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Parallel Beam-Based Alignment in RHIC

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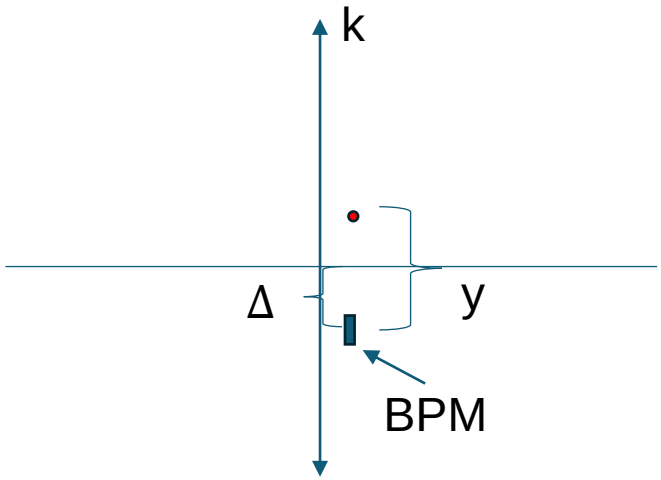
References

Xiaobiao Huang
Phys. Rev. Accel. Beams **25**, 052802 – Published 16 May 2022. Phys. Rev. Accel. Beams 25, 052802 (2022) - Simultaneous beam-based alignment measurement for multiple magnets by correcting induced orbit shift (aps.org)

The principle



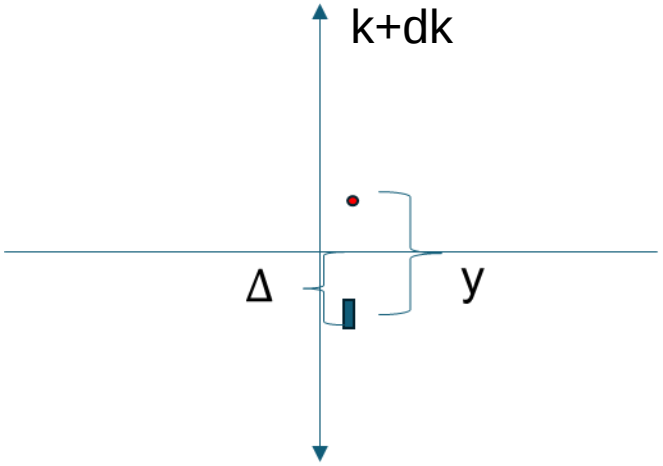
$\Delta\ is\ the\ relative\ offset\ between\ BPM\ electrical\ center\ and\ the\ quad\ magnet\ center$
y is the measured beam position at the BPM.

$$Y = M * kl * (y - \Delta)$$

ORM

deflection

Change quad strength by dk



Change of deflection

$$dY = M * \boxed{dkl * (y - \Delta)}$$

Induced orbit shift

Now for a group of quads

$$\begin{pmatrix} dY_1 \\ \vdots \\ dY_m \end{pmatrix} = M(m,n) * dkl(n,n) * \begin{pmatrix} y_1 - \Delta_1 \\ \vdots \\ y_n - \Delta_n \end{pmatrix}$$

$M(m,n)$ is the ORM from the group of quads to all available BPMs

$dkl(n,n)$ is the diagonal matrix of the integral strength change of the quads

$\begin{pmatrix} y_1 - \Delta_1 \\ \vdots \\ y_n - \Delta_n \end{pmatrix}$ are the difference btw initial orbits and quad offsets

