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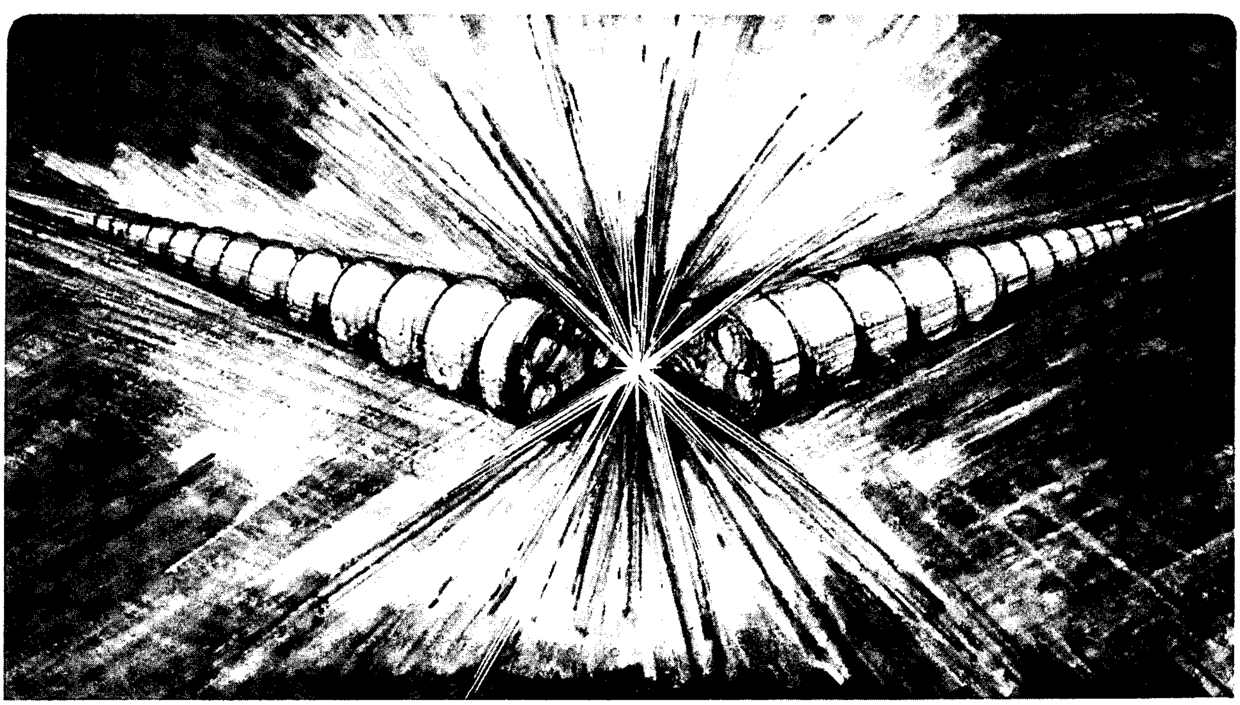

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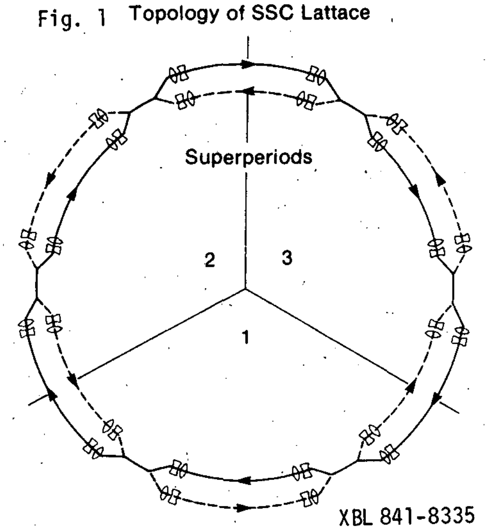
Summary

This note presents an example SSC collider lattice for 20 TeV proton beams using 6.5 Tesla double bore magnets, six collision points, and antisymmetric insertions.

Introduction

The lattice described is based on an earlier design using 8 Tesla dipoles[1]. The main differences are a reduction of the beam separation, higher quadrupole gradients in the interaction region quadrupoles to reduce their β-values, longer drift lengths in the insertions to facilitate injection and extraction, and an increase of the open space about the collision points. Another paper in these proceedings by B. Leemann[2] discusses injection and beam-abort extraction from this lattice.

