



Brookhaven
National Laboratory

BNL-101679-2014-TECH

RHIC/AP/23;BNL-101679-2013-IR

Magnet Shuffling for the RHIC

S. Ohnuma

November 1985

Collider Accelerator Department
Brookhaven National Laboratory

U.S. Department of Energy

USDOE Office of Science (SC)

Notice: This technical note has been authored by employees of Brookhaven Science Associates, LLC under Contract No. DE-AC02-76CH00016 with the U.S. Department of Energy. The publisher by accepting the technical note for publication acknowledges that the United States Government retains a non-exclusive, paid-up, irrevocable, world-wide license to publish or reproduce the published form of this technical note, or allow others to do so, for United States Government purposes.

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or any third party's use or the results of such use of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof or its contractors or subcontractors. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

Magnet Shuffling for the RHIC

S. Ohnuma

November 12, 1985

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, $v_x - v_y = 0$.

At Q2 or Q3.

- $\beta^* = 3m$, two families are orthogonal.
- $\beta^* = 6m$, two families are N&T independent.

$$\underline{(\psi_x - \psi_y) - (v_x - v_y) \cdot \theta}$$

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)

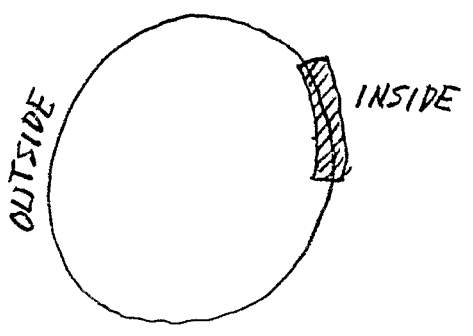
$$(\Delta \hat{X}_p)_\phi = \sqrt{\beta_x(\phi)} \cdot v_x^2 \cdot \sum_{-\infty}^{\infty} \frac{a_n}{v_x^2 - n^2} \cdot e^{in\phi_x} ; \phi = \psi/v$$

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

Error b_1 at $k=1$ to N .

"Local" (b_1 confined to localized area)

OUTSIDE VS INSIDE



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

If $\left(-\frac{\ell}{\rho}\right) \cdot \sqrt{\beta_x} \cdot X_p$ 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

$x \rightarrow y; b_1 \rightarrow a_1$

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

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

③ $(\Delta\beta/\beta)_{x+y}$ by b_1

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

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

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

"Local"

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

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

Two ways of looking at the same problem.

(1) "Local".

Confine the effect such that no effect OUTSIDE.

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

b) Combination of two or more blocks?

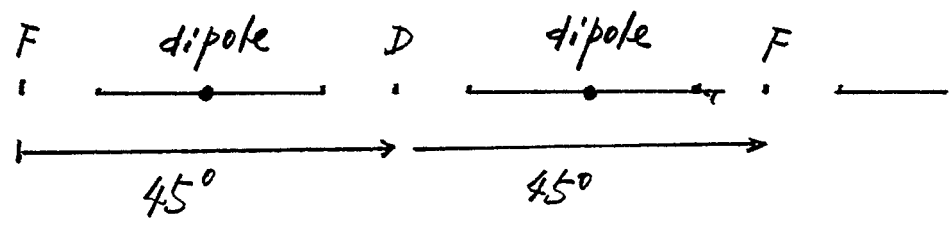
(2) "Global"

Reduce the "important" harmonics.

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

How many harmonics? \longrightarrow Again localized area.

3. Thin-lens approximation



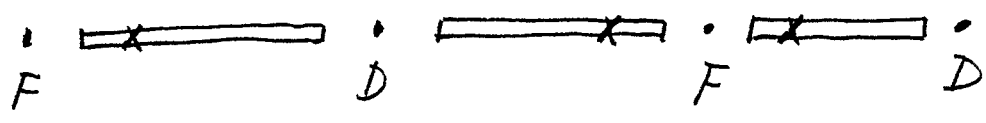
Can we take each dipole as an element or do we have to regard each dipole as several elements?

	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°)

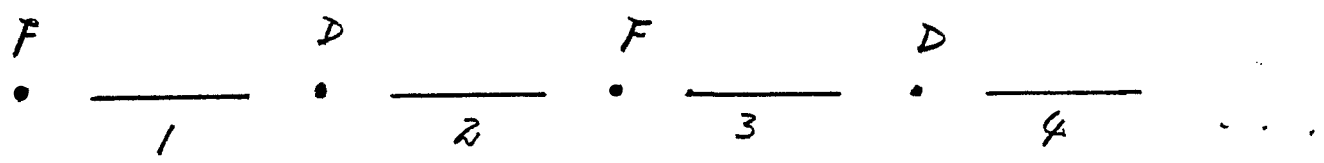
distortion by b_2

$\beta_x^{3/2} e^{i3\psi_x}$	106.0 (37.5°)	112.6 (30.3°)
------------------------------	---------------	---------------

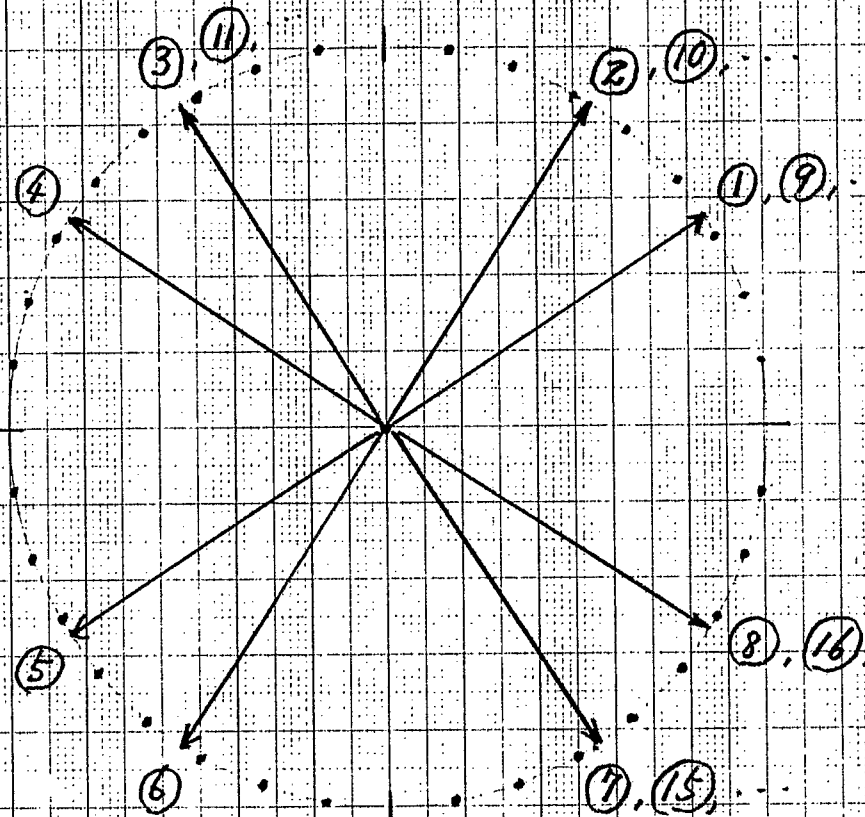
Should be OK for (b_1, a_1) but may have to shift the angle for (b_2, a_2) .



4. Example of "Vector Diagrams" for RHIC.



$$Q_1 \sqrt{\beta_y} X_p e^{-\gamma_y}$$





$$b_1 \sqrt{\beta_x} X_p e^{i\psi_x}$$
$$b_1 \beta_x e^{i2\psi_x}$$

