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Closed Orbit Analysis For RHIC

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RHIC - PG - 48

CLOSED ORBIT ANALYSIS

FOR

RHIC

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Closed Orbit Analysis for RHIC

Value $\hat{y}_P(s)$ not exceeded with a probability P

$$\hat{y}_P(s) = K(P)\left[1 + \frac{\sin \pi\nu}{3}\right]\sqrt{\frac{\beta(s)}{\bar{\beta}}}\sqrt{2}\,\langle y\rangle$$

where for circular vacuum chamber

P	50%	75%	90%	98%
K(P)	1.28	1.63	1.95	2.40

The rms value $\langle y\rangle$ of the expected closed orbit deviation

$$\langle y\rangle = \frac{1}{2\sqrt{2}\,|\sin \pi\nu|}\sqrt{\sum_i m_i\,\beta_i\,\bar{\beta}\,\psi_i^2}$$

Combining

$$\hat{y}_p(s) = K(P) \frac{1 + \frac{\sin \pi\nu}{3}}{2 \cdot |\sin \pi\nu|} \sqrt{\sum_i m_i \beta_i \beta(s) \psi_i^2}$$

Take $\nu = 34.4$ and $P = 90\%$

then

$$\boxed{\hat{y}_p(s) = 1.35 \sqrt{\sum_i m_i \beta_i \beta(s) \psi_i^2}}$$

The results are shown in the next table.

It seems that surveying of the quadrupoles is considerably more important than the dipole errors.

	Horizontal		Vertical	
	Quad	Dipole	Quad	Dipole
Source ψ_i	Displacem. $l_i K_i \Delta y_i$	Field Error $\Delta B/B_i\ \theta_{Bi}$	Displacem. $l_i K_i\ \Delta y_i$	Tilt $\theta_i\ \theta_{Bi}$
θ_{Bi}		0.03885		0.03885
$\Delta B/B_i$		$1/4 \times 10^{-3}$		
θ_i				1/4 mrad
m_i		168		168
β_i		26.4 m		26.4 m
$\sqrt{\sum_i m_i \beta_i \psi_i^2}$		0.000647 $m^{1/2}$		0.000647 $m^{1/2}$
l_i	1.9 m		1.9 m	
K_i	0.05 m^{-2}		0.05 m^{-2}	
Δy_i	$\frac{1}{4}$ mm		$\frac{1}{4}$ mm	
m_i	123		123	
β_i	(51.6 + 7.5) m		(51.6 + 7.5) m	
$\sqrt{\sum_i m_i \beta_i \psi_i^2}$	0.0020 $m^{1/2}$		0.0020 $m^{\frac{1}{2}}$	
$\hat{y}_p / \sqrt{\beta(s)}$ $\beta(s)$ in m	2.84 mm		2.84 mm	
For $\beta(s) = 51.4$ m	2.0 cm		2.0 cm	

Half-Integer Stop Band Width induced by closed orbit and sextupole

The equation is

$$x'' + K(s)\,x = g x^2$$

neglecting coupling with y-plane

Let

$$x = x_c + z$$

$$= \text{closed orbit} + \text{free oscillation}$$

then one derives

$$z'' + K(s)\,z = 2 g x_c z$$

The expectation rms value of the half-integer stopband width is then

$$\Delta\nu = \frac{1}{\pi}\sqrt{\sum_i m_i \left(\beta_i l_i g_i x_i\right)^2}$$

We have two families of sextupoles

	SF	SD
m_i	72	72
β_i	51.6 m	7.5 m
$\langle \eta_i \rangle_{rms}$	15. mm	5.8 mm
$l_i g_i = \frac{1}{2}\left(\frac{B''}{B\rho}\right)_i l_i$	0.05 m^{-2}	0.10 m^{-2}
$\langle \Delta\nu_i \rangle_{rms}$	0.10	0.012

$\langle \Delta\nu \rangle_{rms}$ 0.105

This is <u>too</u> large

Day 1 Operation Mode

1. Closed Orbit Deviations expected to be large (centimeter range)
2. With full sextupoles on the Half-Integer Stopband Width is expected to be quite large (~ 0.1)

(a) Choose β-tunes ~ 34.25
half-way between ½ integer values

(b) Turn Sextupoles completely off
Natural chromaticity ~ 50

(c) Use small pencil beam:
proton beam, bunched, moderate intensity
10^{11} particles / bunch
few bunches are enough
may be one AGS pulse

$\Delta p/p = \pm 0.4 \times 10^{-3} \Rightarrow \Delta\nu = \pm 0.02$ O.K.?

emittance = 0.7π mm·mrad (95% of beam)
($\equiv \pm 6$ mm at $\beta > 51.4$ m) O.K.?

$\boxed{\text{28 GeV}}$

(d) The beam should be able to go around

Confidence level ≥ 90%

(e) Establish one turn circulation
Read Beam Position at B.M

(f) Establish second turn circulation
Read Beam Position at B.M.

(g) Compare B.M. Position between first and second turn
Minimize Difference by adjusting Angle and steering at Injection

(h) When first, second, ..., nth turn identical closed orbit has been established

(i) Move quadrupoles to reduce closed orbit down to ± 2mm peak-to-peak level - Work out strategy !

(j) Fine adjustment with local steering elements - Work out strategy and requirements --- !