Fig. 1 Topology of SSC Lattace



General Description

The collider consists of two concentric counter-rotating proton beams, horizontally separated by 12.7 cm, passing through 2-in-1 superconducting magnets with separate vacuum chambers and coils embedded in a single iron yoke. The beams collide at six equally spaced points at very small angles (see Fig. 1). The gradients are made equal on both beams in each quadrupole, which makes the focussing opposite. This is necessarily the case in the interaction regions, where both beams share single-bore quadrupoles (Fig. 2). Although several alternatives exist, we have chosen to give the focussing pattern on each beam mirror symmetry about the arc centers, and antisymmetry about the crossing points (see Fig. 3). This choice makes all insertions identical and minimizes the number of different quadrupole strengths. Since the inner and outer branches of an insertion have equal and opposite focussing, it suffices to match only one of them between the arc and the crossing point.

Arcs

The arcs of each sextant have mirror symmetry about their centers both in the magnet placement and in quadrupole and sextupole strength (see Fig. 3). Every half-arc consists of 43 cells, each 160 m long, with four dipoles per half-cell (see Fig. 4).

The first 34 cells, starting from the arc center, are normal FODO cells, each containing one SF and one SD sextupole, of strength sufficient to correct the chromaticity of these cells alone.

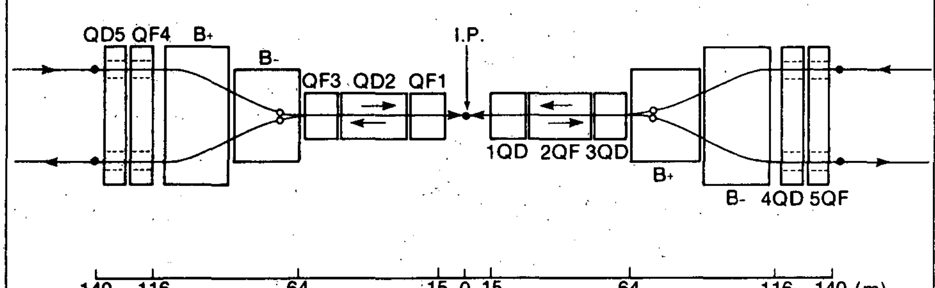


Fig. 2 Interaction Region Geometry

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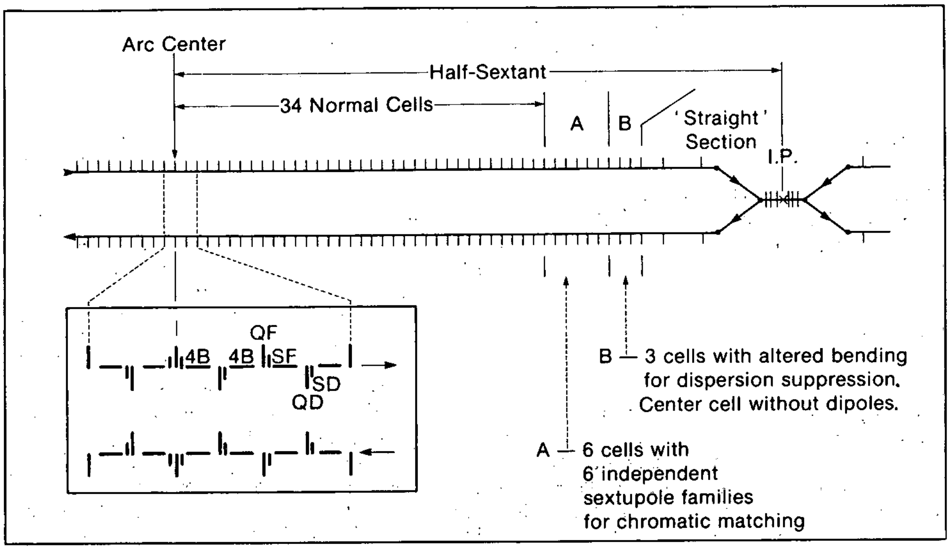

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Fig. 3 Schematic of half sextant

