Performance of Bipolar Correction Magnet with Permanent Magnets

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Abstract

A prototype bipolar correction magnet with permanent magnets, which is realized by rotatable permanent magnet rods, was fabricated and magnetic field measurements were performed. Based on the evaluation, improvement on the magnet structure is under study. The new design will be discussed here.

Basic Parameters for Bipolar Correction Magnet in the ILC damping ring

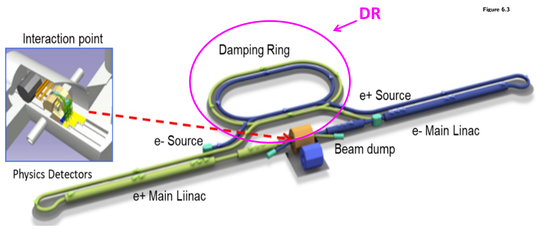


Figure E.1: ILC schematic figure of ILC250 accelerator overview.

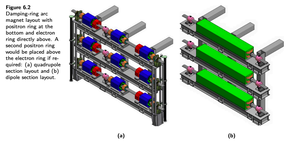


Figure 6.2 Damping-ring arc magnet layout with positron-ring at the bottom and electron ring directly above. A second positron ring would be placed above the electron ring if required. (a) quadrupole section layout and (b) dipole section layout.

From : Recommendations on ILC Project Implementation High Energy Accelerator Research Organization (KEK) October 1, 2019.

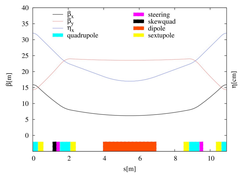
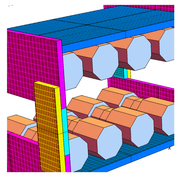


TABLE 2.4-2
Magnet types and counts for a single ILC Damping Ring using the OCS6 lattice. These counts do not include injection and extraction line magnets nor magnets, kickers, and septa associated with the damping ring abort beam dump. Wiggler magnets are superconducting, all others are room-temperature.

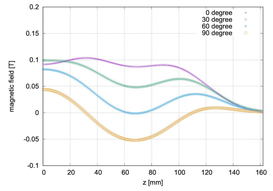
Type	Max KL	L [m]	Max field error	# of types
Dipoles	0.0524	6 ; 3	2×10^{-4}	2
Quadrupoles	0.31 m^{-1}	0.3	2×10^{-4}	4
Sextupoles	0.24 m^{-2}	0.25	2×10^{-3}	1
H correctors	0.002	0.25	5×10^{-3}	1
V correctors	0.002	0.25	5×10^{-3}	1
Skew quads	0.03 m^{-1}	0.25	3×10^{-3}	1
Wigglers	–	2.5	3×10^{-3}	1

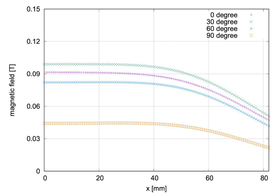
Type	Number	Power Method
Dipoles (6 m)	114	6 strings, 1 per arc
Dipoles (3 m)	12	6 strings, 1 per arc
Quadrupoles	747	Individual
Sextupoles	504	Individual
Horizontal correctors	150	Individual
Vertical correctors	150	Individual
Skew quadrupoles	240	Individual
Wigglers	80	Individual
Kickers	64	Individual
Septa	4	Individual

Design of bipolar correction magnet



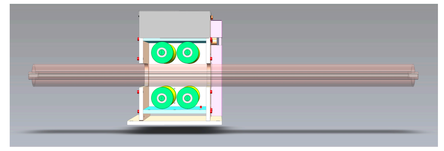
- Rotate the rotor to adjust the strength of the magnetic field.
- A design was formulated using a total of eight octagonal prism ferrite magnets, four on the top and four on the bottom.
- The shape of the ferrite magnet used has been optimized in order to suppress the multi-pole component.

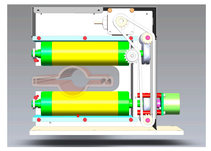


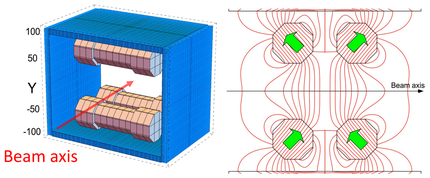


From : PASJ2019 THPH038 Proceedings

Prototype Design



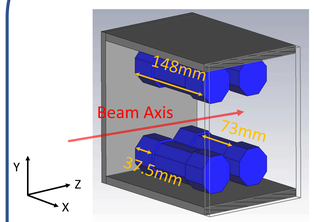


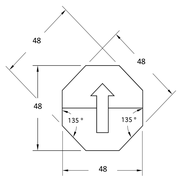


- Designed and manufactured a prototype PM correction magnet that uses a total of four octagonal prism ferrite magnets, two on the top and two on the bottom, as a prototype for principle verification.

