Nonlinear Dynamic Study of FCC-ee

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Acceleraticum is home-made code

- Linear optics (Twiss, Lebedev-Bogacz parametrization)
- Radiation parameters calculation for Twiss
- Symplectic 6D tracking
- Computation of different nonlinear parameters (dynamic aperture, nonlinear chromaticity, tune-amplitude dependence, etc)
- Optimization (linear optics, nonlinear optics from tracking)
- Shatilov's LIFETRAC uses Acceleraticum tracking module for simulation of the beam-beam with the nonlinear lattice

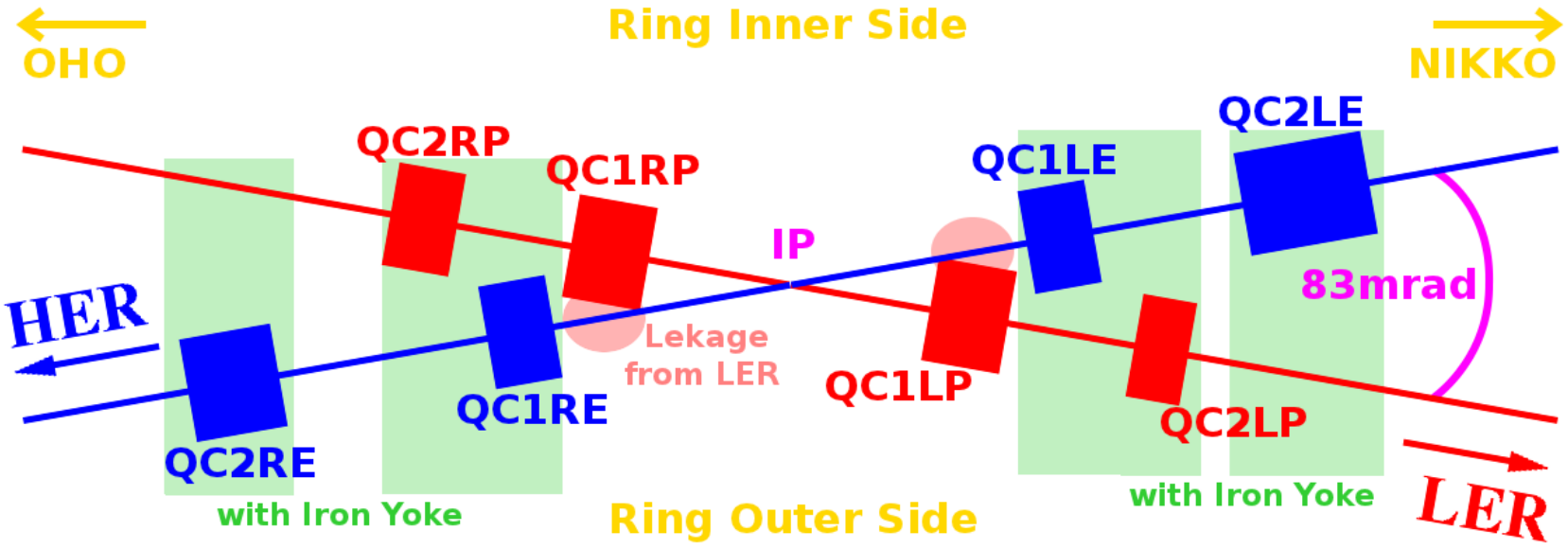
Main elements

- Drift
- Quadrupole with hard-edge nonlinear fringe
- Bending magnet with gradient and high order multipoles
- n-order multipole lens
- Solenoid with gradient and high order multipoles
- RF-Cavity
- Coordinate system transformation
- Gaussian Beam-Beam interaction with an arbitrary crossing angle
- Kinematic term in all elements
- Errors & Misaligments

