The Use of Helicd Dipole Magnets in the RHIC Spin Project

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ABSTRACT

Superconducting helical dipole magnets will be used in RHIC to maintain polarization and to perform localized spin rotations at the two major experimental detector regions. Requirements for the helical dipole system are discussed, and the status of magnet prototypes is reported.

The Relativistic Heavy Ion Collider (RHIC) at Brookhaven National Laboratory allows for the unique possibility of colliding high energy polarized proton beams. To maintain polarization during the acceleration process, two full “Siberian Snakes” are to be inserted on opposite sides of the RHIC lattice for each of the two counter-rotating rings. In addition, other magnetic components – spin rotators – will be located on each side of the two major interaction points (again, for each ring) which allow the spin orientation to be altered from the vertical direction to the longitudinal direction. Superconducting magnets are used in order to contain the magnetic elements for a Snake within a 10 m longitudinal space so as to fit within available room in the RHIC lattice. The use of helical dipole fields to produce spin rotations in RHIC was first suggested by Ptitsin and Shatunov.\textsuperscript{[1]} Four right-handed helical dipole magnets, each 2.4 m long and operating near 4 T or less can produce a Siberian Snake. The strong helical fields also reduce the orbit excursions produced by these devices. Furthermore, a combination of right-handed and left-handed helical dipole magnets also within a 10 m space can perform the desired local 90° rotations of the spin at the major detector regions.

Helical Magnet System

The original proposal of Ptitsin and Shatunov has been refined over the past two years. The Snake helical dipoles are all 360° right-handed helices whose fields begin pointed vertically upward or downward. The “Rotator” magnets are either left-handed or right-handed, but each begins with its field pointed in the horizontal plane. The field strengths of the Snake magnets are essentially constant during the acceleration process, while the appropriate fields in the Rotator magnets are beam energy dependent. Table I shows Rotator fields for 250 GeV proton operation. The maximum orbit deviations listed are for an injection energy of 25 GeV.

\begin{table}
\centering
\begin{tabular}{|c|c|}
\hline
Energy (GeV) & Field (T) \\
\hline
25 & 0.3
\hline
250 & 1.0
\hline
\end{tabular}
\caption{Rotator Field Strengths for 250 GeV Proton Operation}
\end{table}
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mized in order to keep the heat leak due to the power leads as small as possible. Thus, the magnets will have hundreds of turns of superconducting cable as opposed to a smaller number of turns, posing a technical challenge to the construction of these high-field magnets. At present, two possible techniques for producing helical coils are being investigated. (See Fig. 1.) The first method consists of an ordered wound cable placed into a helical groove which is cut into an aluminum cylinder. Thin sheets of epoxy-impregnated fiberglass are placed between layers of cable, and the entire assembly is cured to produce a firm wire matrix. A first prototype coil using this technique has been built and tested at BNL, and a second full field, half length magnet is now being built. Meanwhile, a parallel strategy is being studied, in which the cable is bonded directly onto a stainless steel cylinder, the cable being wound into a helical pattern using a computer controlled multiple-axis winding machine. A full field, half length prototype of this “direct wind” method has been completed by AML, Inc., in Palm Bay, Florida, under contract with BNL and should be ready for testing by November, 1996. *Work performed under the auspices of D.O.E.


