SSC–N–224

THE EFFECTS OF VARYING β^* ON THE SSC CDR COLLISION LATTICE

Lindsay Schachinger

SSC Central Design Group

August 1986

The value of $0.5m$ for β^* in the low-beta interaction regions of the SSC CDR was chosen as the smallest value consistent with the constraints of 230 T/m quadrupole gradient (with $4cm$ coil diameter) and $\pm 20m$ free space for detectors. However, the error multipoles in the IR triplet limit the dynamic and linear apertures at collision, and the $4cm$ coil diameter in the triplet is the limiting physical aperture of the machine. Increasing β^* would relax these limitations, at the cost either of lowered luminosity or increased beam current. In this paper, we investigate the improvements in aperture and chromatic effects due to an increase in β^* from $0.5m$ to $1m$.

Two versions of the CDR collision lattice were created, one with $\beta^* = 1.0m$ and one with $\beta^* = 0.5m$, with one random seed for the multipole errors in the dipoles. The dipoles were sorted, based on their b_2 values, as described in Ref. (1). For each of the two lattices, three other seeds were then used to choose random distributions of multipole errors in the IR quads, utility quads, and vertical bends. Six more machines were created, by correcting the multipole errors in the IR quads so that the remaining errors were 20% of the original. Using TEAPOT (2), the twelve resulting machines were tracked for 400 turns to determine the linear and dynamic apertures. All apertures quoted are measured at $\widehat{\beta}$ in the arcs.

The results are shown in Table 1. The smear quoted is at the needed aperture of $2mm$. If we require the linear aperture to be 2σ greater than the needed aperture (where σ is the measurement error in the linear aperture from Table 1), then the only case which is ruled out is the $\beta^* = 0.5m$, no correction case. As far as on-momentum aperture is concerned, the $\beta^* = 0.5m$ corrected case is indistinguishable from the $\beta^* = 1.0m$ uncorrected case.

β^*	IR quads corrected?	linear ap	dynamic ap	smear
$0.5m$	no	$1.8 \pm 0.4mm$	$3.5 \pm 1.0mm$	$12 \pm 3\%$
$0.5m$	yes, 80%	$4.6 \pm 0.3mm$	$6.0 \pm 0.6mm$	$3.2 \pm 0.4\%$
$1.0m$	no	$4.6 \pm 0.6mm$	$6.3 \pm 0.8mm$	$4 \pm 1\%$
$1.0m$	yes, 80%	$7.3 \pm 0.4mm$	$9.4 \pm 0.4mm$	$1.6 \pm 0.1\%$

Table 1. Apertures

However, when we look at the chromatic properties, the $\beta^* = 1.0m$ uncorrected lattices look better than the $\beta^* = 0.5m$ corrected ones. Figure 1 is a plot of the fractional part of the horizontal tune as a function of momentum for the three machines generated with $\beta^* = 0.5m$ and corrected, and Figure 2 is the corresponding plot for $\beta^* = 1.0m$ and uncorrected. The vertical tune shift with momentum is plotted in Figures 3 and 4. Clearly the $\beta^* = 0.5m$ corrected lattices fail to satisfy the requirement that $|\Delta\nu| \leq 0.005$ for $\delta = \pm 0.001$, while the $\beta^* = 1.0m$ lattices all pass. Since the linear aperture criterion for off-momentum tune shift is that $|\Delta\nu| \leq 0.005$ for $\delta = \pm 0.001$, the linear aperture for

