A Detector Integrated Dipole for the Silicon Detector at the International Linear Collider

R. P. Smith, R. H. Wands
FNAL, Batavia, IL 60510, USA

A Detector Integrated Dipole (DID) has been considered for the Silicon Detector (SiD) of the International Linear Collider(ILC). In an earlier paper a preconceptual design study for a 5 Tesla superconducting solenoid was made for SiD. This paper extends the work to include the addition of a dipole coil system integrated with the solenoid for compensation of finite crossing angles of the ILC beams.

1. INTRODUCTION

In an earlier paper[1] we developed a preconceptual design for a 5 Tesla superconducting solenoid for SiD[2]. In this follow-on, we integrate a dipole coil with the solenoid to provide a Detector Integrated Dipole[3] (DID) for SiD. Beam particles entering SiD at a finite horizontal crossing angle will deviate in the vertical plane. This deviation can be corrected by a special dipole field at the intersection region. The DID corrector can also be used to compensate for rotation of the beam polarization or beam size growth due to synchrotron radiation. For maximum efficiency this special field can be provided by saddle coils mounted on the outer support cylinder of the SiD solenoid.

2. ADDING A DETECTOR INTEGRATED DIPOLE TO SID

Locating the DID coils on the solenoid outer support cylinder offers an ideal environment for them. There is minimal solenoidal field in that region, a slight increase in the size of the solenoid cryostat readily provides for the dipole coils, and the large winding radius of the dipole coils ensures a high quality dipole field on the beam axis with modest attention to the dipole winding geometry. Extending the ANSYS model developed for the solenoid, we find approximately 550 kA-turns are required for the desired ~ 600 G dipole field from each of the coils. In Fig. 1 is seen the DID coil geometry superimposed on the solenoid coil:

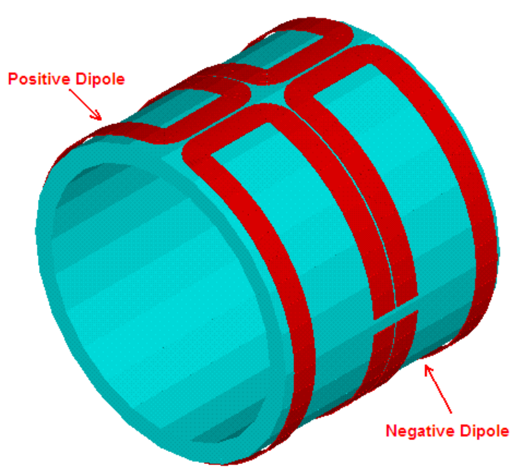

Fig. 1 Detector-Integrated-Dipole Saddles

A DID coil could be wound with a single layer saddle-shaped pancake composed of ~110 turns of conductor operating at ~ 5000 amperes. The conductor could be a small superconducting cable stabilized with high purity aluminum of overall cross section 15 x 15 mm. The field provided by the DID coils is seen in Fig. 2:

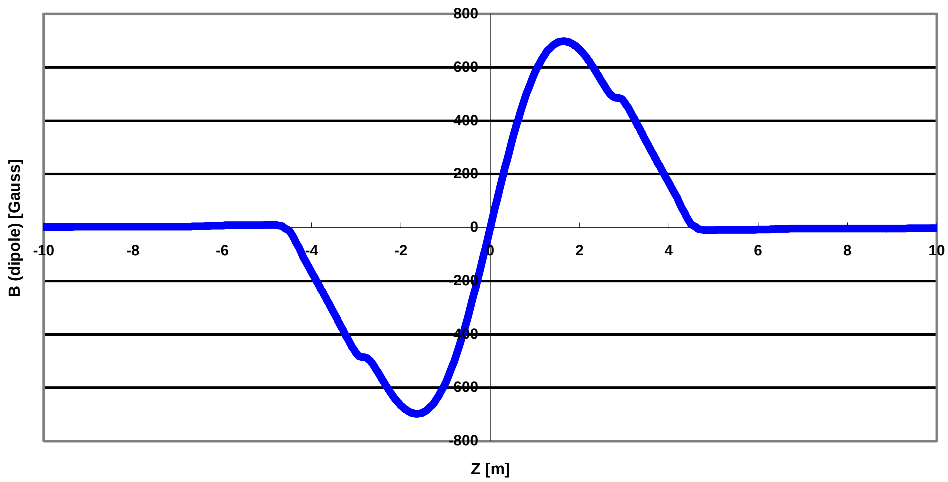

Fig. 2. The DID field on the colliding beam axis. The small deviations at |Z| ~ 2.8 m align with the upstream edges of the muon steel in the endcaps of SiD.

The DID coils couple modestly to the solenoid and some attention must be given to their mutual behavior during upsets. The forces on the DID coils are also modest as seen in Fig. 3 and the required support should be relatively straightforward to engineer into the details of the solenoid outer support cylinder.

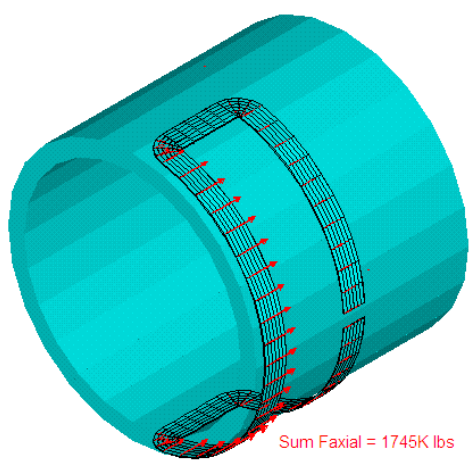

Fig. 3 Axial forces on the DID coil

The axial forces on each saddle coil sum to 1745 K lbs and relatively small bosses on the solenoid support cylinder placed in shear stress would provide adequate support. A similar plot of radial loads on a saddle coil shows they sum to 435 K lbs but they are generated principally on the segment of the saddle next to the adjoining saddle where the radial forces are in the opposite direction.

3. CONCLUSIONS

Preconceptual design work for a Detector Integrated Dipole, added to that of the SiD solenoid itself, indicates that engineering such a system is not likely to be unduly difficult, nor costly to fabricate. Effort must be expended to understand the quench safety of the dipole coils, but given the highly intimate thermal relationship between the dipole saddles and the solenoid outer support cylinder, it is not anticipated that the coils will be difficult to protect in the event of an unexpected upset of the solenoid. Likewise, given the understood safe quench discharge of the solenoid, an unexpected discharge of the dipole coils is not likely to compromise the safety of the solenoid.

We conclude that the designs for the solenoid and DID can continue to evolve to identify the optimum final conductor and winding design choices, even as the design of balance of the detector, especially the muon system, continues to evolve.

Acknowledgements

This work was supported under Department of Energy contract DE-AC02-76CH03000.

References

[1] R. P. Smith, et al., “A 5 Tesla Solenoid for SiD”, 2005 International Linear Collider Workshop, Stanford, CA, USA, March, 2005

[2] J. E. Brau, M. Breidenbach, Y. Fujii, “The Silicon Detector (SiD) and Linear Collider Detector R&D in Asia and North America”, Amsterdam ECFA/DESY Study April 2003, DESY-PROC-2004-01, DESY-04-123G, March 2004.

[3] B. Parker, A. Seryi, “Compensation of the Effects of Detector Solenoid on the Vertical Beam Orbit in NLC”, LCC-0143, SLAC-TN-04-044, BNL-MDN-637-40, June 3, 2004.