Status of 3Qx resonance measurement and correction

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(2008 RHIC APEX workshop, Dec.4-5, 2008)

1. History

- Original goal is to correct 3Qx at injection to allow inject below 0.7
- In run 2006, we found injection below 0.7 not an issue
- In run 2006, we moved to pp run store to correct 3Qx driving term
- TBT data is taken from AC dipole activation
- No beam experiment time for 3Qx after run06

2. Theory

First order resonance driving terms

Sextupoles produce the following first order geometric driving terms,

$$h_{21000} = -\frac{1}{8}\sum_{i=1}^{N}(k_2 dl)_i \beta_{x,i}^{3/2} e^{i\mu_{x,i}}, \quad (1)$$

$$h_{30000} = -\frac{1}{24}\sum_{i=1}^{N}(k_2 dl)_i \beta_{x,i}^{3/2} e^{i3\mu_{x,i}}, \quad (2)$$

$$h_{10110} = \frac{1}{4}\sum_{i=1}^{N}(k_2 dl)_i \beta_{x,i}^{1/2}\beta_{y,i} e^{i\mu_{x,i}}, \quad (3)$$

$$h_{10020} = \frac{1}{8}\sum_{i=1}^{N}(k_2 dl)_i \beta_{x,i}^{1/2}\beta_{y,i} e^{i(\mu_{x,i}-2\mu_{y,i})}, \quad (4)$$

$$h_{10200} = \frac{1}{8}\sum_{i=1}^{N}(k_2 dl)_i \beta_{x,i}^{1/2}\beta_{y,i} e^{i(\mu_{x,i}+2\mu_{y,i})}. \quad (5)$$

They will drive the resonances Q_x, $3Q_x$, Q_x, $Q_x - 2Q_y$, and $Q_x + 2Q_y$, respectively, and are therefore called res-

$$\begin{aligned}
J_x(N) &= J_x + \frac{A_{21000}(2J_x)^{3/2}}{\sin(\pi\nu_x)}\cos\left(\hat{\phi}_{21000} + \phi_x + N2\pi\nu_x\right) \\
&+ \frac{A_{10110}\sqrt{2J_x}2J_y}{\sin(\pi\nu_x)}\cos\left(\hat{\phi}_{10110} + \phi_x + N2\pi\nu_x\right) \\
&+ \frac{3A_{30000}(2J_x)^{3/2}}{\sin(3\pi\nu_x)}\cos\left[\hat{\phi}_{30000} + 3(\phi_x + N2\pi\nu_x)\right] \\
&+ \frac{A_{10020}\sqrt{2J_x}2J_y}{\sin[\pi(\nu_x - 2\nu_y)]}\cos\left[\hat{\phi}_{10020} + \phi_x - 2\phi_y + N2\pi(\nu_x - 2\nu_y)\right] \\
&+ \frac{A_{10200}\sqrt{2J_x}2J_y}{\sin[\pi(\nu_x + 2\nu_y)]}\cos\left[\hat{\phi}_{10200} + \phi_x + 2\phi_y + N2\pi(\nu_x + 2\nu_y)\right] \\
&+ O\left(b_3^2\right), \\
J_y(N) &= J_y - \frac{2A_{10020}\sqrt{2J_x}2J_y}{\sin[\pi(\nu_x - 2\nu_y)]}\cos\left[\hat{\phi}_{10020} + \phi_x - 2\phi_y + N2\pi(\nu_x - 2\nu_y)\right] \\
&+ \frac{2A_{10200}\sqrt{2J_x}2J_y}{\sin[\pi(\nu_x + 2\nu_y)]}\cos\left[\hat{\phi}_{10200} + \phi_x + 2\phi_y + N2\pi(\nu_x + 2\nu_y)\right] \\
&+ O\left(b_3^2\right) \qquad (156)
\end{aligned}$$

where

$$\hat{\phi}_{ijkl0} \equiv \phi_{ijkl} - \pi\left[(i-j)\nu_x + (k-l)\nu_y\right] \qquad (157)$$

3. Simulation

CAD/AP/265
January 17, 2007

Simulation of $3Q_x$ resonance driving term measurement with AC dipole excitation

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Table 7: Measurements in the vicinity of $3Q_x$ without adjustment of first order chromaticities.