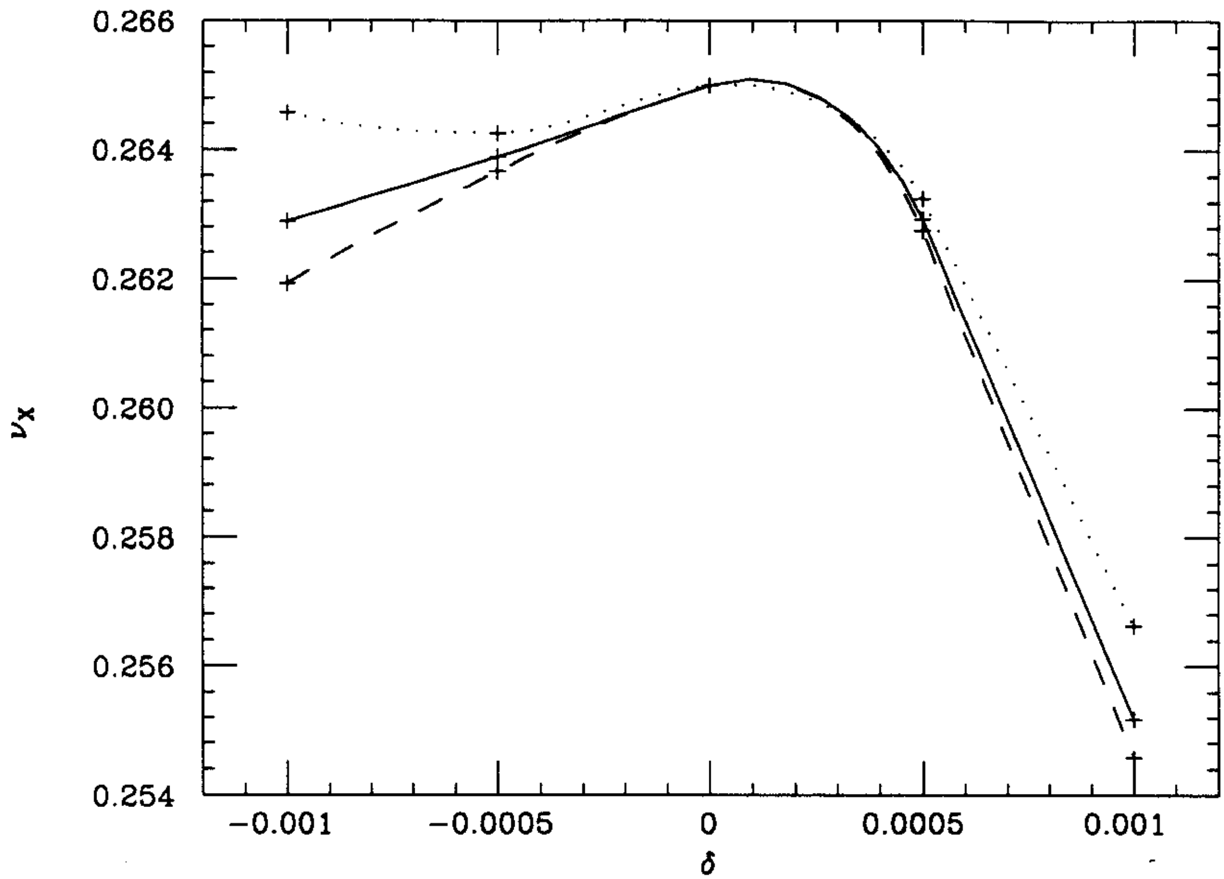

Figure 1. Half−meter, corrected.

