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Design Considerations and Modeling Results for ILC Damping Ring Wigglers Based on the CESR-c Superconducting Wiggler

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Abstract

The ILC damping rings will require construction of wiggler magnets of high field quality on an unprecedented scale. We consider various designs derived from the wigglers presently in operation at the Cornell Electron Storage Ring. Design optimization has been performed based on detailed tracking calculations of dynamic aperture and tune footprint in a full model of the damping ring. Results on finite-element modelling, transfer functions, and the accuracy of analytic models of the wiggler field will be discussed.

INTRODUCTION

The ILC needs damping rings. CESR-c is relevant.

WIGGLER DESIGN OPTIMIZATION

The conversion of the CESR storage ring in 2001 from investigations of bottom quark bound states to charm quark bound states necessitated the design, construction and implementation of superconducting wiggler magnets to restore the damping lost by lowering the beam energy from 5 to 2 GeV. [1, 3] In additions, an analytic model of the wiggler field was developed to allow fast tracking in models used for designing the damping-dominated lattice. [2] This background served as a starting point for the development of a design for ILC damping ring wigglers. Recently, further optimization of the design in view of reducing construction cost while maintaining operational specifications was performed.[4, 5, 6] A full 3D model using the OPERA magnetostatics package from Vector Fields [7] has now been developed, as shown in Fig. 1.

Salient characteristics of this new design include twelve poles of 16-cm length and 23.8 cm width, a vertical gap of 8.64 cm, 660-turn main coils carrying 93 kA to provide a peak field of 1.95 T (see Fig. 2).

The 3/4- and 1/2-pole-length tapering in the end poles has been maintained as in the CESR design. The stringent tolerance on horizontal field rolloff originally motivated by the CESR pretzel orbits was relaxed, allowing the omission of field-shaping pole face cutouts. The resulting horizontal rolloff of the vertical field component in a central pole is shown in Fig. 3. The width of the end-pole main coils has

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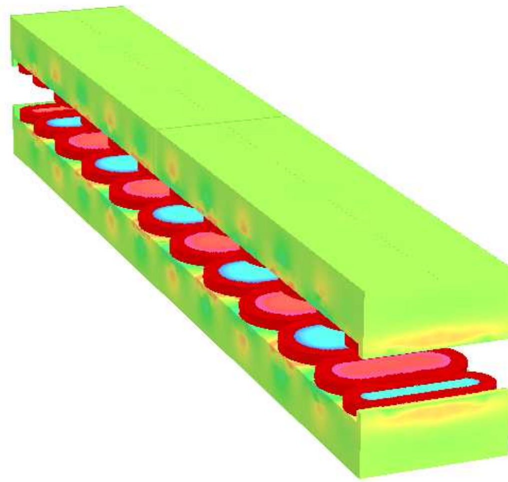

Figure 1: 12-pole optimized damping ring wiggler. The color scale on the surface of the model shows the magnitude of the vertical magnetic field component.

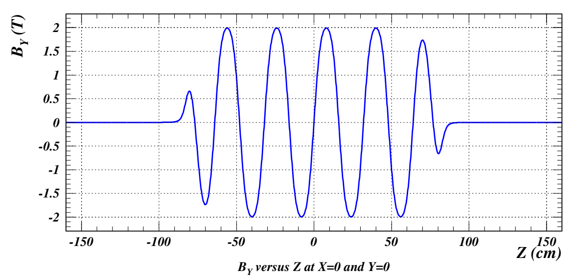

Figure 2: On-axis vertical field component

been tuned to 1.54 cm comprising 398 turns, the same density as in the main pole coils, largely cancelling the second field integral and reducing the residual horizontal orbit displacement for 5 GeV electrons incident on axis to less than 20 μm, as shown in Figs. 4 and 5. Trim coils of 1 cm width comprising 710 turns, which is the density of the CESR trim coils, are included in the design, the trim current being set to zero for the field results described here. As in the CESR-c design, energizing these coils in series with a single power supply results in correcting the second integral of the field, and therefore the orbit offset, rather than the angle kick. This horizontal orbit oscillation and the alternating longitudinal field field component result in a vertically focusing effect. Figure 6 shows the corresponding transfer function for 5 GeV electrons of perpendicular incidence in

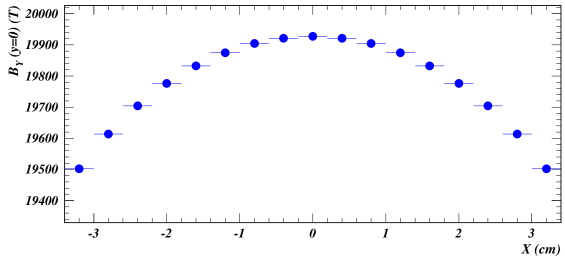

Figure 3: Dependence of the vertical field component on the transverse coordinate in the horizontal midplane for a central pole

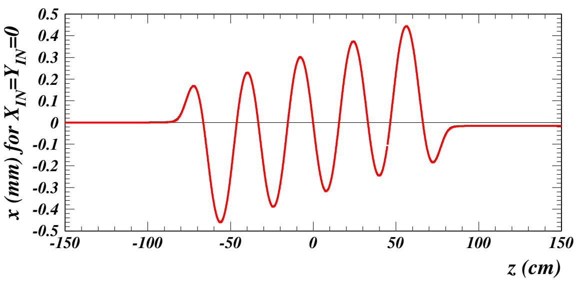

Figure 4: Trajectory in the horizontal plane for 5 GeV electrons of perpendicular incidence on the symmetry axis of the wiggler.

the vertical symmetry plane.

ENGINEERING CONSIDERATIONS

Construction costs reduced.

CONCLUSIONS

Design/modeling continues. An analytic model will be produced as for the CESR-c [2], allowing fast symplectic tracking.

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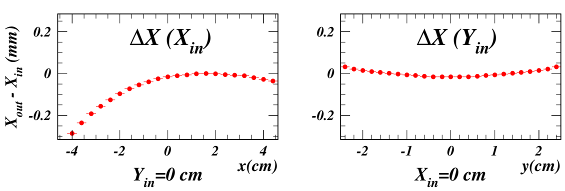

Figure 5: Horizontal orbit displacement at the exit of the optimized wiggler for 5 GeV electrons of perpendicular incidence on the horizontal and vertical planes of symmetry as a function of the horizontal and vertical entrance positions.

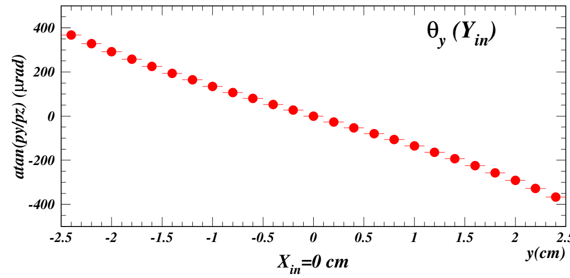

Figure 6: Vertical orbit angular kick at the exit of the optimized wiggler for 5 GeV electrons of perpendicular incidence in the vertical plane of symmetry as a function of the vertical entrance position.

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