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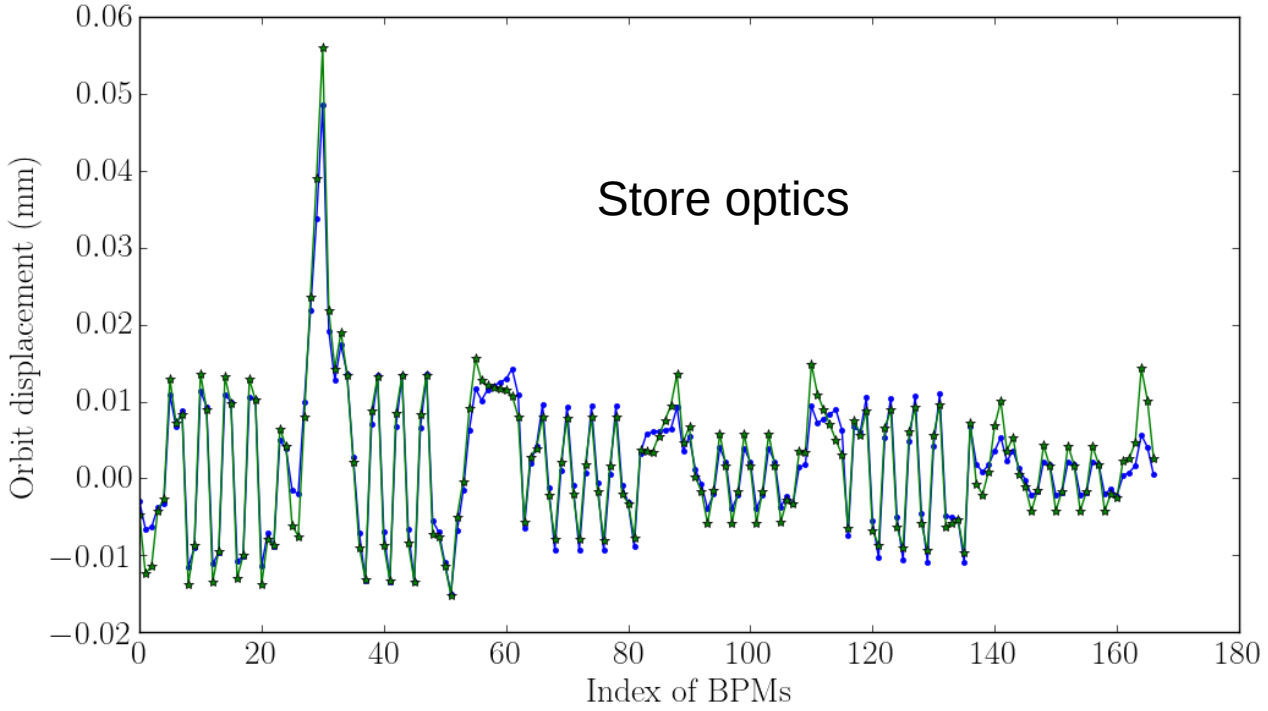
Simulations

- Green is the orbit deviation induced by changing the strength of 12 RHIC quads by 0.1% as simulated in Madx.
- Blue is the orbit deviation induced by changing the strength of 12 RHIC quads by 0.1% as calculated based on the matrix form on the previous slide.



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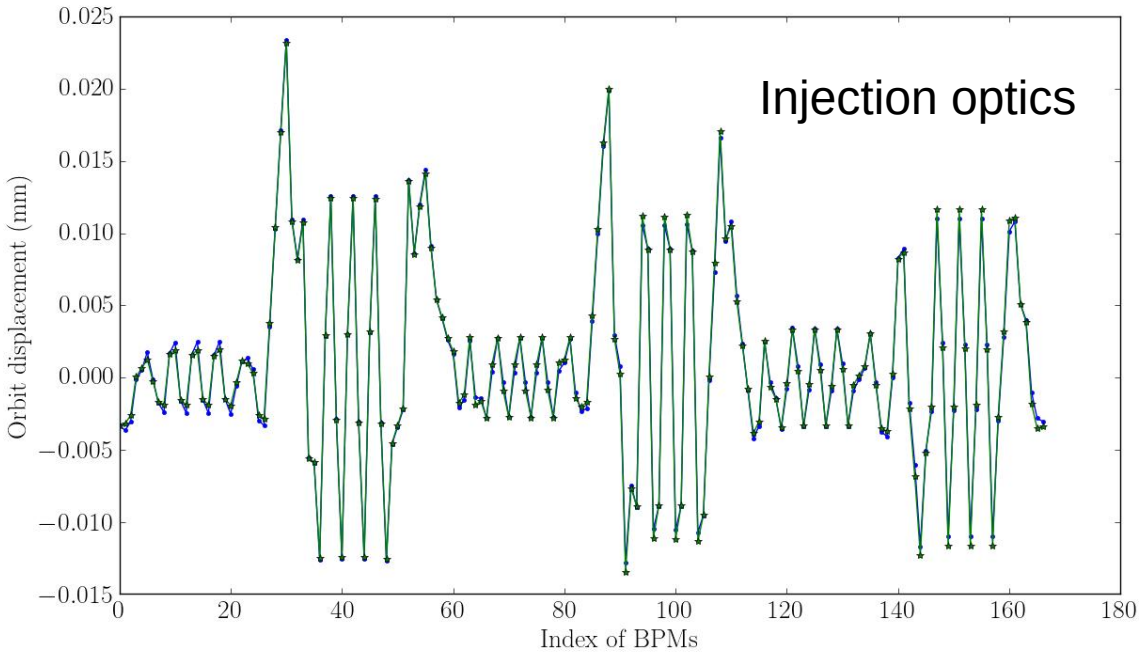

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Notes

- Make up to 4 percent change to the quad strength, but
- strategically change the strength of the quads so that the tunes stay the same.
- Prefer to perform the study at injection, where we can get beam quickly and the lattice distortion is less.
- No feedbacks during the measurements.
- Implementation is different from the reference.
- Multiple iterations could help.

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