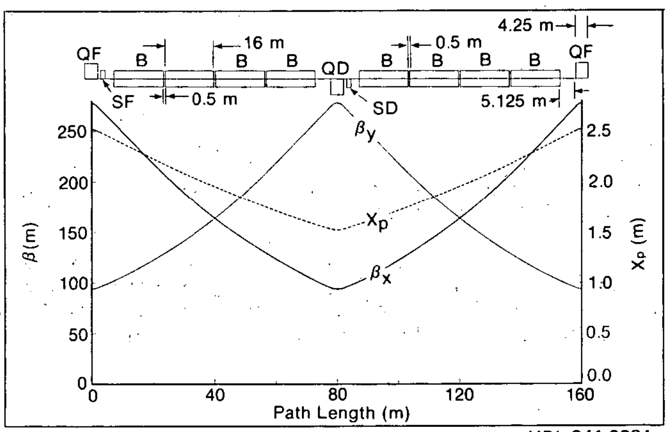

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Fig. 4 Normal cell

Following the normal cells are six cells which serve to compensate the chromatic effects of the insertions. This scheme, invented by T. L. Collins[4], is an extension to second order of the linear matching of long straight sections, which he invented previously. An essential feature of this scheme is that the special sextupole cells occupy an integral number of betatron wave lengths, and that the sextupole strengths have a $\sin(2\phi)$ dependence on the betatron phase ϕ which causes the geometric aberrations to be largely suppressed. This scheme gives excellent chromatic properties. Over the range $|\Delta p/p| \leq 0.004$, the tunes vary by 0.035 with the Collins scheme as compared to 0.27 with two sextupole families, and the beta function values at the crossings and in the nearby quadrupoles vary by 10% compared to 540%! The remaining tune variation can be compensated with weak octupoles. Tracking studies will be carried out in the near future to confirm that the dynamic aperture is also good, as expected.

The last three cells of the arc comprise the dispersion suppressor. These cells contain no sextupoles other than those that may be needed to compensate sextupole fields in the dipoles.

Dispersion Matching

The focussing antisymmetry causes a complication in dispersion matching, since one requires a dispersion suppression section at the ends of the insertion that simultaneously brings the dispersion to zero on the two oppositely focussed beams. R. Helm discusses this problem in another paper of these proceedings, and exhibits solutions for various betatron cell phase advances μ.[3] We have chosen $\mu = 60^\circ$ partly because the dispersion suppressor then can be made simply by removing all dipoles from the next to last cell of the arc. The resulting open spaces with normal β-values may be useful for RF cavities. An additional adjustment to compensate for the effects of the beam splitting dipoles in the interaction regions consists of shifting the dipoles longitudinally in the first and third cells from the end of the arc.

Straight Sections

The dispersion suppresor cells are followed by the 'straight' part of the insertion that contains the interaction point (I.P.). (The "straight" sections include the beam-splitting dipoles, but there is no net bending). Fifteen meters of open space is provided on each side of the I.P. for the detectors. The straight section also includes 305 m and 186 m drift spaces to be used for the beam-abort and injection systems. They might also serve for RF cavities in place of the 76 m straights in the center dispersion suppressor cell.

Orbit Functions and Parameters

The lattice and orbit functions of the cells and of the outer and inner half-insertions are shown in Figs. 4, 5, and 6 respectively. For the beam going from left to right, the outer half is the left side, the inner half the right. All of the lattice design calculations were done using the SYNCH program[5].

