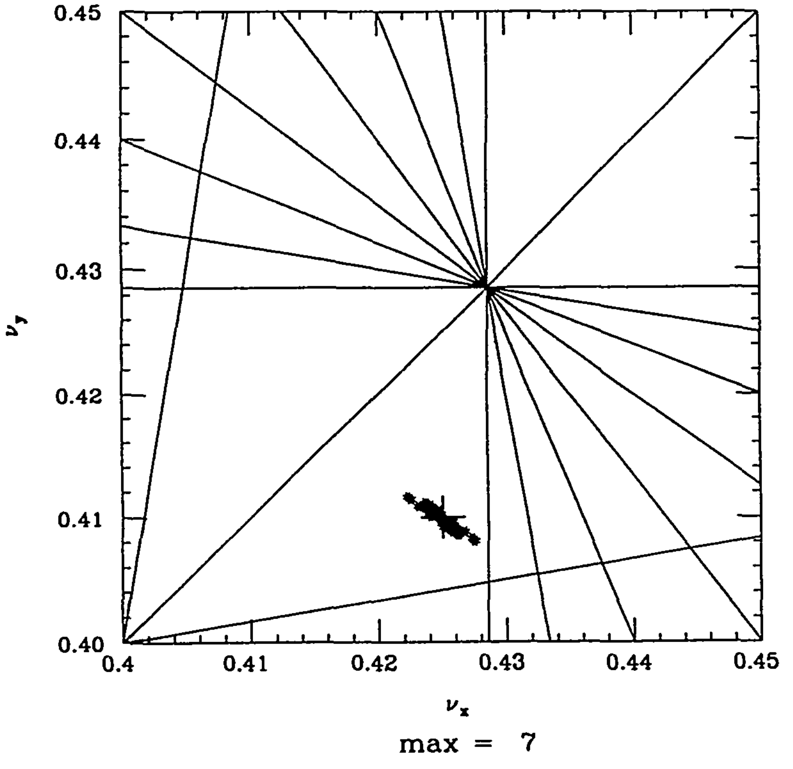

Figure 7: Tune shift 25, 4 cm magnet $x = y = 0.300$ cm.

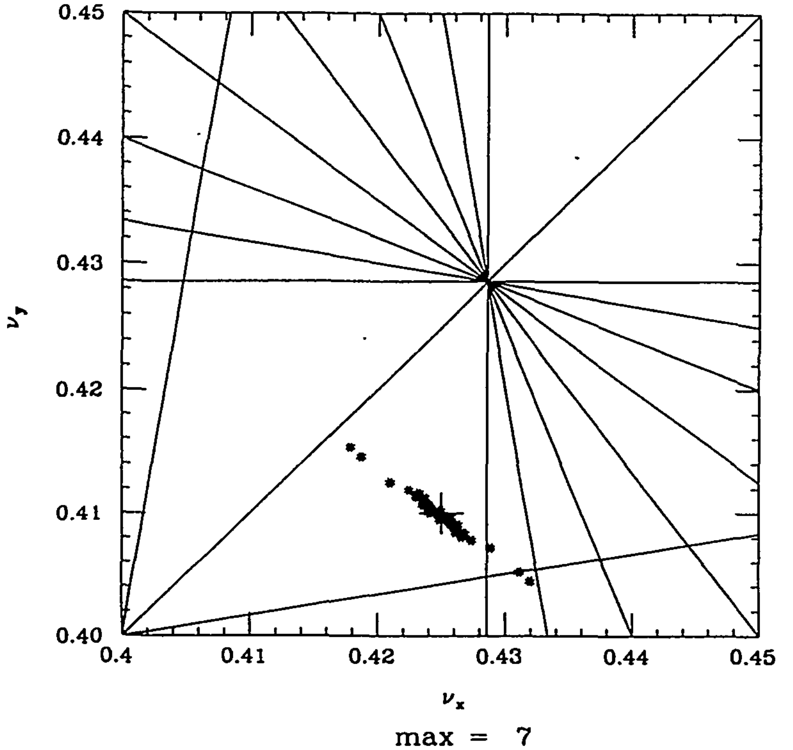

Figure 8: Tune shift 26, 4 cm magnet $x = y = 0.500$ cm.

