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DESIGN, CONSTRUCTION, and FIELD MAPPING of the HISTRAP PROTOTYPE DIPOLE

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Abstract

HISTRAP is a proposed 2.67 T-m synchrotron-cooler-storage ring having eight 45°, C-design dipole magnets. A prototype dipole has been designed, fabricated, and mapped. The magnet design utilizes curved and angled coil ends to compensate for end effects in the field. Construction of the prototype dipole has been completed by the FNAL magnet factory. The magnetic field has been mapped using a Hall-effect probe affixed to a newly constructed, PC-based, horizontal positioning system. Results of the field mapping are presented.

Introduction

HISTRAP, Heavy Ion Storage Ring for Atomic Physics, is a proposed synchrotron-cooler-storage ring optimized for advanced atomic physics research[1]. The ring is 46.8 m in circumference and has a maximum magnetic rigidity of 2.67 T-m. In addition to the prototype dipole magnet discussed here, a prototype RF cavity[2] and a vacuum test stand[3] have been built and tested. The most critical aspect of HISTRAP is a laminated pulsed magnet system consisting of 8 dipoles, 12 quadrupoles, 16 sextupoles, and numerous corrector elements positioned around the ring as shown in Fig. 1.

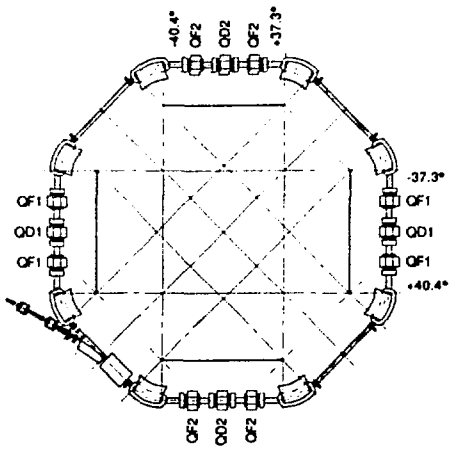

Figure 1: The HISTRAP Lattice

The dipoles require special consideration for several reasons: 1) Their short path length, 131 cm, results in a 3-D geometry with complicated end effects; 2) a large gap, 7 cm, is needed to contain bake-out insulation necessitated by ultra-high vacuum requirements; 3) the radius of curvature is small, 1.67 m, producing a large sagitta which mandates a curved geometry; 4) they must exhibit good field quality from 0.06 to 1.6 T with a 12 cm good field width; and 5) they must be C-shaped to permit merged laser beam studies. To address these concerns, a prototype dipole has been designed, fabricated, and measured.

Dipole Design

The eight dipoles are conventional, laminated, C-design magnets. Each weighs 12.25 tons including coils, has a 123 cm long yoke, a 12.8-cm sagitta, and parallel ends giving 22.5° beam entrance and exit angles. Lamination cross-sections are 110 cm high by 101 cm wide and the shims and Rogowski roll-off are essentially scaled from the FNAL designed and measured Loma Linda synchrotron dipoles[4]. The Rogowski end cuts also follow standard FNAL practice. Figure 2 shows relative deviations from a pure dipole field as a function of horizontal distance from the central trajectory as calculated by the 3-D magnet code TOSCA.

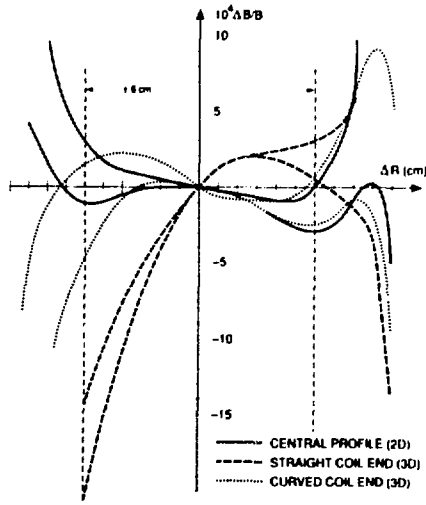

Figure 2: Calculated Field Profiles

The upper curve of each type in Fig. 2 is the result at 0.8 T and the corresponding lower curve is the high-field result at 1.6 T. The solid curves are the field profiles in the center of the dipole, excluding end effects, and are identical to results from the 2-D magnet code POISSON. The permeability drop at high field causes the two curves to separate by about 4 x 10^{-4} at ±6 cm, the horizontal good-field requirement. Equal inside and outside shims give a small quadrupole component to the field profile. The dashed and dotted curves show calculated 3-D TOSCA results, including end effects, obtained by integrating along the ion trajectories through the dipole. The dashed curves show the integrated profiles with straight coil ends parallel to the yoke end. The end effects are large and produce appreciable quadrupole and sextupole components. These components were significantly reduced by curving and angling the coil ends, as shown in Fig. 3.

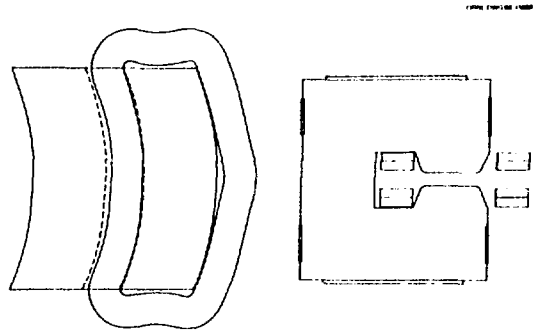

Figure 3: Curved and Angled Coil Ends

The angle of the coil end with respect to the yoke adjusts the integrated quadrupole component, and the

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