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Transverse Beam Echoes In The IOTA

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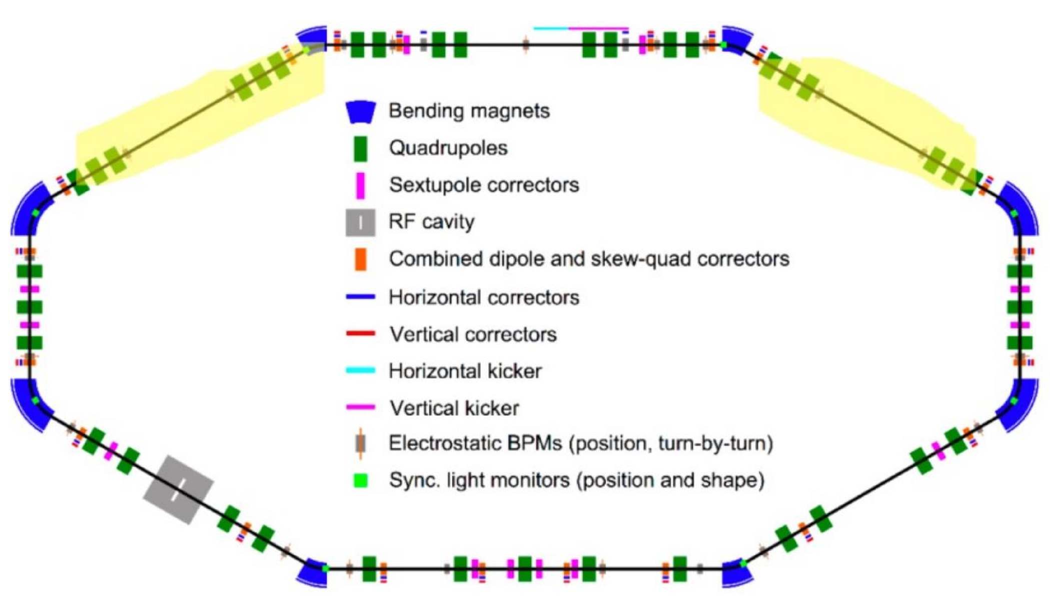
Introduction to the IOTA

- Storage ring for advanced beam physics
- Stores 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