(Q_x,Q_y)	$(\xi_x^{(0)},\xi_y^{(0)})$	A_{30000} measured	ϕ_{30000} measured	A_{30000} analytical	ϕ_{30000} analytical
[...]	[...]	[...]	[degrees]	[...]	[degrees]
(28.690,29.695)	(0.66,0.87)	11.69	147.7	6.46	153.7
(28.685,29.695)	(1.00,1.00)	7.84	145.3	6.40	149.3
(28.680,29.695)	(1.35,1.12)	12.57	133.0	6.34	146.2
(28.675,29.695)	(1.72,1.24)	6.74	113.6	6.29	143.1
(28.6725,29.695)	(1.90,1.30)	10.20	165.5	6.26	142.5
(28.670,29.695)	(2.08,1.36)	9.73	131.5	6.24	140.1

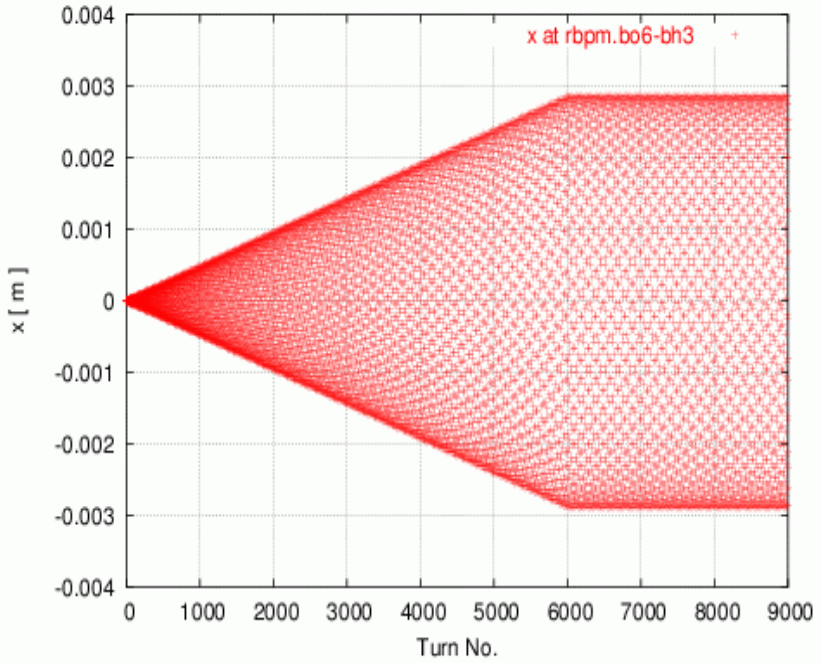

Figure 1: Turn-by-turn x data at rbpm.bo6-bh3 during ramp-up and flattop of AC dipole excitation.

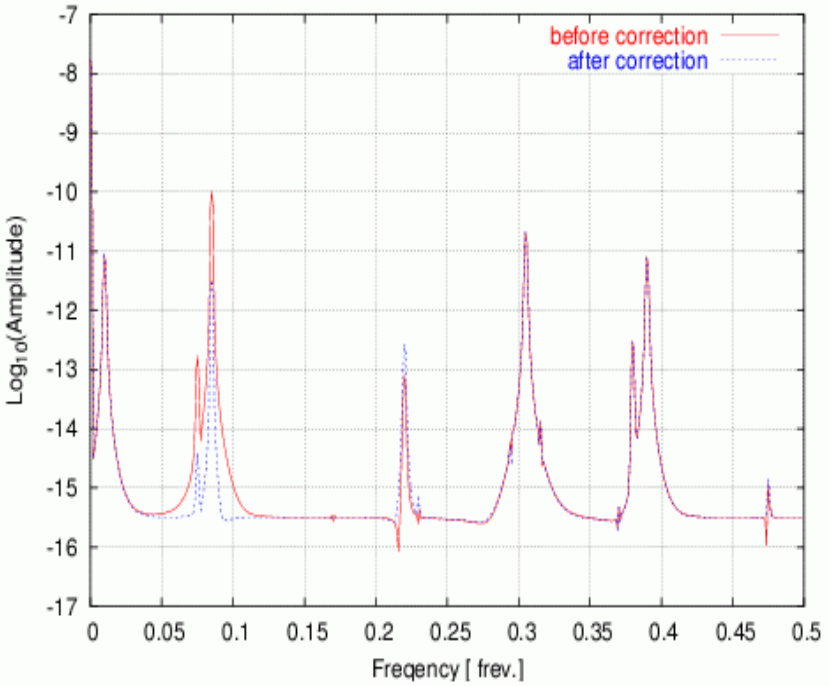

Figure 7: Spectrum of $2J_x(N)$ before and after h_{30000} correction.

4. Experiment in run06

Measurement and Correction of Third Resonance Driving Term in the RHIC*

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PAC07 paper

Online data analysis codes are robust and tested.

