Project name

Ring-tuned, permanent magnet-based Halbach quadrupole

Classification (accelerator)

Accelerator

Institution(s) and personnel

University of California, Los Angeles, Department of Physics and Astronomy:
James B. RosenzweigJames Rosenzweig (professor), Gerard Andonian (graduate student)

Fermi National Accelerator Laboratory:
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Project Overview

Significant operational cost savings may be obtained by use of permanent magnet quadrupoles in main accelerators of a linear collider (LC). Promising work has been performed at Fermilab in designing and fabricating permanent magnet-based quadrupoles at FNAL. Needed tunability of quadrupole gradient was demonstrated in prototypes while simultaneously holiding the magnetic center constant to less than 10 microns, as required for suppression of emittance growth in the LC linac.

This work has not progressed to investigate one of the more promising designs, the ring-tuned Halbach (patent number 4,549,155) quadrupole. Fermilab has already procured the permanent magnets for a prototype of such a design, and performed a full mechanical design. It is proposed that UCLA complete the fabrication of the prototype, utilizing the leverage that the departmentally-subsidized, expert machine shop offers. Further, UCLA will develop a three-dimensional computer model of the Halbach quadrupole using the code RADIA. This effort will aid in understanding tuning systematics, and finite-length effects. Testing of the quadrupole will be initially performed at UCLA, and completed at the Fermilab magnet testing laboratory. A combination of prototyping, testing and computational analysis will allow us to optimize the Halbach quadruple for LC linac focusing use.

This project is synergistic with the present UCLA program in ultra-high strength, compact permanent magnet quadrupole development. These powerful quads are employed in plasma acceleration and Thomson scattering experiments. The Halbach design is not only tunable, but also could produce very strong gradients when scaled to small bores. Development of an ultra-high strength version of this quad for potential use in the LC final focus will also be studied at UCLA.

Description of first year project activities

In the first year, the FNAL design for the Halbach quadrupole prototype will be fabricated at UCLA. FNAL will provide final drawing, magnetic pole pieces, and precision tuning bearings. UCLA will be responsible for the machined components (iron, and non-magnetic supports). The prototype will be assembled, tested and initially tuned in the UCLA magnet lab, using Hall probe maps. It will then be sent to Fermilab for further analysis in the FNAL and SLAC magnet test facilities. These tests will employ stretched wire and rotating coil techniques, and will allow precision study of magnetic center stability while the quadrupole is tuned.

UCLA presently uses RADIA to make three-dimensional computational models of permanent magnet quadrupoles and undulators that are needed in the beam physics program. UCLA will construct a 3-D RADIA model of the Halbach quadrupole, to allow comparison with the gathered data. The benchmarking of the RADIA model will then give a tool for optimization of the design, and extending it to higher gradient versions.

Budget

Institution	Item	Cost
UCLA	Machinist time	$11,000
UCLA	Stock for fabrication	$4,500
UCLA	One-half year support for graduate student	$16,500
UCLA	Indirect costs	$4,950
UCLA	UCLA total	$36,950
FNAL	FNAL total[1]	$0
	Grand total	$36,950

[1] FNAL is providing already procured material worth over $7k to this project.