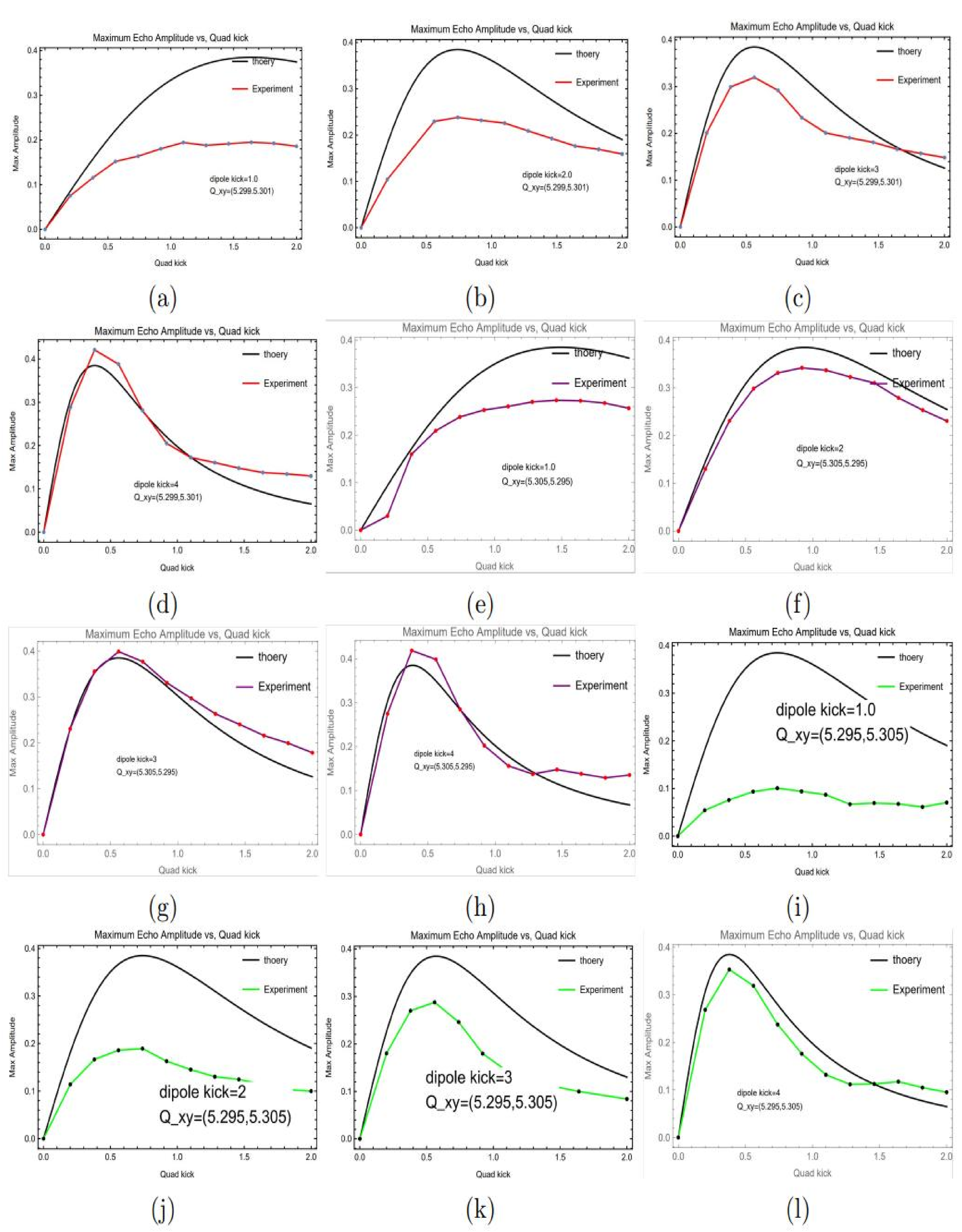
Parameter	Value
Beam Kinetic Energy, E	2.5 MeV
Beam Intensity, N	9 x 10^{10}
Normalized Emittance, ε	0.3 μm
Tune Shift (coasting, bunched)	-0.5, -1.2
Space Charge Perveance (coasting, bunched)	1.3 x 10^{-6}, 6.06 x 10^{-6}

Purpose of project

- Develop a new method to measure diffusion
- Identify beam and machine conditions that maximize beam echoes

