

Magnet Shuffling for the RHIC

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Magnet Shuffling for the RHIC

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magnet Shuffling for the RHIC (?)

1. Remarks

- Correction Systems (What type, How many Families, How to tune them, What on Day One).
- Magnets in the insertions are special.
special consideration at the colliding points.

Skew quadrupoles at Q2 or Q3 to control the coupling, $\nu_x - \nu_y = 0$.

At Q2 or Q3.

- $\beta^* = 3m$, two families are orthogonal.
- $\beta^* = 6m$, two families are NOT independent.

$$\underline{(\psi_x - \psi_y) - (\nu_x - \nu_y) \cdot \theta}$$

2. "Local" vs "Global"

"Closed Form" vs "Fourier Series"

- Example
- isolated resonances, resonance extraction.
 - localized source of errors
(e.g. elements in insertions)

① ΔX_p by b_1

$$(\Delta \hat{X}_p) \equiv \frac{\Delta X_p}{\sqrt{\beta_x}} + i \left\langle \Delta X_p' + \frac{\alpha_x}{\beta_x} \cdot \Delta X_p \right\rangle \cdot \sqrt{\beta_x}$$

"Global" (b_1 distributed around the ring)

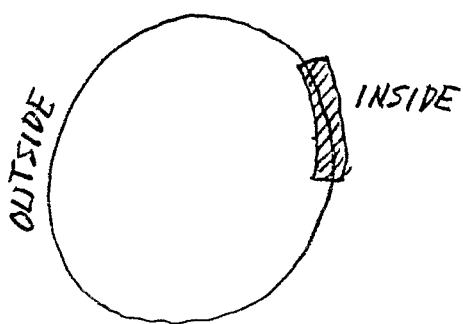
$$(\Delta \hat{X}_p)_\phi = \sqrt{\beta_x(\phi)} \cdot v_x^2 \cdot \sum_{-\infty}^{\infty} \frac{a_n}{v_x^2 - n^2} \cdot e^{in\phi_x} ; \phi = \psi/v$$

$$a_n = \frac{1}{2\pi v_x} \sum_k^N \left[\left(-\frac{\ell}{f}\right) \cdot b_1 \cdot X_p \cdot \sqrt{\beta_x} e^{-in\phi_x} \right]_k$$

Error b_1 at $k=1$ to N .

"Local" (b_1 confined to localized area)

OUTSIDE VS INSIDE



$$(\Delta \hat{X}_p)_0 = \frac{e^{-i\pi v}}{2 \sin(\pi v)} \cdot \sum_k^M \left[\left(-\frac{\ell}{f}\right) b_1 \sqrt{\beta_x} X_p \cdot e^{i\psi_x} \right]_k$$

If $\left(-\frac{\ell}{f}\right) \cdot \sqrt{\beta_x} \cdot X_p$ is the same at $k=1 \sim M (\ll N)$

$$(\Delta \hat{X}_p)_0 = 0 \longrightarrow \boxed{\sum_k^M (b_1 \cdot e^{i\psi_x})_k = 0}$$

Confine the effect within the localized area.

② Y_p by a_1

$$x \rightarrow y; \quad b_1 \rightarrow a_1$$

"Local" $\left[\left(\frac{\ell}{\rho} \right) \cdot a_1 \cdot X_p \cdot \sqrt{\beta y} \cdot e^{i\psi_y} \right]_k \rightarrow \sum_k^M (a_1 e^{i\psi_y})_k = 0$

"Global" $\left[\left(\frac{\ell}{\rho} \right) \cdot a_1 \cdot X_p \cdot \sqrt{\beta y} \cdot e^{-in\phi_y} \right]_k$

③ $(\Delta\beta/\beta)_{x+y}$ by b_1

$$\hat{\Delta} \equiv (\Delta\beta/\beta) - i \left\langle \Delta\alpha - \frac{\Delta\beta}{\beta} \cdot \alpha \right\rangle$$

"Global" $\hat{\Delta} = (2\nu^2) \cdot \sum_{-\infty}^{\infty} \frac{J_n}{4\nu^2 - n^2} \cdot e^{in\phi}$

$$J_n = \frac{1}{2\pi\nu} \cdot \sum_k^N \left[\left(-\frac{\ell}{\rho} \right) \cdot b_1 \cdot \beta \cdot e^{-in\phi} \right]_k$$

"Local"

$$\hat{\Delta}(\text{OUTSIDE}) = \frac{e^{-i2\pi\nu}}{25i\pi(2\pi\nu)} \cdot \sum_{k=1}^M \left[\left(-\frac{\ell}{\rho} \right) \cdot \beta \cdot b_1 \cdot e^{i2\psi} \right]_k$$

$$\hat{\Delta} = 0 \rightarrow \boxed{\sum_k^M (b_1 \cdot e^{i2\psi})_k = 0.}$$

Two ways of looking at the same problem.

(1) "Local".

Confine the effect such that no effect OUTSIDE.

a) Given ~~EN~~ N, what M?

b) Combination of two or more blocks?

