SINGLE PASS COLLIDER MEMO

SLAC-CN--237

DE84 012067

AUTHOR: J. J. Murray

DATE: 7/25/83

REPLACE

N#

TITLE: EFFECTS OF SUPERPOSITION OF DETECTOR SOLENOID AND FFS QUADRUPOLE FIELDS IN SLC AND CORRECTION METHODS

INTRODUCTION

For the so-called superconducting FFS option with $L^* = 2.2$ m, the MK2 solenoid does not overlap Q1, the FFS quad nearest the IP. For the permanent magnet option with $L^* = 0.75$ m, the MK2 solenoid would overlap both Q1 and Q2. In either case an 8 m long solenoid, contemplated for the SLD detector, would overlap both Q1 and Q2. The solenoid field cannot be shielded so in an overlap region one will have a superposition of solenoid and quadrupole fields.

Recently, Roger Erickson raised the question, "What are the optical consequences when the solenoid and quad fields are superimposed?" The question had not been considered before, but rough estimates suggested immediately that there might indeed be ugly consequences in terms of an enlargement of spot size at the IP.

The purpose of this note is to answer Roger's question quantitatively and to consider methods of correction of the "ugly consequences".

MODEL FOR SUPERPOSITION OF SOLENOIDS AND QUADRUPOLES

There is no straightforward way in TRANSPORT or TURTLE to superimpose solenoid and quad fields, so one needs a trick. We will assume square-ended solenoids which are treated exactly to second order in TRANSPORT and TURTLE. A quadrupole embedded in a solenoid will be represented approximately as a normal quad of length L , followed by a negative drift of length $-L$, followed by a solenoid of length L . The same elements in any order would do as well. That package is then subdivided into N similar packages which together span the length of the actual quad. Results of calculations are examined for convergence as a function of N and a value of N large enough to give the desired accuracy is used.

RESULTS OF CALCULATIONS FOR THE SUPERCONDUCTING FFS OPTION WITH AN 8 M LONG, 10 KG SOLENOID AT 50 GeV

In this case the solenoid overlaps Q1 and Q2 with its entrance just downstream of Q3. The beam line upstream of the solenoid is a representation of the remainder of the north arc with no misalignments or any other defect included. The beam has an emittance of $300\text{E}-10$ rad-cm in both planes and a gaussian momentum distribution with a standard deviation of 5 ppm truncated at 5 ppm. Calculations of the rms beam size, SG_x and SG_y , at the IP were made using TURTLE, second order. The ideal rms beam size at the IP, is 1.2 microns. With chromatic aberrations included, this grows to about 1.3 microns in both planes.

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

NOTICE

PORTIONS OF THIS REPORT ARE ILLEGIBLE. It has been reproduced from the best available copy to permit the broadest possible availability.

MASTER

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

Results for SGx and SGy as a function of $1/N$ are shown in Fig. 1. Both their values converge to about 3.5 microns for large N. This is more perturbation than one would normally expect to tolerate.

The spot size enlargement is a first order phenomenon so it might be wondered how phase space conservation comes about. By inspection of the TURILE outputs, Figs. 4-8, showing the correlations between various coordinates at the IP, it is evident that phase space conservation comes about through strong correlations of x, y' and y, x' .

POSSIBLE METHODS OF CORRECTION

How much can this perturbation be reduced by deliberate axial rotations of quads in the Q1,Q2,Q3 triplet? Fig. 2 shows SGx and SGy for $N = 8$ as a function of rotation of Q2. Both have minima of about 1.3 microns for a rotation of Q2 of about four hundredths of a degree. But it is probably not feasible to use rotations of Q1,Q2,Q3 as tuning parameters.

Suppose instead one regards the effects we have observed as simply consequences of the presence of unwanted cross-plane matrix elements in the transfer matrix between the entrance to the solenoid and the IP. It has been shown (Ref.1) that a suitable array of skew quads can be used to synthesize or compensate arbitrary cross-plane couplings.

An application of that technique has been considered here with an array of four skew quads, the first just upstream of Q3 and the other three each just downstream of Q4,Q5,Q6 respectively as sketched in Fig. 3. There is nothing very critical about such an array except that it must be interrupted by at least one erect quad for a perfect correction of an arbitrary perturbation to be possible.

It turns out there is a "perfect" solution with that array, perfect in the sense that all cross-plane matrix elements are reduced to zero and the spot size enlargement is eliminated. The maximum skew quad strength for that solution was about 200 gauss/cm. The only undesirable side effect was a slight defocussing which pulled the spot upstream about 1.5 mm in both planes, not enough to have a significant effect on spot size.

An approximate solution was also studied where with SQ1 only, one finds a compromise which almost eliminates the most damaging cross-plane matrix elements, R13,R14,R31 and R32. The strength of SQ1 in this case was only about 50 gauss/cm and the results were essentially indistinguishable from those with the perfect solution except that the defocussing effect was almost eliminated also.

Moreover, with such a skew quad array in the final transformer of the FFS, one can also make non-mechanical corrections for rotational misalignments in the critical quad triplet Q1,Q2,Q3.

Fig. 1 Spot size (rms) at IP versus $1/N$ where N is number of subdivisions of quad-solemoid packages. Solumoid is on.

Fig. 2 Spot size (rms) at IP versus axial rotation of Q2. Solumoid is on, $N = 8$.

Fig. 3 Schematic layout of the final transformer of the FF5 with
 a) 8 m long detector solenoid overlapping Q1 and Q2.
 Also shown is a four-skew-quad array for correcting
 the effects of the solenoid.