Fig. 5 Insertion—Left Outer Half

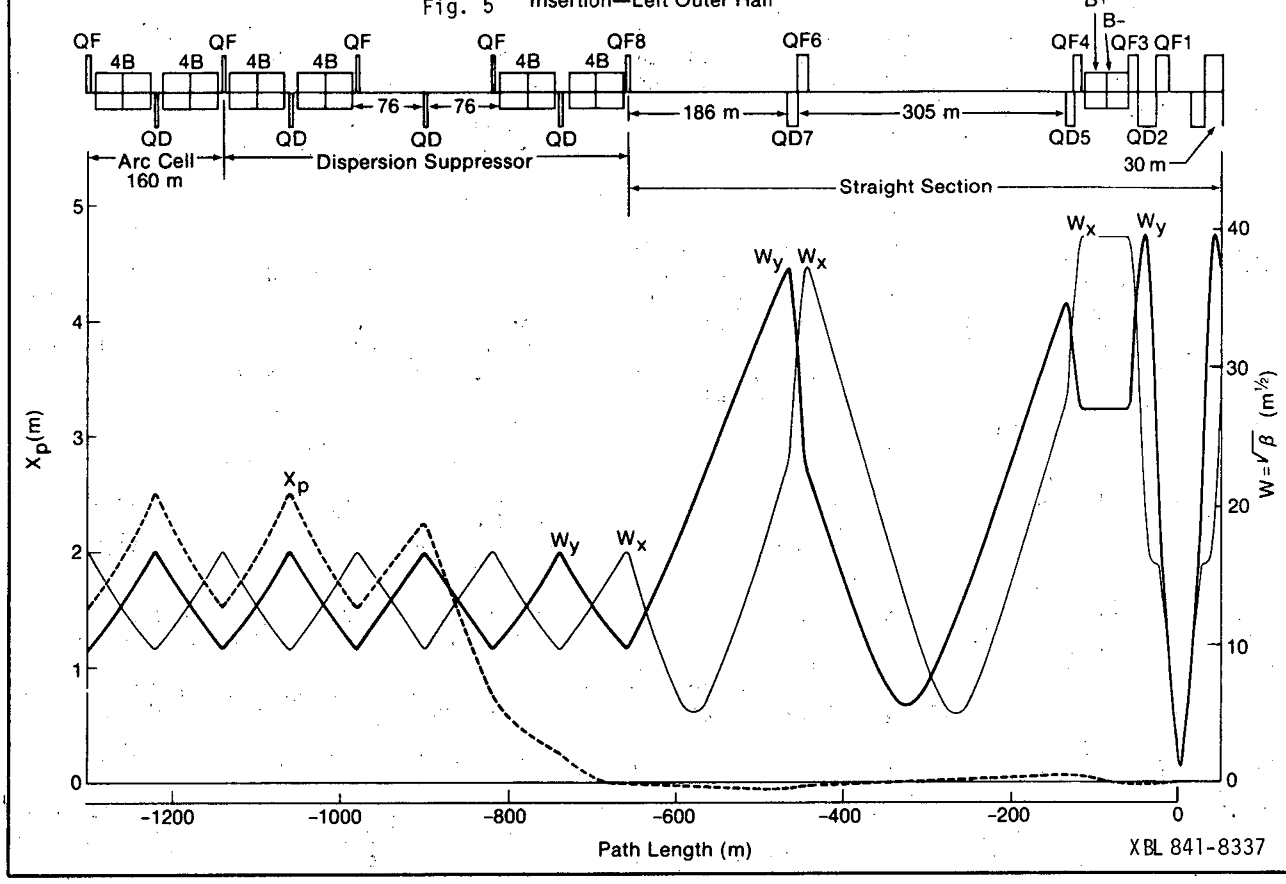
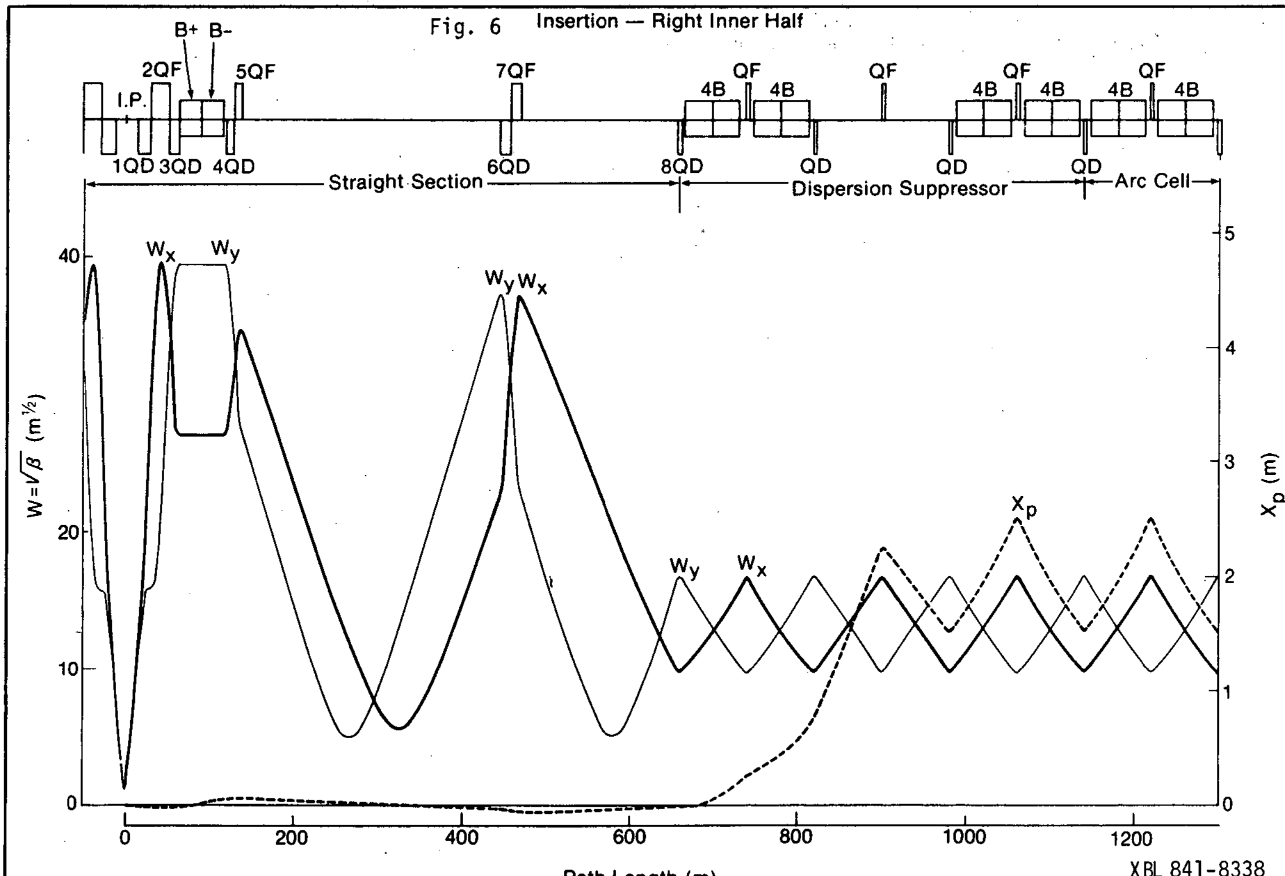


