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# CORRECTION MAGNET WITH PERMANENT MAGNETS

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## INTRODUCTION

ILC Damping Ring (DR) has been designed by the well-established experiences on the past and coming ring accelerators. Although the cost of DR accelerator is about 4 % of total in the Technical Design Report (TDR) and the impact of cost reduction for DR by new technology is limited, there may be a room to discuss, for example, permanent magnet for main and correction dipoles. Some studies on PM dipoles as the dipoles have been reported.

Among these magnets, correction magnets are investigated because they need to generate both polarities of magnetic fields. This can be realized by rotating permanent magnet rods. The number of correction magnets in the current ring design is 304. When magnets are excited by permanent magnets, there is no DC power supplies, no cooling water, and then these failures will never happen. This also eliminates thick power cables and their wiring in addition to the electricity saving. Water leaks would be annoying events among maintenance activities, which would also be dramatically reduced if permanent magnets were applied. While motor controllers for the magnet rotors may have failures, the unit with a failed controller still keeps its orbit correction function, but looses only the adjustability. The structure and the field adjustment scheme of a trial conceptual design are discussed.

## SCHEME FOR BIPOLAR ADJUSTMENT

The bipolar adjustability of magnetic field can be realized by rotation of magnets (see Fig. 1). Assumed outer diameter of abeampipe is 60 mm. Fig. 2 shows the proposed structure for the bipolar correction magnet, where four magnet rods located at four corners of a rectangle are rotated each other by a stepping motor to vary the magnetic field distribution (see Fig. 3). Since the required magnetic field is not high, economical ferrite magnet is used as a magnet material. The vertical field component changes its distribution and the longitudinally integrated value (BL product) changes its polarity (see Fig. 4), while symmetry of the system eliminates the longitudinal component.

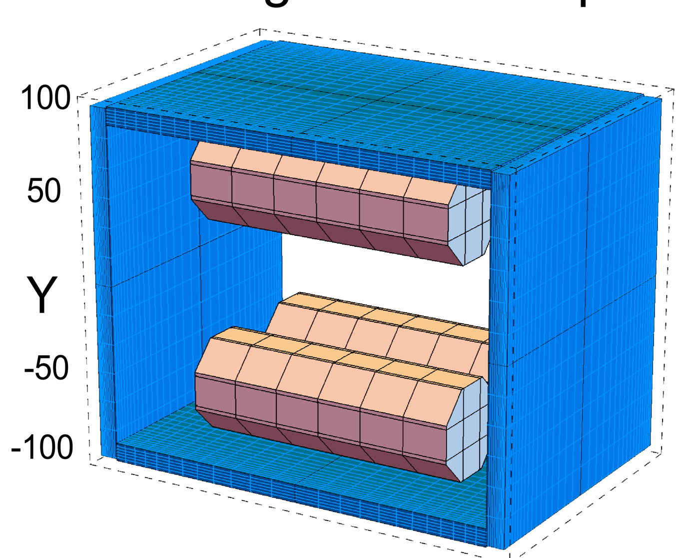



Fig.1: Bipolar adjustment scheme.