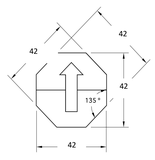
From : MT26 Tue-Mo-Po2.08-08 Poster

Magnetic field calculation



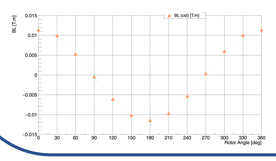


L = 37.5 mm

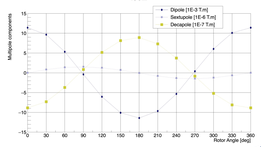


L = 73 mm

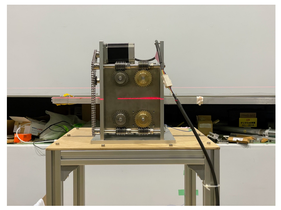
Calculation result of integrated magnetic field for each rotor angle



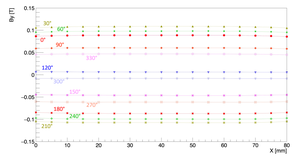
Calculation result of integrated multipolar magnetic field component for each rotor angle



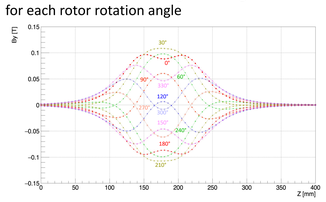
Magnetic field Measurement



Measurement result of magnetic field strength for each rotor rotation angle

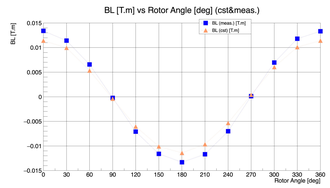


Measurement result of integrated magnetic field strength for each rotor rotation angle

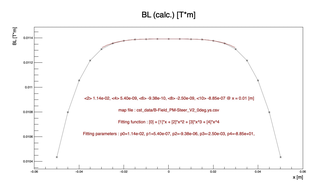


Comparison of Measurement results and Calculation results

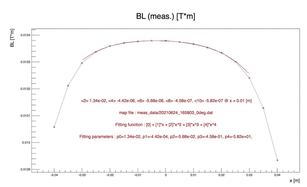
Comparison of integrated magnetic fields for each rotor rotation angle



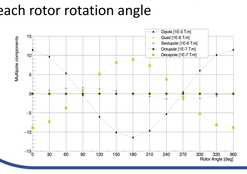
Calculation result of integrated magnetic field in the horizontal direction



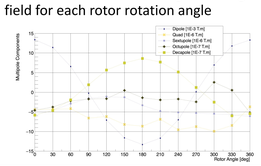
Measurement result of integrated magnetic field in the horizontal direction



Calculation result of integrated magnetic field for each rotor rotation angle

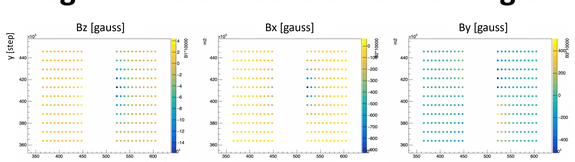


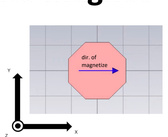
Measurement result of integrated magnetic field for each rotor rotation angle



- Derivation of multi-pole components by fitting with a fourth-order polynomial to the integrated magnetic field.
- The symmetry breaking can be seen from the magnitude of the even-order magnetic field components.
- It is presumed that there was an error in the magnet installation accuracy / assembly accuracy.

Magnetic field measurement of single ferrite magnet

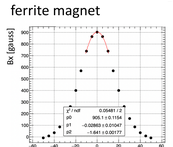




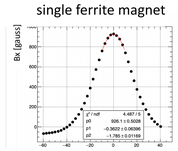
- Magnetic field measurement was performed with a ferrite magnet alone.
- One rotor consists of two types of ferrite magnets.
- Check the direction and strength of magnetization.

Comparison of measurement results and calculation results for a single ferrite magnet

Calculation result of a single ferrite magnet



Measurement result of a single ferrite magnet



- The magnetic field calculation result and the measurement result were compared.
- The magnetic field strength is consistent with the calculated results within a maximum of 6%.
- The direction of magnetization in the horizontal plane coincides with the expected direction within 11 mrad.

Summary

- PM correction magnet prototype was manufactured and magnetic field measurement was carried out.
- It was confirmed that the polarity reversal required for the correction magnet was realized.
- The integrated magnetic field was calculated from the measurement results of the PM-corrected magnet prototype, and a magnetic field performance evaluation method was established to derive the multipolar components contained in the integrated magnetic field.
- The second prototype with improved evaluation accuracy of residual magnetization of octagonal prism ferrite magnet and assembly accuracy of magnet is underway.