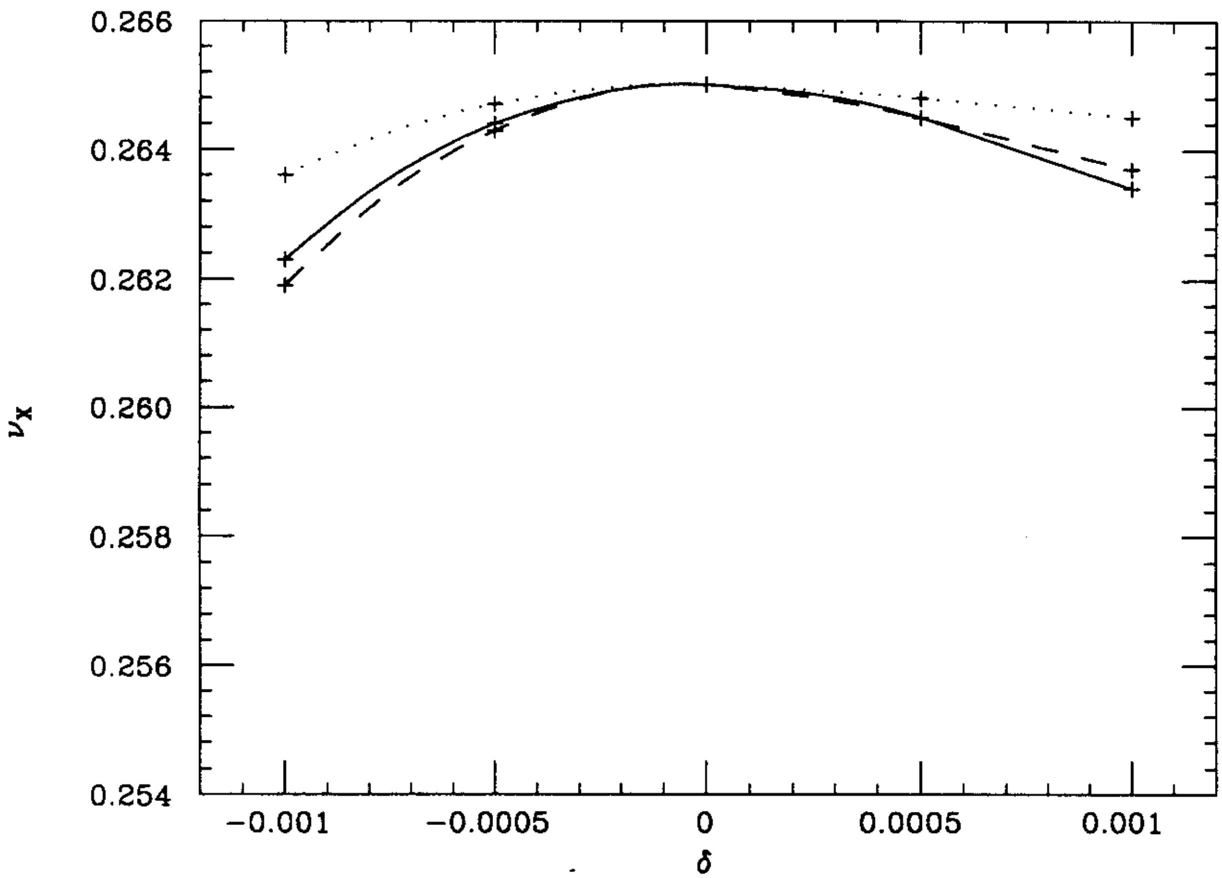

Figure 2. 1 meter, uncorrected.