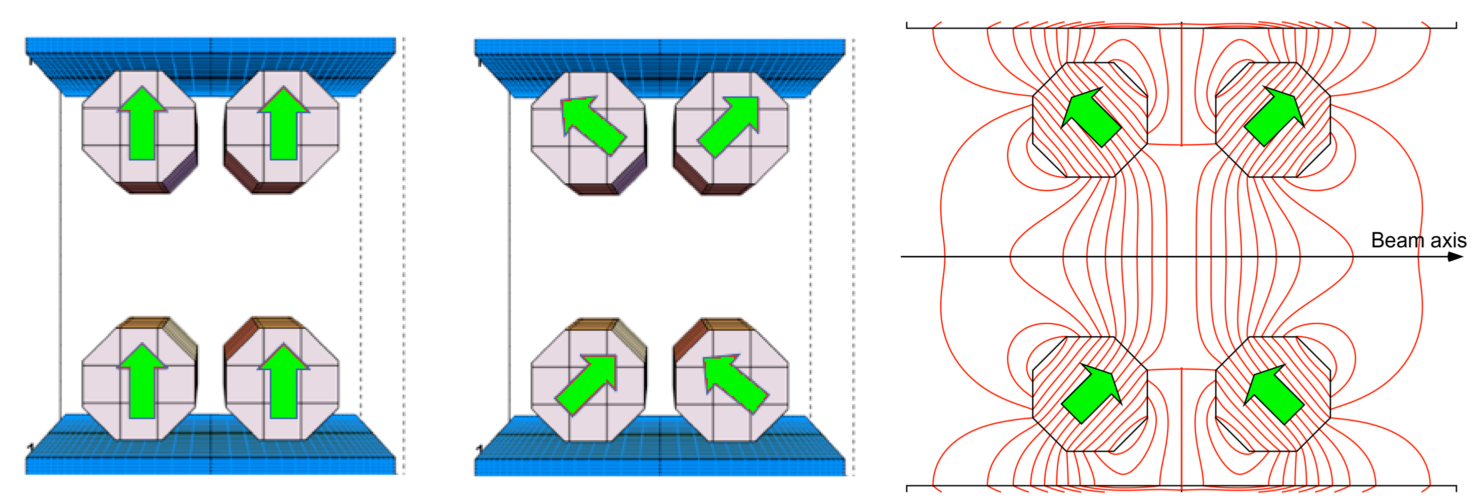



Fig. 2: Cross section of the magnet. Green arrows show easy axes.

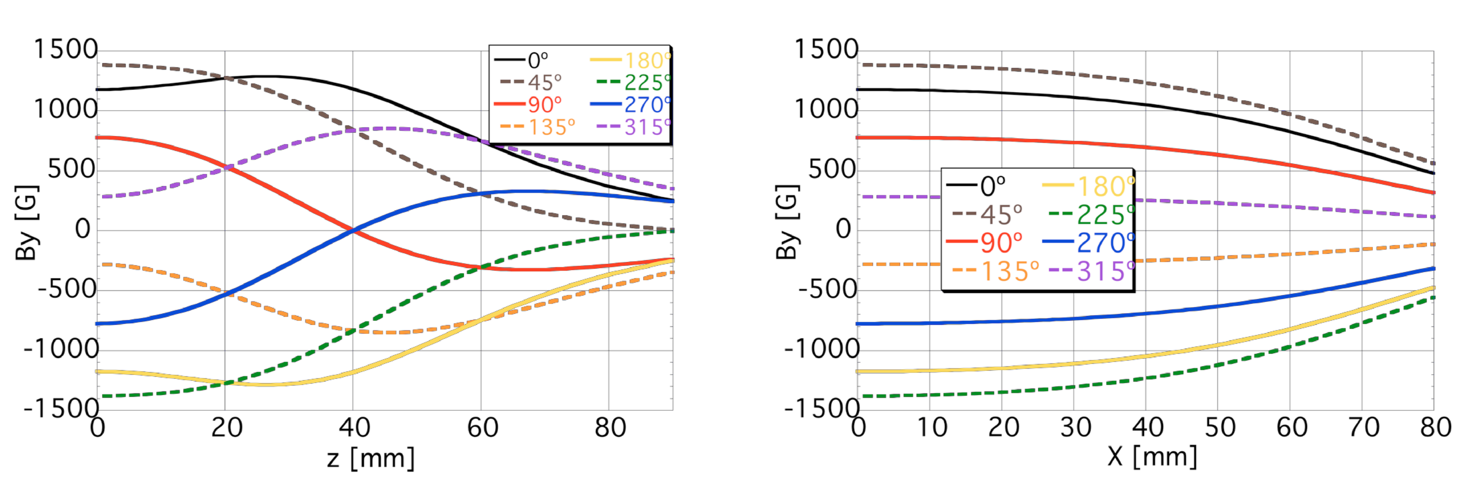



Fig. 3: Field distribution along beam axis and transverse direction.