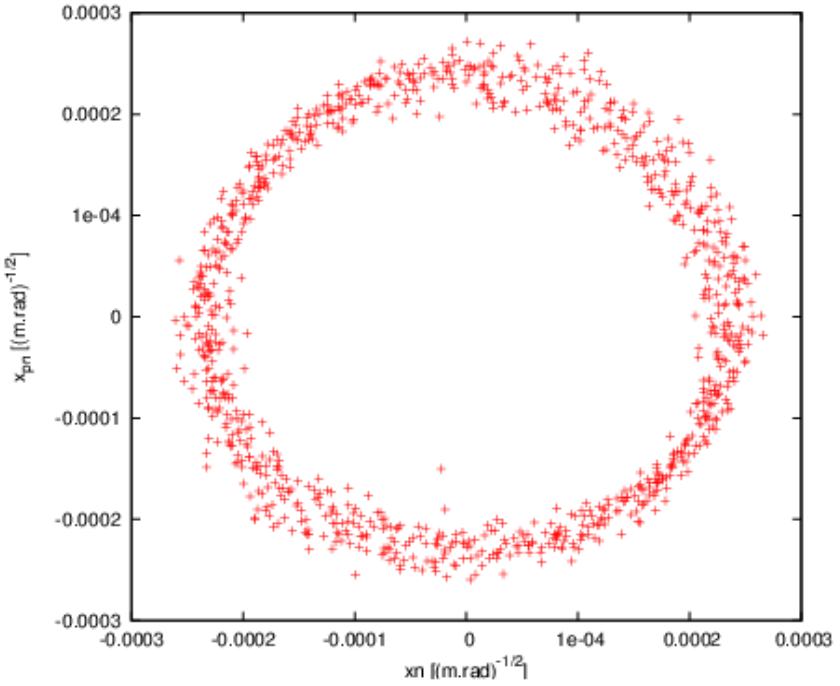

Figure 1: The TBT normalized coordinates (x_n, x_{pn}).

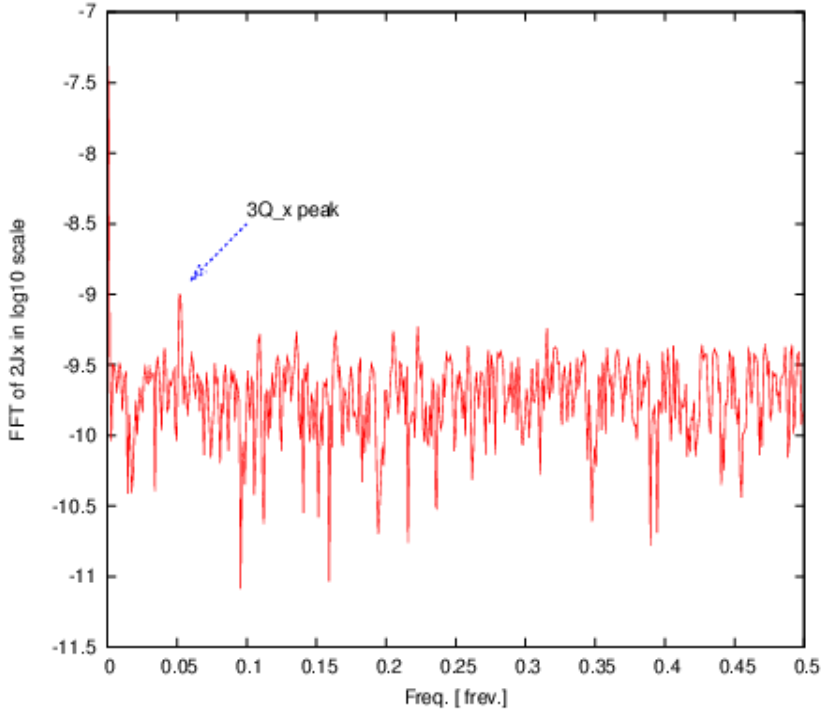

Figure 3: The spectrum of $J_x(N)$.

5. Problem

- We saw not small fluctuations in the h30000 amplitude and phase even under the same beam and measurement condition, which might due to the **failed BPM TBT data**.

- According to M. Bai: **failed AC dipole** low-level function generator (software) which affected the shaking frequency and amplitude.

6. Correction

CAD/AP/264
December 20, 2006

Simulation of proposed on-line third order resonance correction schemes

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Table 8: Using 4 IR sextupole correctors in IR6 and IR8 to compensate h_{30000} only.

quantity	value
Driving terms (real part, imaginary part):	
h_{21000}	(-34.73, 58.65)
h_{30000}	(-0.00, -0.00)
h_{10110}	(188.44, -119.17)
h_{10020}	(120.97, 69.24)
h_{10200}	(3.21, 215.21)
Chromaticities:	
$(\xi_x^{(1)}, \xi_y^{(1)})$	(1.85, 1.94)
$(\xi_x^{(2)}, \xi_y^{(2)})$	(221, 2513)
$(\xi_x^{(3)}, \xi_y^{(3)})$	(352173, 12236)
Strengths after correction:	
B2M05C3B	-0.005903
B2M06C3B	-0.031119
B2M07C3B	0.031119
B2M08C3B	0.005903