BNL-101601-2014-TECH

RHIC/PG/58;BNL-101601-2013-IR

Course Aperture Study For The Window Frame Dipoles In RHIC

A. Antillon

June 1984

Collider Accelerator Department

Brookhaven National Laboratory

U.S. Department of Energy

USDOE Office of Science (SC)

DISCLAIMER

Coarse Aperture Study for the Window Frame Dipoles in RHIC

Armando Antillón

June 22, 1984

Abstract.

We use PATRICIA to study the quality of the multipolar contribution in the Window Frame Dipoles (WFD). In order to avoid possible noise with insetions, we only use 81 characteristic RHIC cell. As we want to make a comparison with available information on the Dedicated RHIC dipoles (DRD), we only determine the apperture of WFD for some values of $\Delta p/p$.

This exercise is made in order to provide information, from the dynamical point of view, of possible magnets to be used in RHIC. This study has already been made for the dedicated RHIC dipoles[1], and we will take it as reference to compare the WFD results. The structure of the cells are of the FODO type with a dipole (10.7m) in between. Two families of sextupoles (with zero lenght) have been used to correct the natural cromaticity to a zero value. One family is in the center of the focusing quadrupole and the other in the center of the defocusing quadrupole. The multipolar contribution to ideal dipoles is simulated with zero lenght multipoles in the edges of dipoles. This is a rough approach, and work to take a better integration along dipoles is under progress.

Usually people in magnet design use coefficients (b'_n) that give directly the deviation of the field, respect B_o, in a certain reference point, i.e.

$$\frac{B}{B_o} = \sum_n b'_n \left(\frac{X}{X_o}\right)^n$$, where X_o is the reference point,

while Patricia use as input coefficients b_n given by

$$\frac{B}{B_o} = \sum_n b_n X^n$$

The obvious relation between them is

$$b_n = \frac{b'_n}{X_o^n}$$

The coefficients b'_n have been provided by J. Jackson[2], and for low field dopoles (1.9T) they are as follows (others wich are not shown are zero for $n \leq 22$)

n	$b'_n \times 10^4$ (at 2.54 cm)	bn
4	-.08	-19.2201
6	.08	2.9791×10^4
8	.02	1.15441×10^7
18	.01	5.16408×10^{22}
20	-.01	-8.00434×10^{25}

The quality of the dipole field is measured making a comparision between maximun beam size for ideal magnets (no multipoles) and maximum beam size when multipoles are included. The beam size in one direction is determined with the emittance and the β function as $u(s) = \sqrt{\frac{\epsilon_u \beta_u(s)}{\pi}}$

For a given aperture of the elements in the ring, we count the number of turns that a particle can give in the ring without exceed in amplitude the aperture imposed. This will give information about the physical aperture. When this physical barrier is made too large (1000 mm), we will have information about the dynamical stability of the beam, i.e. the dynamical aperture.

We chose in PATRICIA a reference emittance of $\epsilon_o = 0.5\pi \times 10^{-6}$ m-rad in terms of its units, emittance is controlled by a parameter A in the way

$$\epsilon = \left(\frac{A}{10}\right)^2 \epsilon_o$$

Changing A we can see the number of turns a particle can give in the ring.

1.- Dynamical Aperture of Dipoles.

We will present results in the same way as in 1).

A has the same meaning as before.

B is the number of turns the particle will give if its amplitude does not exceed the aperture given.

C is the number of turns the particle gives in the ring.

D=beam size=$(x^2+y^2)^{1/2}$. With $\epsilon = \epsilon_x = \epsilon_y$, $D = \left[\frac{\epsilon}{\pi}(\beta_x+\beta_y)\right]^{1/2}$

At the end of dipoles $\beta_x + \beta_y \sim 52.7$ m

$\frac{\Delta p}{p}$ (%)	A(B)	D (mm)
+0.2	80 (100)	>41.0
0.0	115 (100)	>59.0
-0.2	80 (100)	>41.0

Table I.- Dipoles with no multipoles have larger dynamical aperture that shown (taken from reference 1)

$\Delta p/p$ (%)	A(B), A(C)	D (mm)
+0.2	99(100), 101(62)	$50.8 \leq D \leq 51.8$
0.0	109(100), 111(93)	$56.0 \leq D \leq 56.9$
-0.2	107(100), 109(100)	$54.9 \leq D \leq 56.0$

Table II.- Dipoles with Window Frame multipoles. Dynamical aperture.

Last table shows that at $\frac{\Delta p}{p} = 0$ the dynamical aperture of WFD is $\sim$ 20 mm bigger than the corresponding DRD aperture.

2.- Physical Aperture of Dipoles.

To determine how stable is the beam near the operation emittance, a physical aperture of 30 mm has been taken in the elements of the lattice. Next table shows these results.

$\Delta\rho/\rho$ (%)	A(B), A(C)	D(mm)
+0.2	48(100), 50(6)	$24.6 \leq D \leq 25.7$
0.0	50(100), 52(13)	$25.7 \leq D \leq 26.7$
-0.2	44(100), 46(25)	$22.6 \leq D \leq 23.6$

Table III.- Dipoles with Window Frame multipoles. Physical aperture.

If we consider that the physical aperture for ideal dipoles (without multipoles) is of the same magnitude as for DRD, ($26.7 \leq D \leq 27.7$), then for the WFD, the physical aperture is $\sim$ 1 mm smaller. Finally we must to point out that this is not the real physical aperture. In order to determine it is necesary, as we already menciones it, to integrate the effects of multipoles in smaller pieces in each dipole.

References.

1.- G.F. Dell, Aperture Dependence of RHIC cell on multipole fields in the Dedicated RHIC Dipoles. Internal Report.

2.- J. Jakson, Private communication.