FERMILAB-POSTER-22-099-STUDENT

Transverse Beam Echoes In The IOTA

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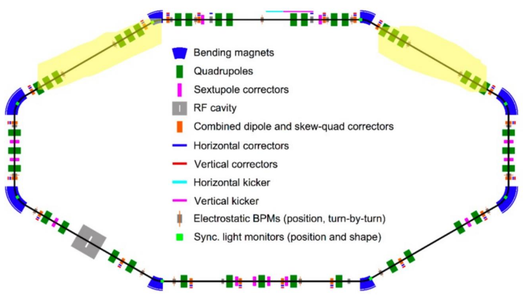
Introduction to the IOTA

- Accelerator for advanced beam physics
- proton and electron beams
- Currently running experiments with electrons
- Small and can be easily reconfigured to accommodate a wide-ranging experimental program



Space charge effect

- Self generated electro-magnetic force
- Net repulsive
- Negligible in particle accelerators moving at relativistic speed but not in the IOTA
- Beam distributions effect the space charge $F = \frac{e^2 N}{2\pi\epsilon_0 r \gamma^2}$

Method

- Madx was used to run simulations without space charge
- Pyorbit was used to run simulations with space charge
- Nonlinear theory of echoes was used to compare theory with experiments

$$A = \frac{< x >}{\beta_k \theta} \approx \frac{Q}{(1+Q^2)^{3/2}}$$

$$Q = q\omega' \epsilon_f \tau,\ q = \frac{\beta_{quad}}{f}$$

Iota Proton Beam parameters

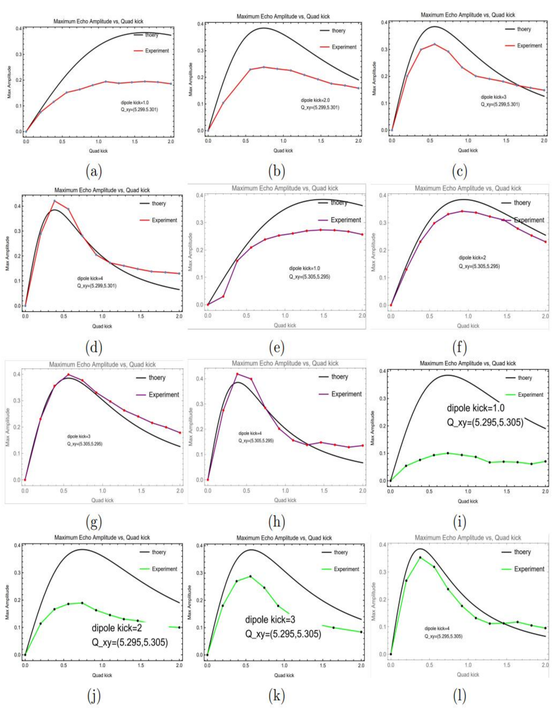
Parameter	Value
Beam Kinetic Energy, E	2.5 MeV
Beam Intensity, N	9×10^{10}
Normalized Emittance, ε	0.3 μm
Tune Shift (coasting, bunched)	-0.5, -1.2
Space Charge Perveance (coasting, bunched)	1.3×10^{-6}, 6.06×10^{-6}

Purpose of project

- Identify beam and machine conditions that maximize beam echoes to better measure diffusion
- With and without space charge.

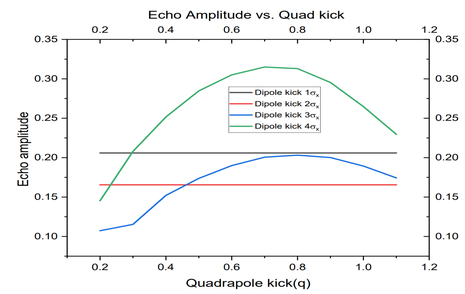
Results

Quadscan at nominal tunes

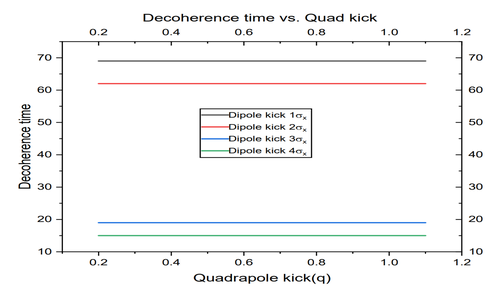


- Increase in dipole kick yields a better match with Theory, Shows Q dependence on the dipole kick

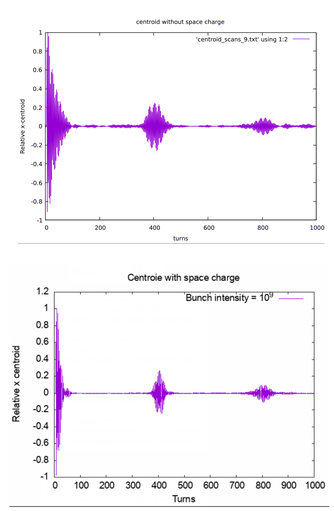
Dipole kick dependence



- Increasing max echo amplitude with dipole kick shows dipole dependence

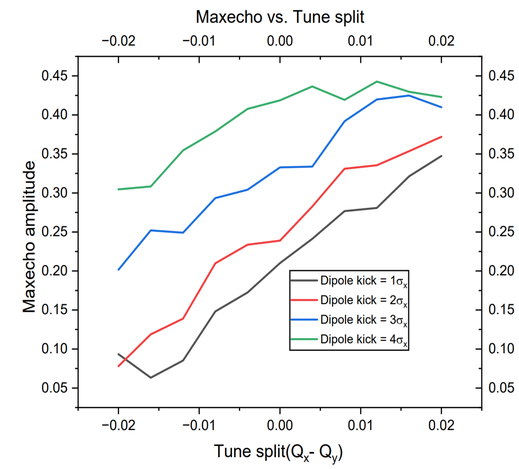


- Decoherence time for the beam depends on dipole kick as well



- X-centroid with and without space charge where some particles are lost in space charge effects

Coupling



- Evidence of coupling occurring at closer tune pairs. As distance increases between tune pairs, less coupling occurs and yields greater max echoes.

Conclusion & Discussion

- We have characterized echoes in the absence of space charge; simulations mostly agree with theory
- The maximum echo depends on the quadrupole and dipole kicks and the transverse coupling
- Multipole echoes can be seen at large dipole kicks
- This will enable an experimental study of echoes in the IOTA ring to measure diffusion
- Work is being continued for full characterization with space charge.

Acknowledgement

Special thanks to my mentors, Tanaji Sen and Jean-Francois ostiguy for their guidance and supervision on this project

This manuscript has been authored by Fermi Research Alliance, LLC under Contract No. DE-AC02-07CH11359 with the U.S. Department of Energy, Office of Science, Office of High Energy Physics.