Submitted to: Proceedings for Summer Study on the Physics of the Superconducting Supercollider, Snowmass, Colorado June 23-July 11, 1986

BNL--39047

DE87 004177

CONF-8606215--31

BNL-39047

THE ACCEPTANCE OF THE SSC CLUSTERED LATTICE*

G.F. Dell
Brookhaven National Laboratory, Upton, New York 11973

Random multipoles in the quadrupole triplets Q1-Q3 adjacent to the interaction regions limit the dynamic aperture of the SSC storage lattice to 2.5 mm. When all random multipoles in these triplets are assumed to be 90% corrected, the dynamic aperture increases to approximately 5 mm.[1] However due to the large beta functions in the Q1-Q3 triplets, dynamic apertures of 5 mm in the arc quadrupoles lose significance, since they imply amplitudes in the triplets that exceed their bores. In fact, the dynamic aperture of 2.5 mm obtained with no correction of the triplet multipoles corresponds to amplitudes in the triplets nearly equal to their inner bore. This consideration has led to the present study in which the physical apertures of all elements are included to determine whether correction of random multipole fields in the triplet quadrupoles is necessary when betatron amplitudes there are no more than the inner radius of the beam pipe of ≈ 16 mm.

Tracking has been performed with PATRICIA on the same five machines used to generate the results of Reference 1. In all cases $\sigma a_1 = \sigma b_1 = 0$ and $(\sigma a_n, \sigma b_n) \neq 0$ for $2 \leq n \leq m$ with m=5 for quadrupoles and m=10 for dipoles. Each σa_n and σb_n for every magnet was generated from a gaussian distribution that was truncated at $\pm 3\sigma_{n_o}$, where the σ_{n_o} are the rms values of the random multipoles listed in the CDR[2]. No systematic multipole fields due to magnets were included, but two families of sextupoles have been used to set the horizontal and vertical chromaticities to zero at $\Delta P/P = 0\%$.

During tracking the influence of random multipole fields was included as a kick given to the test particle at the center of each quadrupole and at both ends of every dipole. Prior to each kick, a test was made to determine whether or not the radial amplitude of the particle had exceeded the inner dimensions of the vacuum chamber. Test particles were launched with equal horizontal and vertical emittances. The initial emittance was gradually increased until the test particle hit the wall of the vacuum chamber before the specified number of turns had been completed.

For the first part of the study, the acceptance at $\Delta P/P = 0\%$ was determined when the degree of correction of the triplet multipoles was varied from 0 to 100%. For the second part of the study, the momentum dependence of the physical aperture was determined for zero and 90% correction. In all cases the determinations were made for five independent random multipole distributions (five different machines), and the average value and rms variation was evaluated. The aperture determinations were made at $\nu_x = 78.265$, $\nu_y = 78.283$ which is near one of the nine working points, $\nu_x = 78.265$, $\nu_y = 78.285$, considered in Reference 1.

The results of the first study--the degree of multipole correction needed at $\Delta P/P = 0\%$--are shown in Figure 1. The curve indicates that almost no increase in acceptance (physical aperture) is realized for corrections greater than 50%, and it even suggests that operation with no correction of the triplets might be possible.

The dependence of the acceptance on momentum is plotted on Figure 2 for 90% correction and for no correction of the triplets. The normalized emittance of the SSC beam is $\varepsilon_n(\text{rms area}/\pi) = 10^{-6}$ m radians[3], and the momentum spread is 0.0175% and 0.005% at injection and 20 TeV, respectively. At injection the beam σ in the arc quadrupoles is: $\sigma = (\sigma_x^2 + \sigma_y^2)^{1/2} = 0.65$ mm, and at $\Delta P/P = 0.02\%$, the results of Figure 2 indicate an acceptance of $\pm 3\sigma$ for the storage lattice when no correction is made in the Q1-Q3 triplets. The present results suggest that operation of the storage lattice gives an acceptance of at least $\pm 3\sigma$ at 1 TeV and $\pm 6\sigma$ at 4 TeV. Thus it seems that operation without correction of random multipoles in the triplets may be possible and that, if correction is necessary, no more than 50% is beneficial.

References

1). SSC Conceptual Design Report, SSC-SR-2020, March, 1986, pg. 158.
2). Conceptual Design Report, op. cit. pp. 127-128.
3). Parameter List, SSC Conceptual Design, SSC-SR-2020A, March, 1986, pg. 1

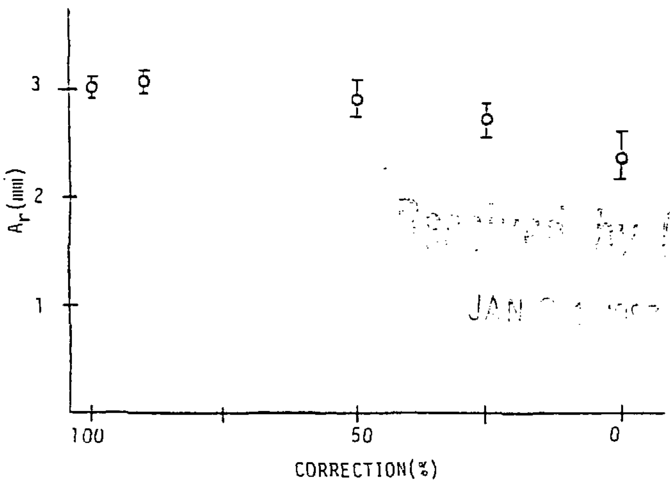

Figure 1. Dependence of the physical aperture $A_r = (\varepsilon(\beta_x + \beta_y))^{1/2}$ measured at the center of arc quadrupoles on the percentage correction of the random multipole fields in the Q1-Q3 triplets. Corrections of >50% produce little increase in acceptance.

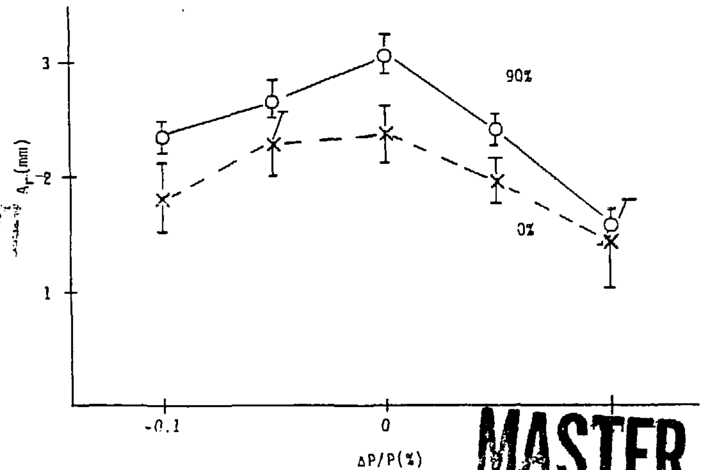

Figure 2. Momentum dependence of the physical aperture for 90% correction and for 0% correction of the random multipoles in the Q1-Q3 triplets. $A_r = (\varepsilon(\beta_x + \beta_y))^{1/2}$ is measured at the center of arc quadrupoles where $\beta_x = 330$ m and $\beta_y = 110$ m for focusing quadrupoles and $\beta_x = 110$ m and $\beta_y = 330$ m for defocusing quadrupoles at $\Delta P/P = 0\%$. All elements have 32 mm ID bore tubes.

*Work performed under auspices of the U.S. Department of Energy.

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