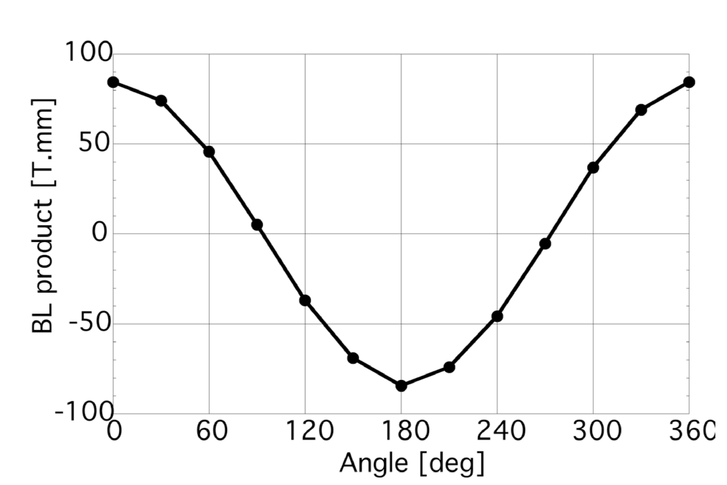



Fig. 4: BL product as a function of rotor angle

## BIPOLAR CORRECTION MAGNET

Because of the finite length of the magnet rod, the magnetic field falls down towards both edges, which corresponds to the sextupole component. The sextupole component in the integrated magnetic field can be compensated by reducing diameters of central parts of magnet rods (see Fig. 5) . Fig. 6 show a contour plot of integrated sextupole component as a function of waist length Lin and rotor angle θ. While the sextupole component oscillates with the rotation angle, the amplitude can be minimized by setting Lin 75.5 mm (see Fig. 7). The multipole components are shown in Fig. 8 as functions of rotor angle. The sextupole component is well suppressed within the ILD-TDR specification. Because the return flux goes through the side yoke, multiple 4-rotor units can be repeatedly used for wider adjustability ranges. A possible practical design is shown in Fig. 9.

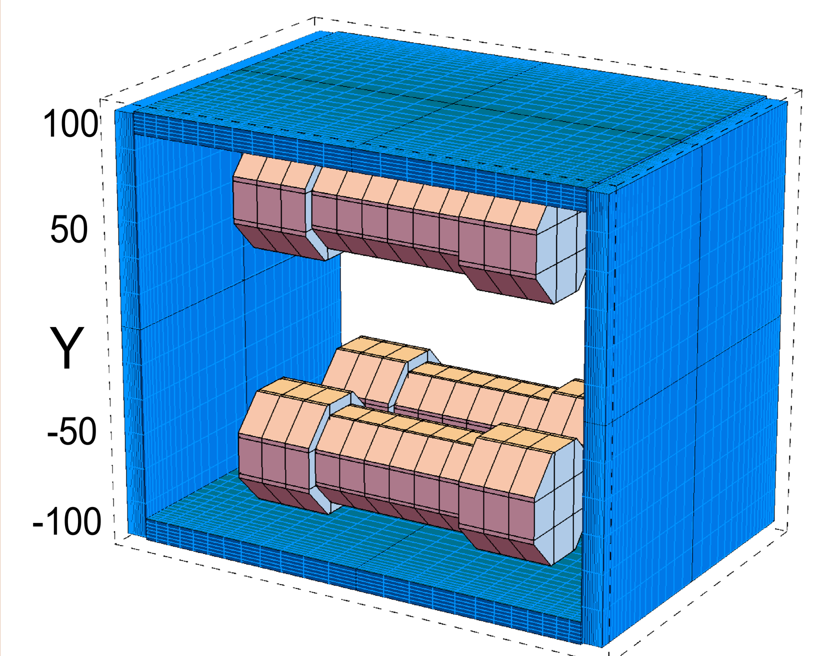



Fig. 5: Modified simulation model.

