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MOMENTUM MATCHING IN ISA LONG INSERTIONS

A. Garren, R. Helm, M. Month
July 14, 1972

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INTERSECTING STORAGE ACCELERATOR NOTES

MOMENTUM MATCHING IN ISA LONG INSERTIONS

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Abstract

In the long insertion options of the ISABELLE lattice, the momentum dispersion functions are designed to be zero. Quadrupoles and bending magnets at the ends of the insertions are used for this purpose. However, this momentum matching is destroyed within the insertion if focusing and bending of the beam for experimental purposes become coupled. The momentum mismatch due to this coupling is described and some undesirable consequences are pointed out. The present ISABELLE options manifest this mismatch, and a modification that would solve the problem is proposed. Finally, some numerical results are given using the computer program SYNCH.

Introduction

The long experimental insertion geometries, Figs. IV-3, 4, 5, 6 of the BNL preliminary storage ring design¹, are not yet perfectly matched in momentum due to the bending and focusing that occurs between the momentum-matching sections at the ends of the insertions. In this note, we will explain how the mismatch arises, and list some undesirable consequences of the mismatch. We will then present one possible modification that would solve the matching problem. Finally we discuss the off-momentum orbit for the geometry of option 1 in Ref. 1 as obtained by a computer run using SYNCH.

Description of Problem

The momentum mismatch occurs in all of the long insertion configurations. We will limit the discussion to the High Luminosity Insertion I, Fig. IV-3 of the Gray Book¹, and Fig. 1 of this note. Referring to Fig. 1, and going from left to right, the beams are first brought to zero dispersion by the momentum-

1. 200 GeV Intersecting Storage Accelerators: ISABELLE, BNL 16716, May 1972.

matching section A-B. The beams are then brought together by the vertical bending magnets C-D. These bends produce a vertical displacement of the off momentum orbit, P, of 0.2 m at D. This orbit is focused by the triplets T and T' which will affect the vertical dispersion through the complete lattice.

In the horizontal plane the dispersion vector P has zero displacement at the entrance to the region E-F. If the triplet T were absent, P would again be zero horizontally in FF'. However, the triplets T and T' disturb P and cause a horizontal closed orbit distortion for off-momentum particles through the whole ring.

Effects of the Momentum Mismatch

1. Interaction Point

The vertical dispersion at the center of the insertion will decrease the luminosity. The horizontal dispersion increases the interaction length which increases the beam-beam tune shift.

2. Normal Lattice

The mismatch may lead to increased values of both the horizontal and vertical dispersion functions in the main lattice cells which may require extra aperture.

3. Among the non-linear consequences of momentum mismatch is the practical difficulty of removing chromaticity with sextupoles without exciting third order resonances. The complication arises because of the azimuthal variations of the off-momentum orbit.

A Possible Cure

Our proposed redesign of the Insertion diagramed in Fig. 1 that would remove the momentum mismatch is sketched in Fig. 2. The low β quadrupoles (triplets T and T') are now outside of the region of bending magnets, both vertical and horizontal, used to obtain beam crossing. In this configuration there will be a vertical dispersion $y_p = 0.2$ m at the interaction point. However, y_p is zero at T and T', so the insertion is matched to the rest of the lattice.

With this scheme a small crossing angle could be obtained in the horizontal plane by means of the horizontal magnets H1, H2, H2' and H1'. If a vertical crossing were preferred, it could be obtained by making V1 and V2 weaker than V1' and V2'.

We would like to point out another advantage of our proposed geometry. In the "Gray Book" geometry¹, Fig. 1, the beams cross at points D, D' as well as at E, and undesirable beam-beam interactions occur there. Furthermore, these crossings will add background. With the scheme of Fig. 2, there is only one crossing point.

Conclusions

We have pointed out some consequences of not matching the momentum dispersion functions of insertions to the main lattice. In general one may accomplish momentum matching by (1) bringing the dispersion functions to zero at the ends of the insertion, and (2) decoupling the focusing and bending in the remainder of the insertion. The focusing is required to obtain the desired betatron functions at interaction points and/or detection points. The bending is needed to obtain the appropriate geometry for crossing and detection. Decoupling will result if we insist that quadrupole magnets for focusing only be placed at points in the insertion where both dispersion functions are zero. This constraint is satisfied by our proposed redesign of the "Gray Book" Insertion I. The original and the redesigned insertions are given in Figs. 1 and 2, respectively.

As an exercise, we have computed, using the SYNCH computer program, the effect on the momentum dispersion functions of including bends in the insertion as in Fig. 1. The mismatch induces a horizontal dispersion in the interaction region of $-4 \text{ mm}/\% \frac{\Delta p}{p}$, while vertically, we have, $y_p = 0.4 \text{ mm}/\% \frac{\Delta p}{p}$. Since the insertions are not matched to the main lattice, the momentum dispersion functions vary from cell to cell, thus causing the aperture requirements to vary from cell to cell. This will result in a larger aperture needed when compared to the matched case. In our example, the horizontal aperture is increased by about $2 \text{ mm}/\% \frac{\Delta p}{p}$. Vertically, the dispersion is now non-zero, with a value of about $2 \text{ mm}/\% \frac{\Delta p}{p}$. Although these effects are relatively minor, it should be remembered that the magnitudes will vary from insertion to insertion and one cannot guarantee that in a different insertion the consequences will not be more serious. Furthermore, since sextupoles will be used to correct the high chromaticity characteristic of the ISABELLE lattice options¹, the mismatched dispersion functions cause a practical difficulty in powering the sextupole corrections. The choice is this: if we power the sextupoles inversely proportional to the dispersion functions, then the chromaticity will be properly corrected, but third integral resonances (imperfection type resonances) will be excited; while, if we power the sextupoles

in a reasonably combined manner, then nearby sextupole resonances can be avoided, but gradient stopbands (structure type resonances) will be enhanced.

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M. Goldhaber, L.J. Haworth, G.H. Vineyard

Fig. 1 Insertion I (Fig. IV-3 of Ref. 1, "Gray Book").

Fig. 2 Proposed Interaction Region Geometry.

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Fig. 2 Proposed Interaction Region Geometry.

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