Dynamic Aperture Analysis in Particle Accelerators

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Introduction

- SC registering errors in CLS storage ring.
- Dynamic aperture determines the stability of particle motion.
- Crucial for accelerator performance and beam lifetime.
- Investigate stability using SCdynamicAperture function.

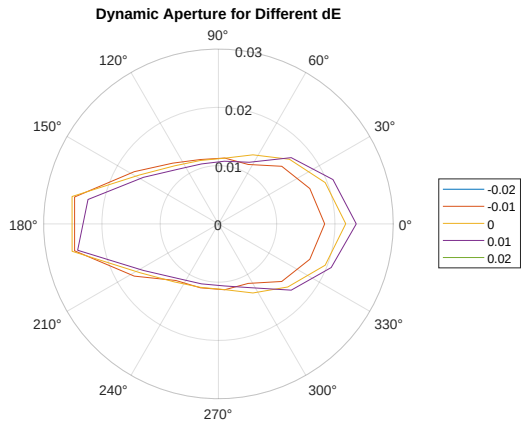
Objectives

- Study dynamic aperture for various energy deviations.
- Analyze the impact of angular resolution.
- Investigate sensitivity to lattice element variations.

Methodology

- MATLAB function: `SCdynamicAperture`
- Evaluated for different:
  - Energy deviations (`dE`)
  - Angular resolutions (`thetas`)
  - Lattice element strengths
- Polar plots used for visualization.

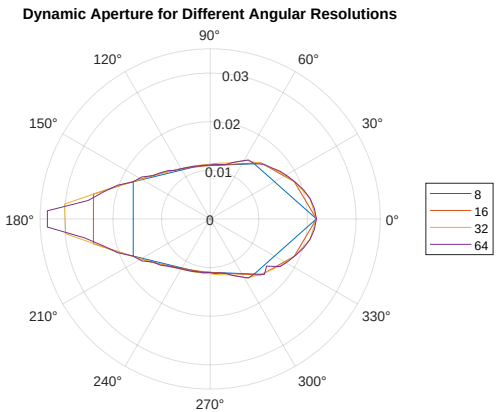
Results: Energy Deviation Analysis



- Smaller aperture at higher deviations due to chromaticity effects.
- Symmetry observed around on-momentum (dE = 0).

Figure: Dynamic aperture for different energy deviations.

Results: Angular Resolution Study



- Higher resolution shows detailed shape.
- Computational cost increases with resolution.

Figure: Aperture shapes with varying angular resolutions.

Results: Long-Term Stability Checks

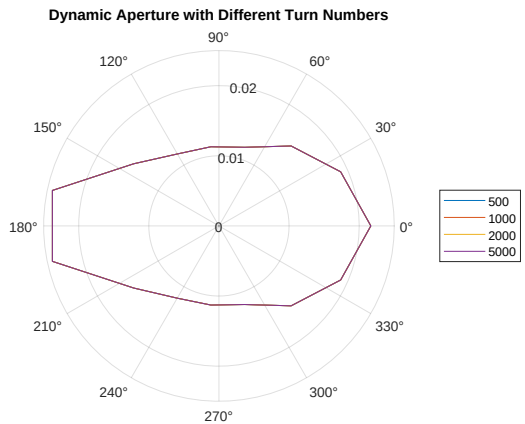


Figure: Investigate long-term stability by varying the number of turns

Discussion

- Off-momentum particles affect the aperture asymmetrically.
- Angular resolution impacts the accuracy of the shape.
- Quadrupole strengths significantly influence stability.

Conclusion and Future Work

- Dynamic aperture provides insights into particle stability.
- Nonlinearities and lattice imperfections influence results.
- Future work:
  - Investigate nonlinear elements (sextupoles, octupoles).
  - Compare with experimental measurements.
  - Optimize using advanced algorithms.

References

[1] T. Hellert et al., *Lattice correction and commissioning simulation of the Advanced Light Source upgrade storage ring*, Phys. Rev. Accel. Beams 25/110701, 2022.