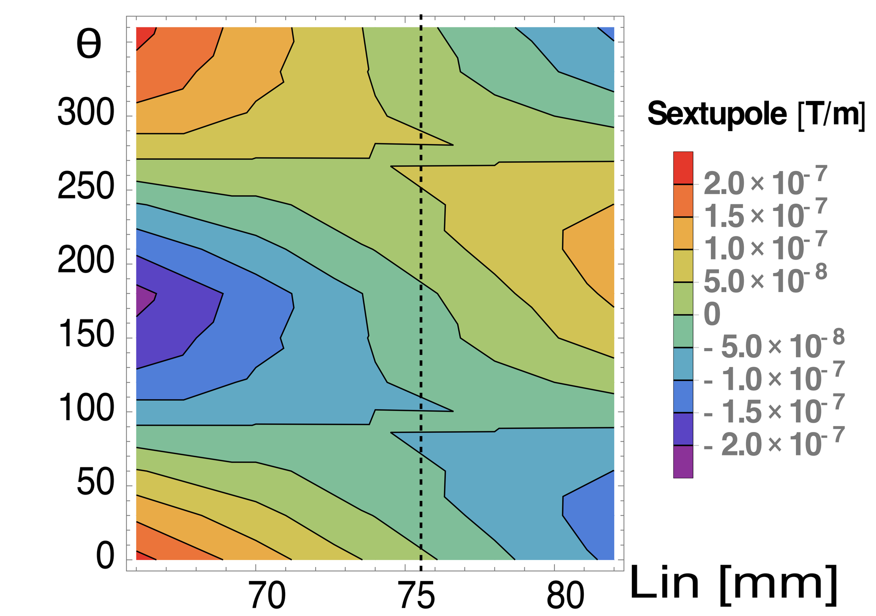
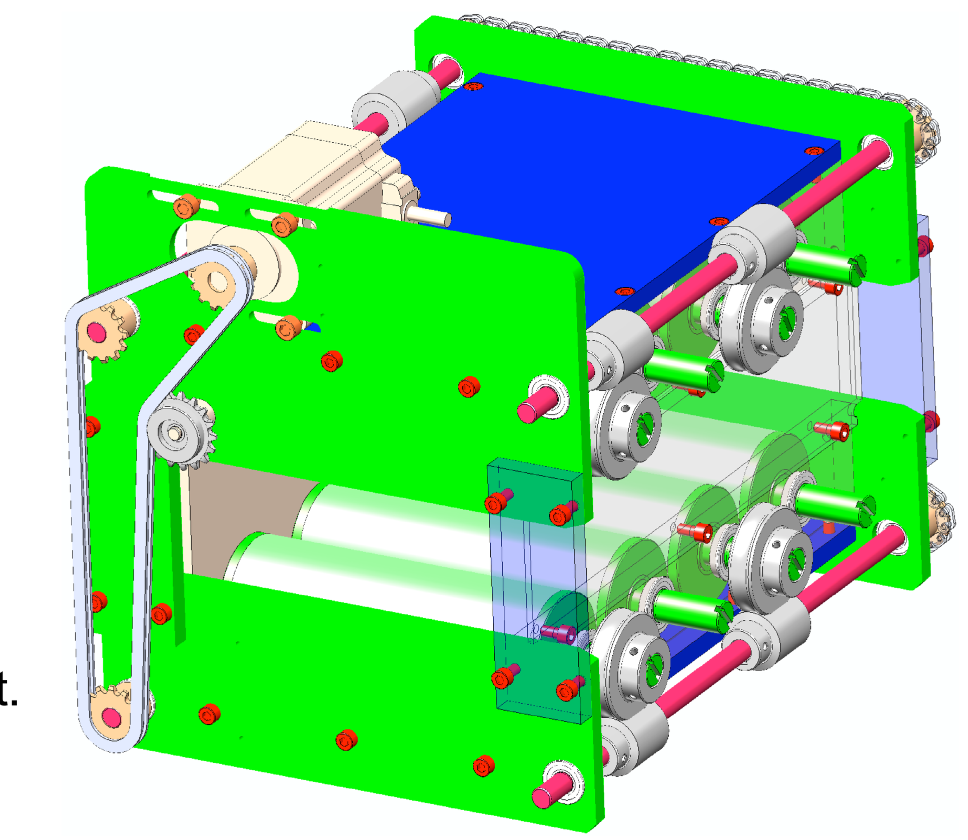



Fig. 6: Contour plot of sextupole component.