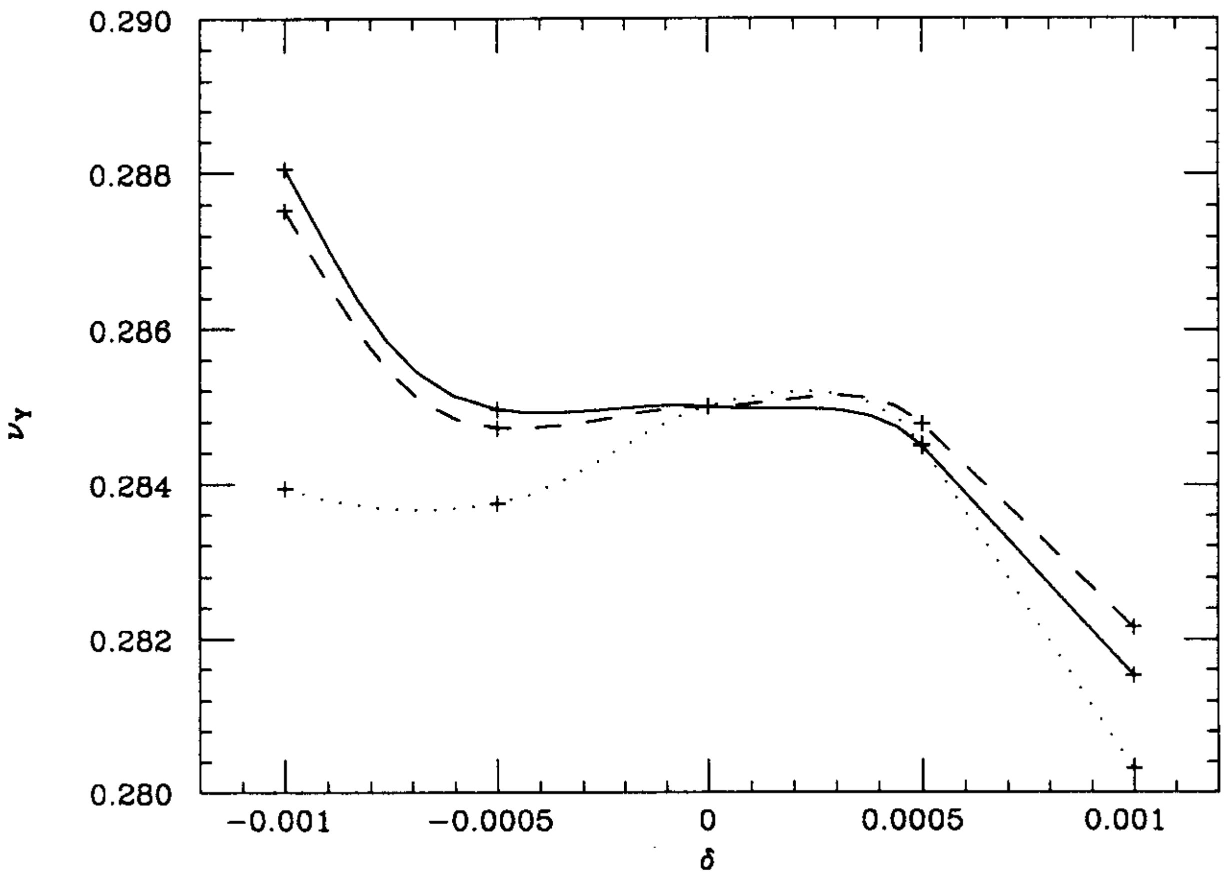

Figure 3. Half−meter, corrected.