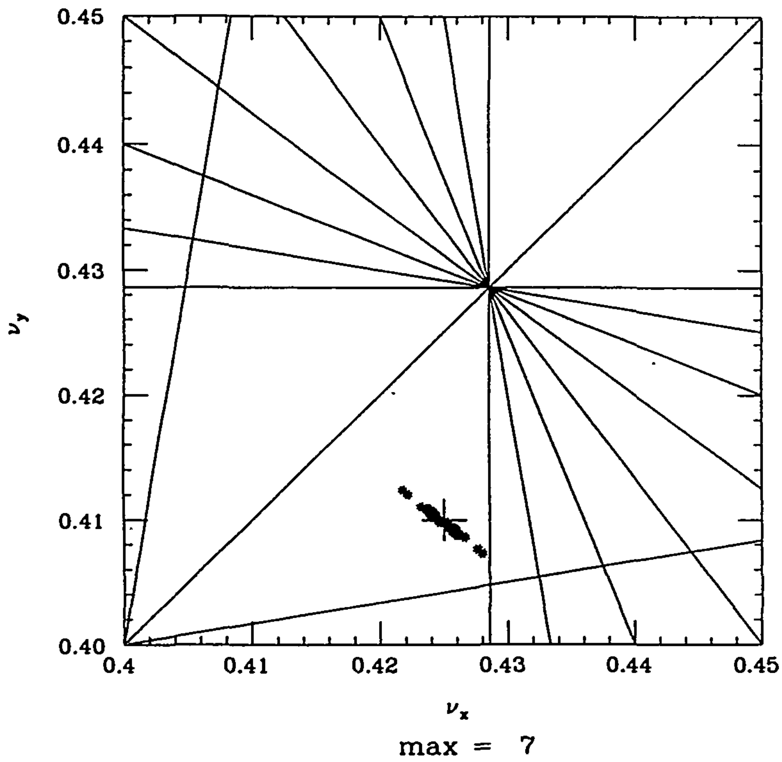

Figure 9: Tune shift 27, 4 cm magnet $x = y = 0.400$ cm.

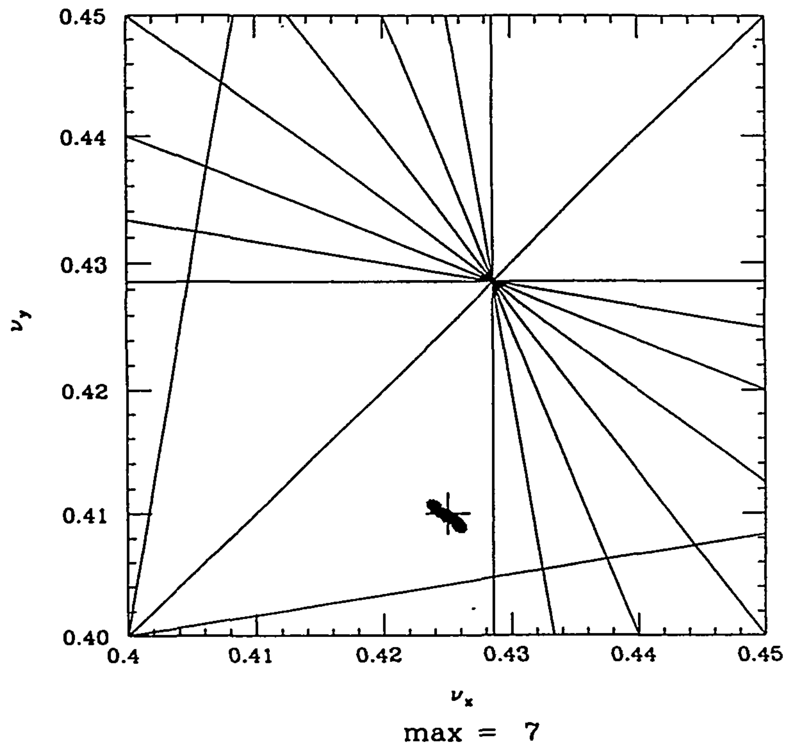

Figure 10: Tune shift 28, 4 cm magnet $x = y = 0.300$ cm.

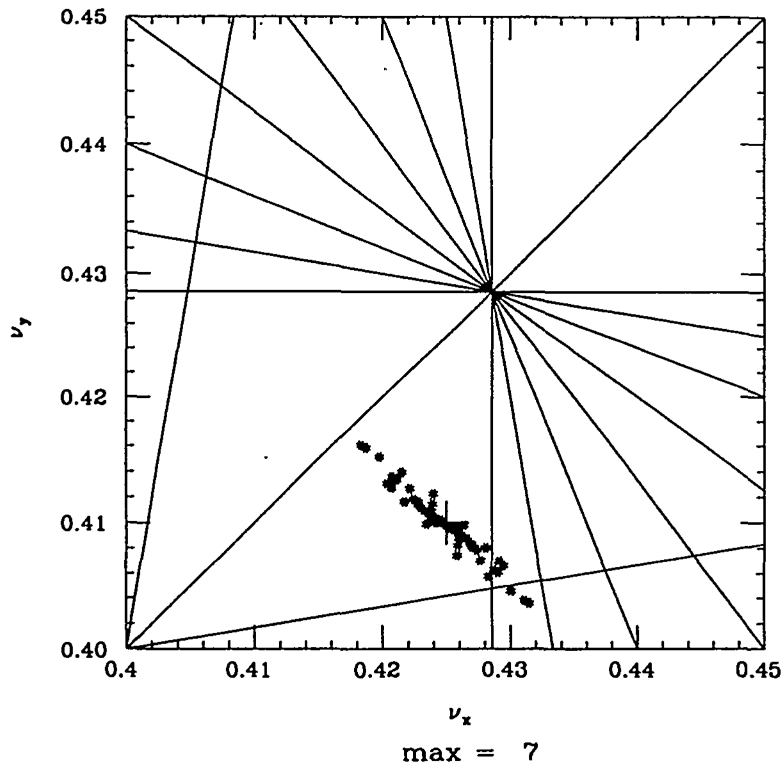

Figure 11: Tune shift 29, 4 cm magnet $x = y = 0.500$ cm.