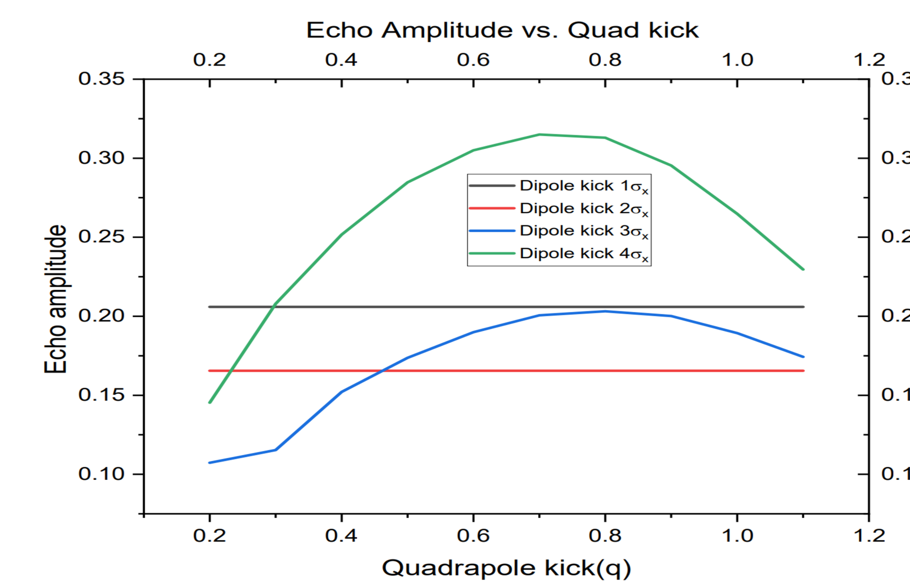
Results

Quadscan at nominal tunes

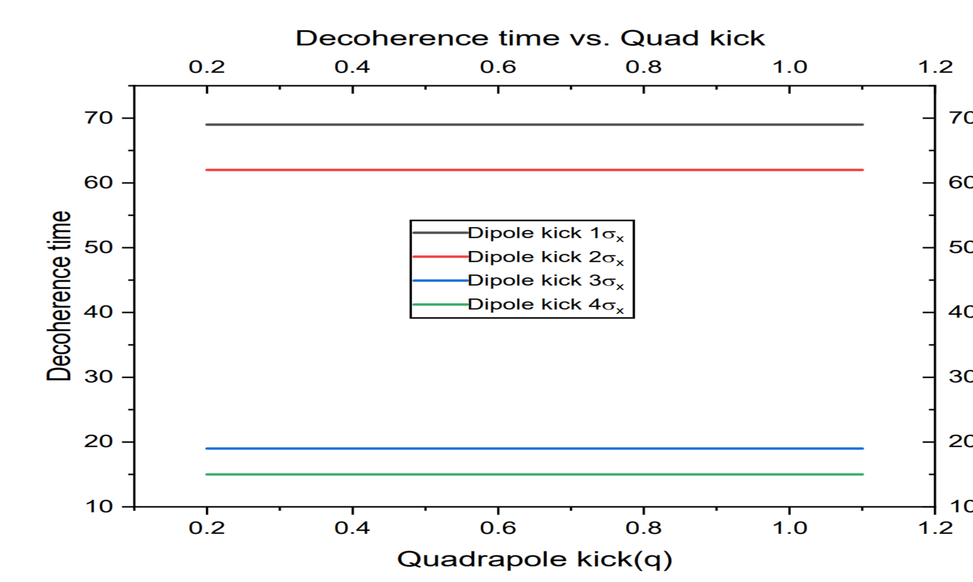


- Increase in dipole kick yields a better match with Theory, Shows Q dependence on the dipole kick