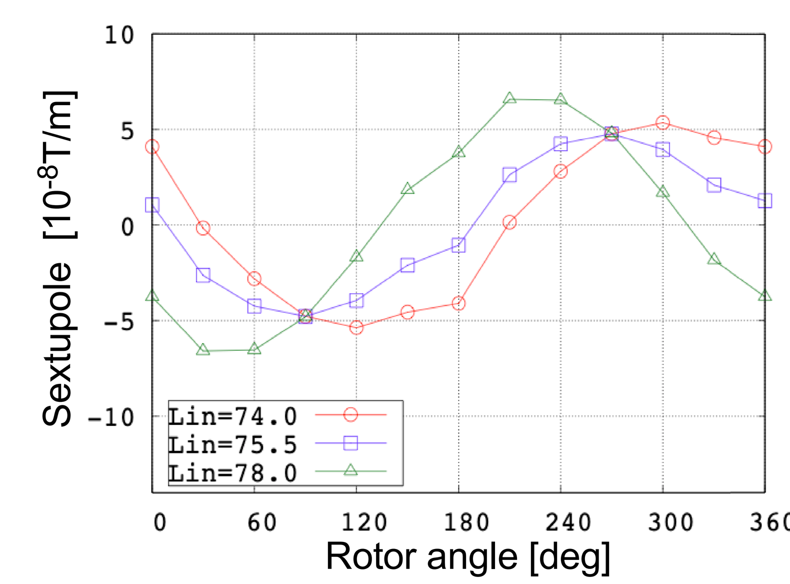



Fig. 7: Sextupole component as functions of rotor angle

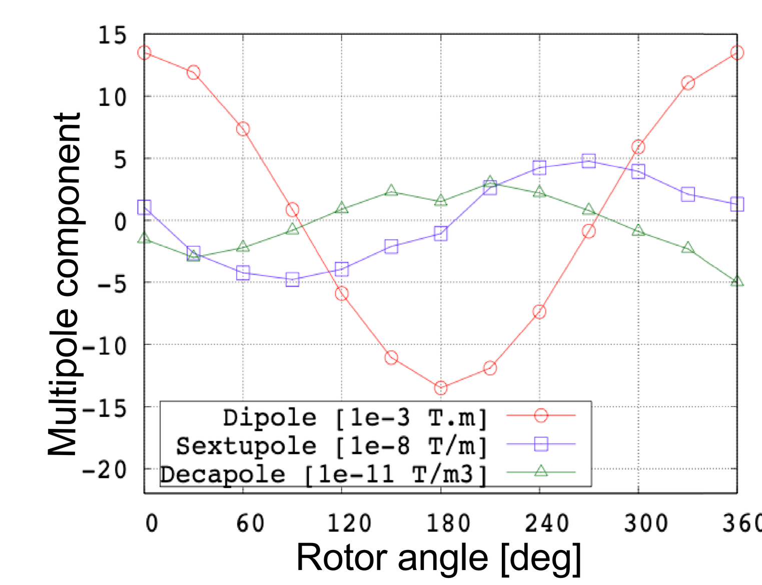



Fig. 8: Multipole components after optimization.

Fig. 9: Possible practical design for the double unit configuration. The pulse motor drives four shafts, which drive the rotors. One of the magnet side could be opened without mechanical disassembly of the rotors for conveniences of installation to beamlines. More units can be lined up according to each strength requirement.

## Summary

Permanent magnet can be considered as the magnets for ILC damping ring. It has a possibility to reduce the fabrication cost in addition to the operation and maintenance cost. A conceptual design of the correction magnet is proposed using less expensive ferrite magnet compared with strong rare earth magnets. Magnetic field adjustability for correction magnet can be realized by rotation of magnet rods, which vary the magnetic field distribution. Temperature dependence of the magnet material can be cancelled by a shunt circuit with special magnetic material and/or the adjustability function. Since there is not much information on demagnetization caused by radiation of ferrite magnets, studies on the issue are under investigation.