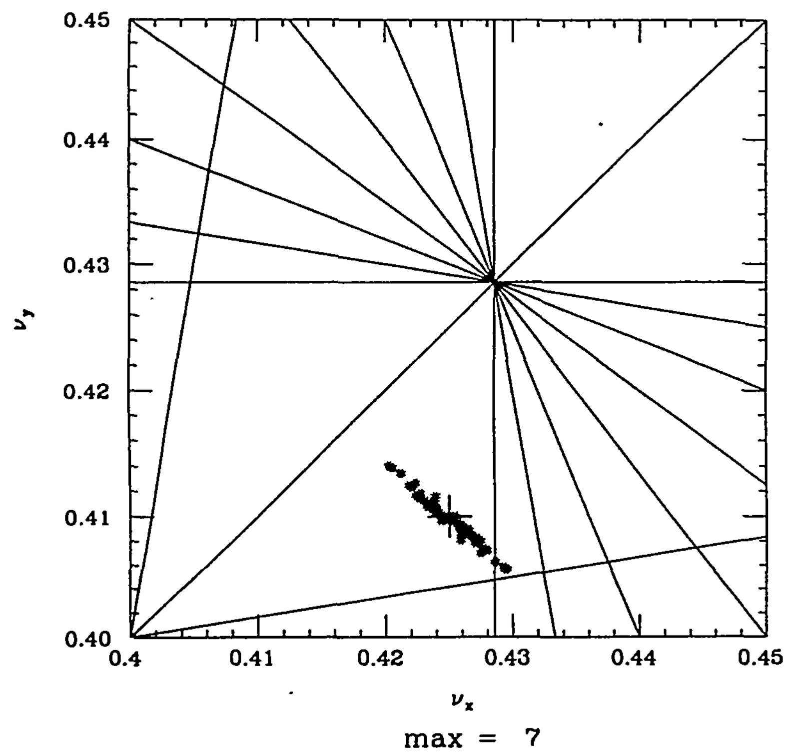

Figure 12: Tune shift 30, 4 cm magnet $x = y = 0.400$ cm.

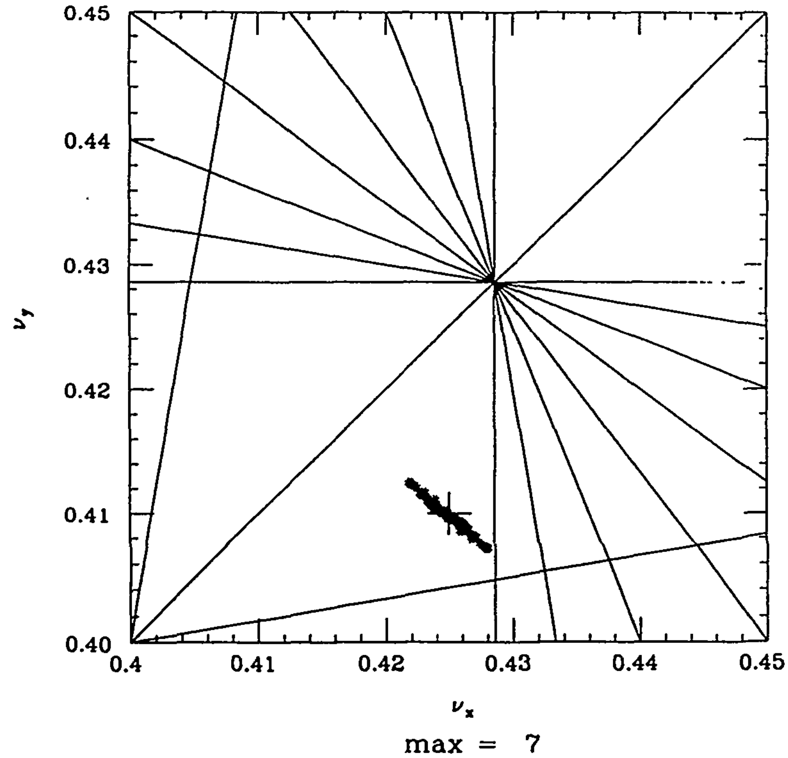

Figure 13: Tune shift 31, 4 cm magnet $x = y = 0.300$ cm.