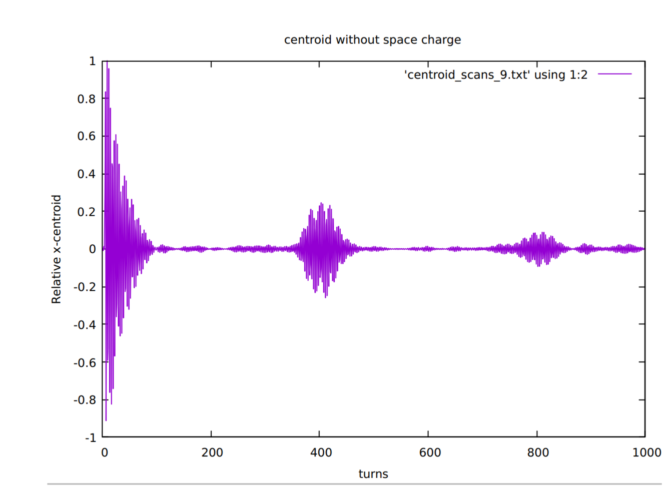
Dipole kick dependence

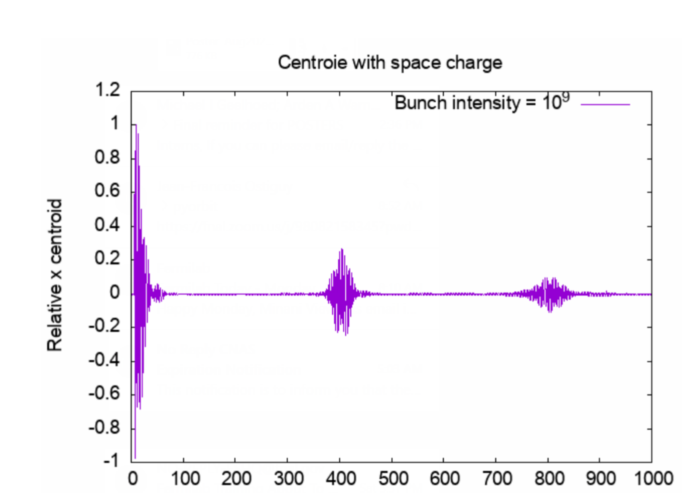


- Increasing max echo amplitude with dipole kick shows dipole dependence



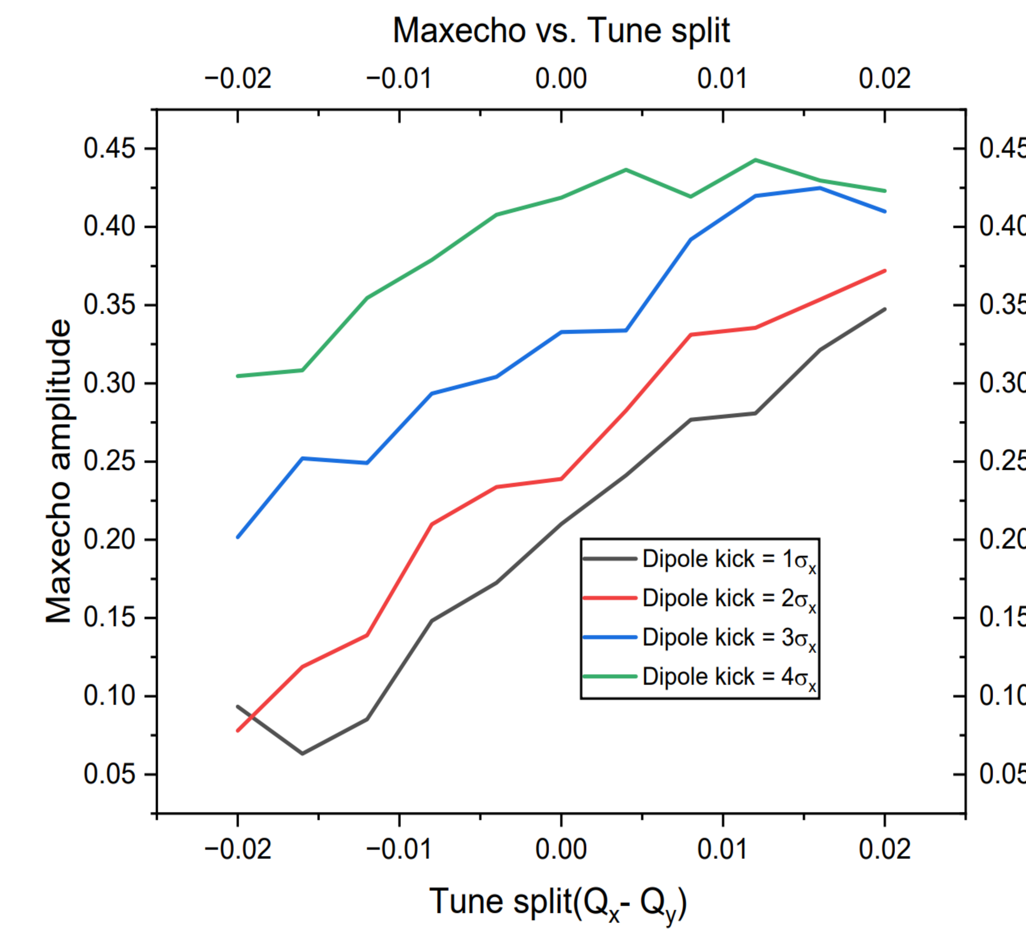
- Decoherence time for the beam depends on dipole kick as well





- 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

- Results show that echo amplitudes depend on the dipole kick
- In order to maximize echo amplitudes, optimal, reasonable dipole kicks must be chosen in order to minimize particle loss.
- Work is being continued for full characterization with space charge.

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