Fig. 6 Insertion — Right Inner Half



The principal parameters of the lattice are shown in Table I. The design was made for β*-values at the crossings of 2 m. Lower or higher values can be obtained using relatively small gradient changes. The limiting low β-value will be constrained by the chromatic effects.

Table I

Peak energy	E	20	TeV
Magnetic field	B_O	6.498	T
Gradient in cells	G	199.2	T/m
Gradient in I.R.	G_{IR}	250.2	T/m
Magnetic radius	ρ	10.27	km
Circumference	2πR	90.48	km
Average radius	R	14.40	km
No. of superperiods	N_{SP}	3	
No. of collision points	N_{IR}	6	
Number cells/arc	N_{CA}	86	
Cell phase advance/2π	μ	0.1661	
Lengths (no./half-cell)			
Half-cell	L_C	80	m
Dipole (4)	L_B	16	m
Quadrupole (1)	L_Q	4.25	m
Corrector space (2)	OO	4.125	m
Dipole Separation (3)	O	0.5	m
I.R. drift length	L_{int}	± 15	m
Beam separation	w	0.1266	m
Tunes (H/V)	ν-97	.241/.231	
Chromaticity	ξ	-170	
Bunch separation	ℓ_{sep}	15	m
Crossing angle	α	50-120	μrad
Orbit functions:			

	Quadrupoles	Dipoles	I.P.	Maxima	
β_x	276	255	1.999	1548	m
β_y	276	255	1.996	1550	m
x_p	2.50	2.40	0.000	2.508	m

Conclusions

An example SSC lattice has been designed which shows promise of meeting the technical requirements. Further optimization and refinements will be done for the final design, but it is hoped that this lattice will serve as a useful vehicle for designing sub-systems, for cost estimates, and as a step in the evolution of the best machine possible for the purpose.

Acknowledgements

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3) Note on Reversible Dispersion Matching, Richard H. Helm, these proceedings.

4) Thomas L. Collins, Private Communication.

5) "SYNCH, A Computer System for Synchrotron Design and Orbit Analysis", A.A. Garren, A.S. Kenney, and J.W. Eusebio, LBL Internal Report UCID-10153 (1965).

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