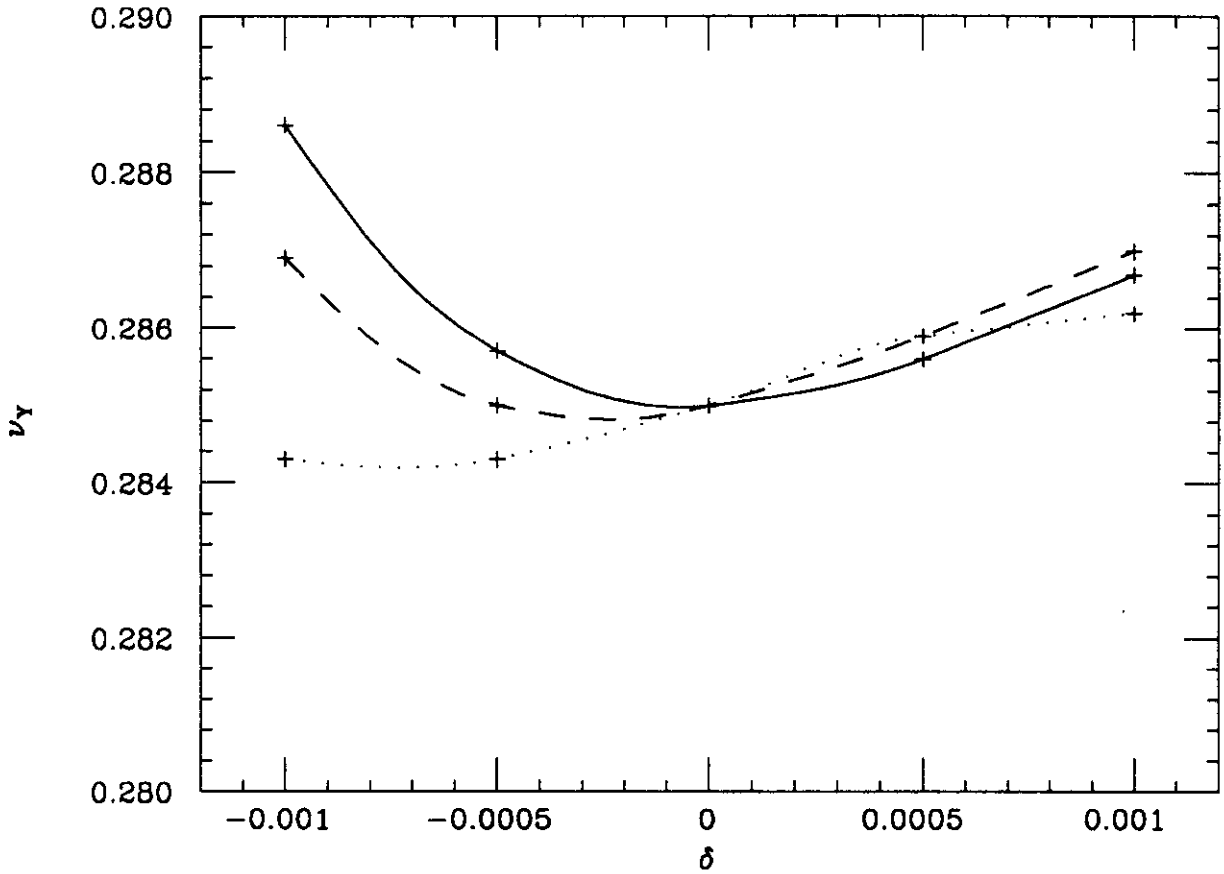

Figure 4. 1 meter, uncorrected

the $\beta^* = 0.5m$ lattice is zero at $\delta = 0.001$. From the smear criterion the linear aperture for the $\beta^* = 0.1m$ uncorrected lattice at $\delta = 0.001$ is $4.2 \pm 0.7mm$, and at $\delta = -0.001$ it is $3.8 \pm 0.5mm$.

A larger physical aperture is another advantage of $\beta^* = 1.0m$. For a crossing angle of $75\mu r$, the physical aperture of the machine in collision mode at $\widehat{\beta}$ in the arcs is limited by the triplet physical aperture to $2.6mm$ for $\beta^* = 0.5m$ and $3.7mm$ for $\beta^* = 1.0m$. When the crossing angle is increased to $150\mu r$, these apertures become $1.46mm$ and $2.06mm$, the first of which is smaller than the needed aperture. Thus the crossing angle could not be increased to $150\mu r$ for the $\beta^* = 0.5m$ machine in the CDR. If it were not necessary to correct the multipole errors in the triplet, absence of the correction package would increase the available physical aperture further. Increasing the coil diameter would increase the physical aperture and decrease the errors in the triplet, improving the linear and dynamic apertures. It is not clear whether the gradients required to produce a β^* of $0.5m$ could be achieved for, say, a $5cm$ coil diameter.

If β^* were increased to $1m$, the triplet correction package could probably be dispensed with, the physical aperture of the machine would increase, and its chromatic properties would be greatly improved. This may be overkill, however, and further simulations should be done to explore the region between $\beta^* = 0.5$ and $1m$, and the dependence on coil diameter. The beam crossing angle, which leads to an off-center trajectory through the triplet, should be included in the simulations. If the SSC in collision mode is to have non-zero off-momentum linear aperture and the ability to increase the crossing angle to $150\mu r$, some changes in the design are necessary, and the cost of increased beam current needs to be weighed against the increased apertures obtained by increasing β^*.

REFERENCES

1. L. Schachinger, "Dynamic and Linear Apertures of the SSC Clustered IR Test Lattice with Dipole Sorting," SSC-N-123, January 1986.

2. L. Schachinger and R. Talman, "TEAPOT. A Thin Element Accelerator Program for Optics and Tracking," SSC-52, December 1985.