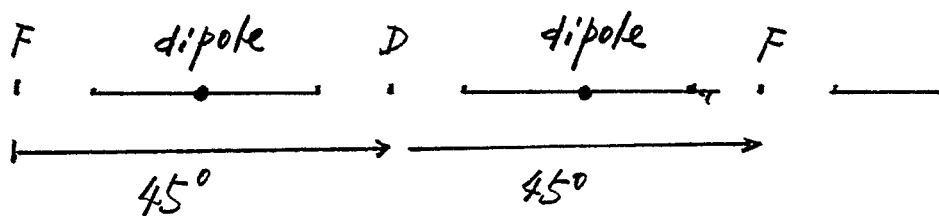
(2) "Global"

Reduce the "important" harmonics.

($n \approx \nu$ or $n \approx 2\nu$).

How many harmonics? \longrightarrow Again localized area.

3. Thin-lens approximation



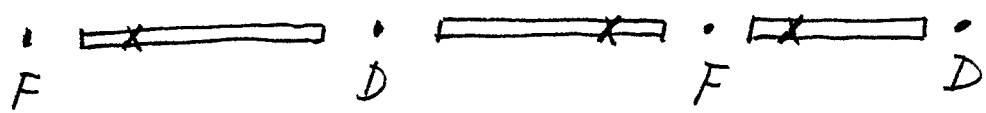
Can we take each dipole as an element
 or do we have to regard each dipole
 as several elements?

	thin-lens	integrated
$\sqrt{\beta_x} \cdot X_p \cdot e^{i\psi_x}$	4.95 (12.5°)	5.15 (11.5°)
$\sqrt{\beta_y} \cdot X_p \cdot e^{i\psi_y}$	4.95 (33.0°)	4.89 (31.9°)
$\beta_x \cdot e^{i2\psi_x}$	22.4 (25.0°)	22.8 (22.5°)
$\beta_y \cdot e^{i2\psi_y}$	22.4 (65.9°)	22.8 (68.4°)

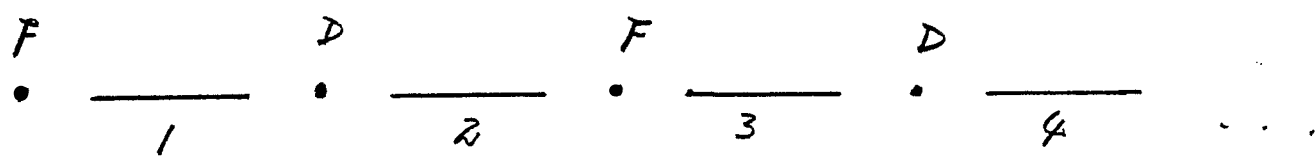
distortion by b_z

$\beta_x^{3/2} e^{i3\psi_x}$	106.0 (37.5°)	112.6 (30.3°)
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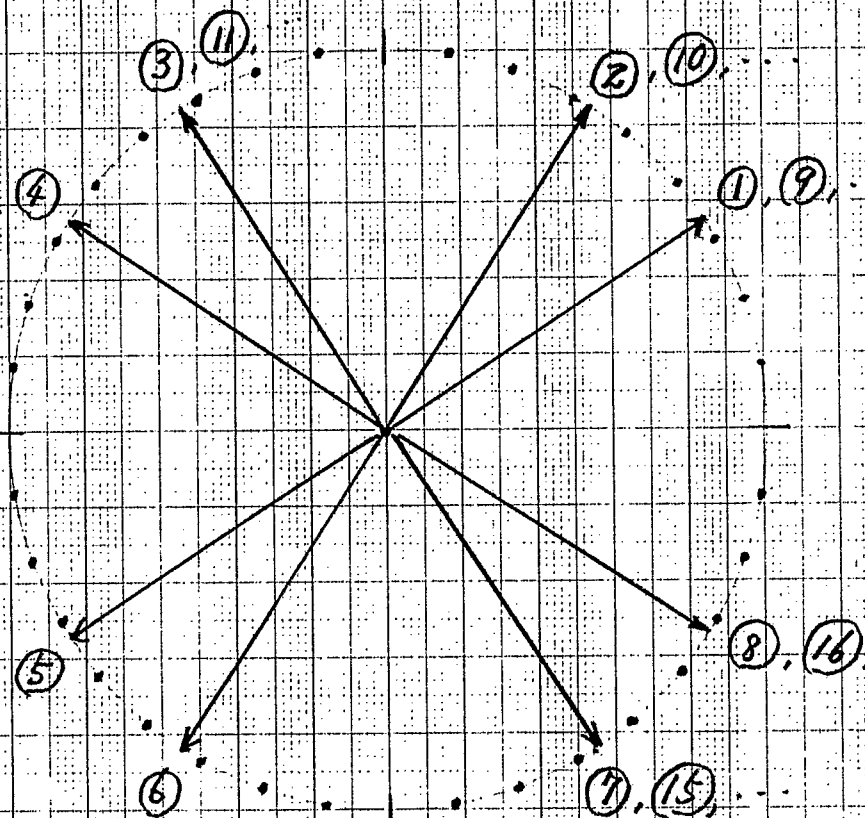
Should be OK for (b_1, a_1) but may have to shift the angle for (b_2, a_2) .



