Effect of a Dipole Error on the Performance of the Alternating Solenoid Lattice

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1 Introduction

It has been suggested that the alternating solenoid lattice is extremely sensitive to small error fields [1]. An example was given where a 0.25 mr angular tip of one solenoid coil at the beginning of the second cell completely wiped out the 6-D cooling of the 25 m long, 15 T lattice. If this were true, it would be extremely difficult to build a practical alternating solenoid cooling channel. Although we cannot exactly duplicate the study in question with ICOOL, we can superimpose a dipole field error and investigate the change in performance as the error field is increased.

2 Procedure

We cannot tip an individual coil in ICOOL. However, we can superimpose a dipole field over one of the regions in the problem. The standard alternating solenoid solution uses a solenoidal field map that is repeated with alternating polarity over each cell (half period of the magnetic field). For this study the standard map is applied over the first cell and again over cells 3-16. A new field map with opposite polarity was prepared just for the second cell. This procedure reproduces the alternating solenoid field over the whole channel, but gives us specific access to the regions of the second cell We then added a dipole field in the region of the second cell between the exit widow of the liquid hydrogen absorber and the entrance window to the first *rf* cavity. A constant dipole field was applied over the length of the region, which was 4.84 cm. One should note that this study is not an exact comparison with the earlier work since (1) the hard edge dipole field applied here does not exactly satisfy Maxwell's equations, and (2) the location of the kick in the second cell is downstream from

the location used in the previous study.

3 Results

The results for the transmission, transverse and longitudinal cooling factors for the whole 25 m channel are given in the following table. One thousand particles were used in the simulation.

Effect of dipole perturbation on 15 T alternating solenoid			
B_Y [T]	Tr	fεT	fεL
0	0.967	0.505	1.59
5	0.979	0.511	1.57
10	0.951	0.578	1.87
20	0.812	0.760	2.43
30	0.705	0.747	2.61
50	0.482	0.740	2.41
60	0.383	0.754	2.24

A significant change in the lattice performance requires a dipole kick of at least 10 T. This means the error threshold corresponds to an integrated field error of

$$10\ \text{T} \times 0.0484\ \text{m} = 0.48\ \text{T m}$$

For comparison a tip of 0.25 mr in a 15 T solenoid coil gives a dipole error of $3.8\ 10^{-3}$ T. If we assume that this error applies over a length roughly equal to the coil radius (10 cm), the corresponding integrated dipole error is

$$3.75\ 10^{-3}\ \text{T} \times 0.10\ \text{m} = 0.38\ 10^{-3}\ \text{T m}$$

We conclude that the alternating solenoid is roughly a factor of 1000 less sensitive to this type of error than the earlier result suggested.

Notes & References

[1] P. Lebrun, MUCOOL note 33, p. 24, 35.