4. Example of "Vector Diagrams" for RHIC.

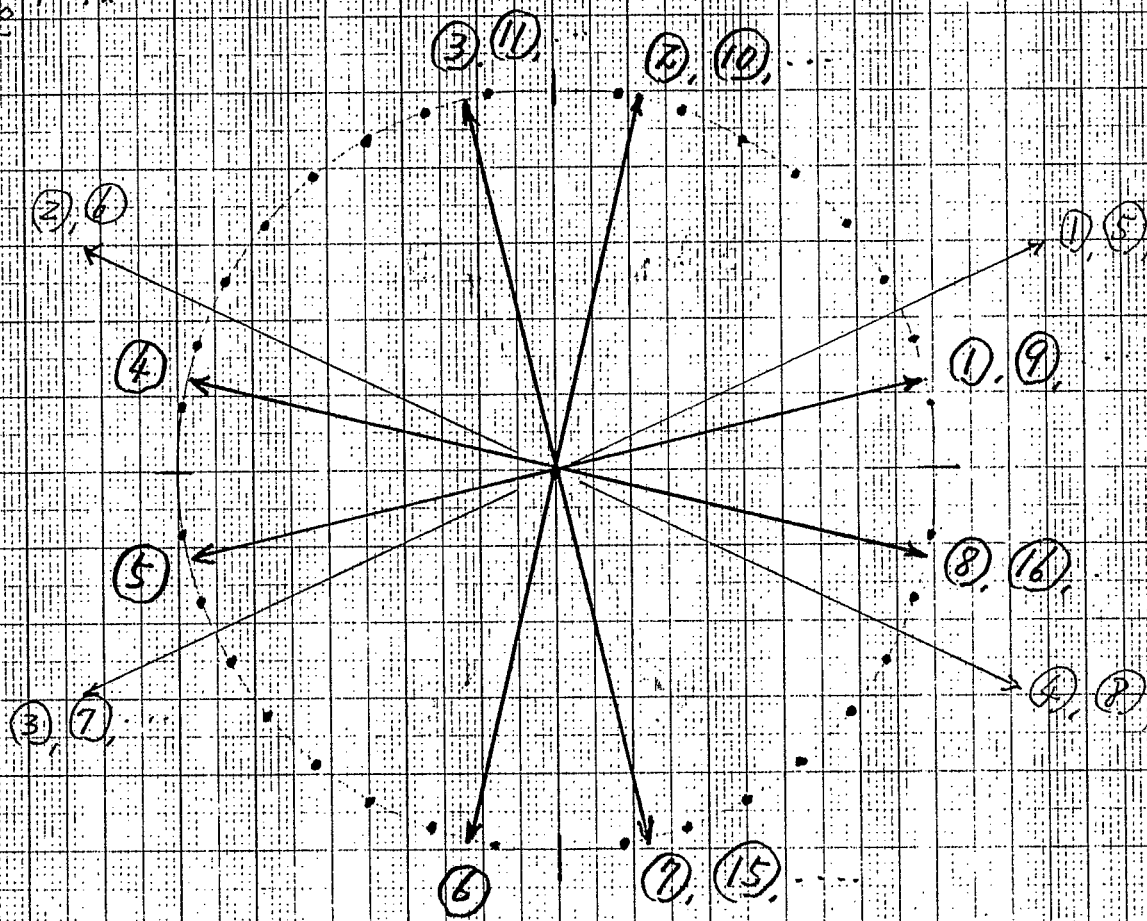


$$Q_1 \sqrt{\beta_y} X_p \in \mathbb{R}_y$$



$$b_1 \sqrt{\beta_x} X_p e^{i\psi_x}$$

$$b_1 \beta_x e^{i2\psi_x}$$



Important differences from the Tevatron

(1) Tevatron : b_2, a_2, a_3

(2) RHIC : $b_1, a_1, b_2, a_2(?)$

Phase advance/cell. RHIC : 90°

Tevatron : 68°

For RHIC, various effects coming from one multipole (for example, b_1) are correlated.

5. What I should do

Given $\langle b_1 \rangle, \langle a_1 \rangle, \langle b_2 \rangle$ & $\langle a_2 \rangle$.

(1) max. allowed values (if Gaussian)

(2) $M = 8$ (~~four~~ four cells) or 16 (eight cells)

(3) "manual" and "automated" shuffling processes combined.

(4) performance estimates.

Compare
with random
cases.

[$(\Delta X_p)_{\max}, (Y_p)_{\max}, (\Delta \beta/\beta)_{\max},$
 $\langle \Delta X_p \rangle_{\text{RMS}},$ " "
 Distortion functions - - -]