Code comparison

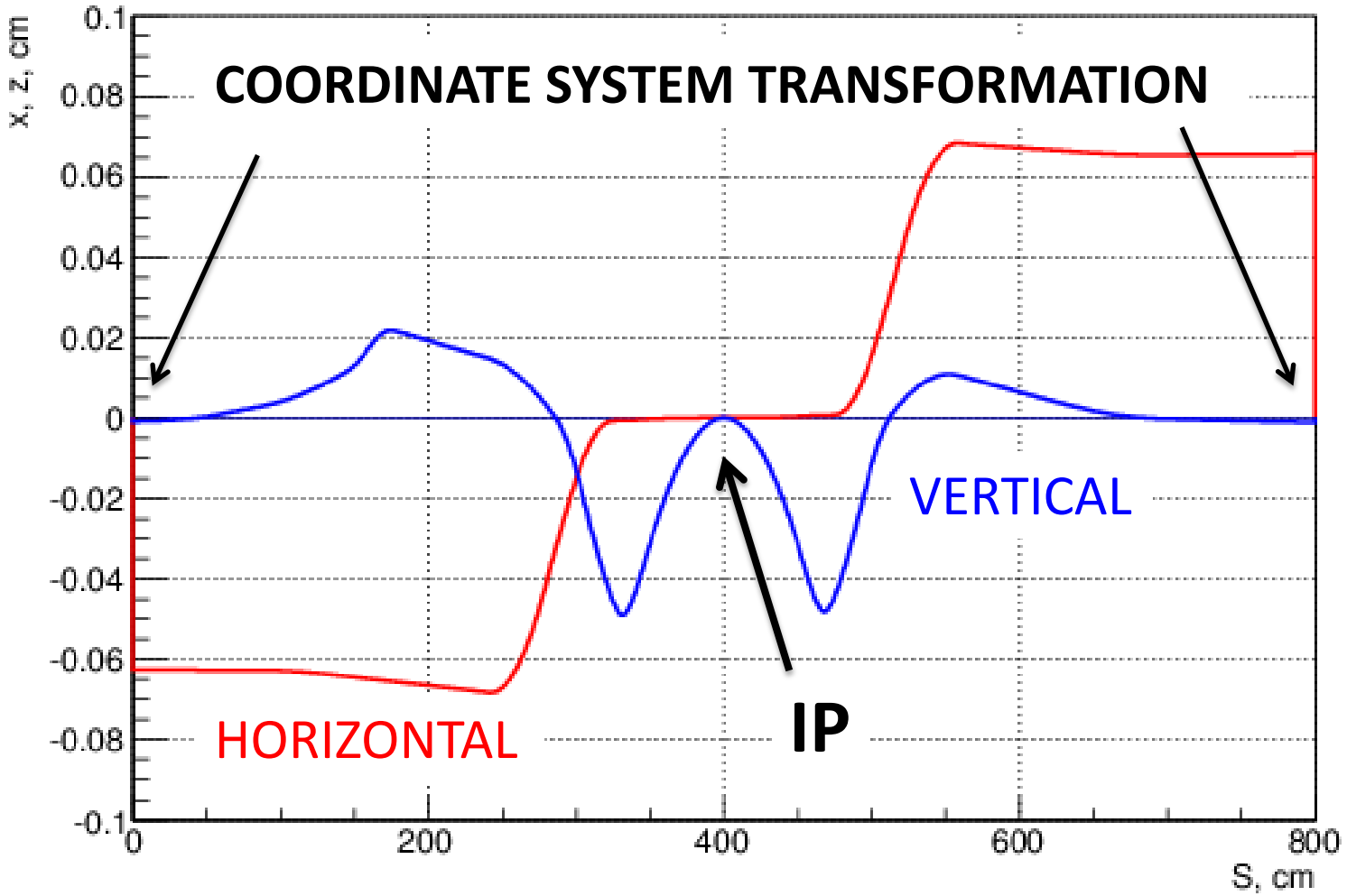
- Comparison of Lattice Codes by D.Einfeld, 2nd Nonlinear Beam Dynamic Workshop, Diamond, 2009
- Checking by myself with MAD-8, MADX, SAD
- Used for VEPP-4M, VEPP-2000 (round beams), ALBA, DAΦNE, Super-ct-Factory (Novosibirsk), SuperB, SuperKEKB, ultra low emittance ring projects, etc
- Good agreement with SAD for SuperKEKB with realistic interaction region

SuperKEKB with realistic IR



IR length of 8 m is sliced by 1 cm solenoids with dipole and gradient (rotated and shift) and nonlinear kicks (up to 21st multipole order) including quadrupole fringe field and kinematic term

Local orbit in IR HER SuperKEKB

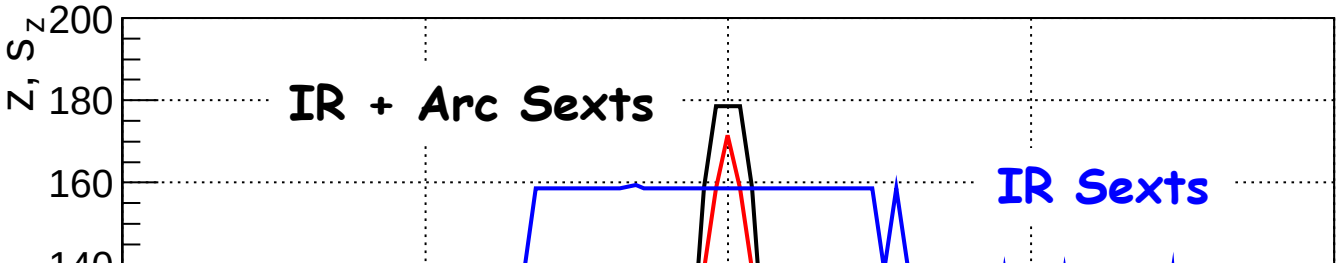


FCC-ee Dynamic Aperture Procedure

1. Arcs w/o IR dynamic aperture & energy acceptance optimization
2. Local compensation of nonlinear distortion of the Interaction Region
3. Study of Crab Sexts Influence
4. Advance Optimization of the whole Ring with Interation Region
5. Solenoids, Realistic field, Damping, Errors, etc…

Dynamic Aperture @ IP

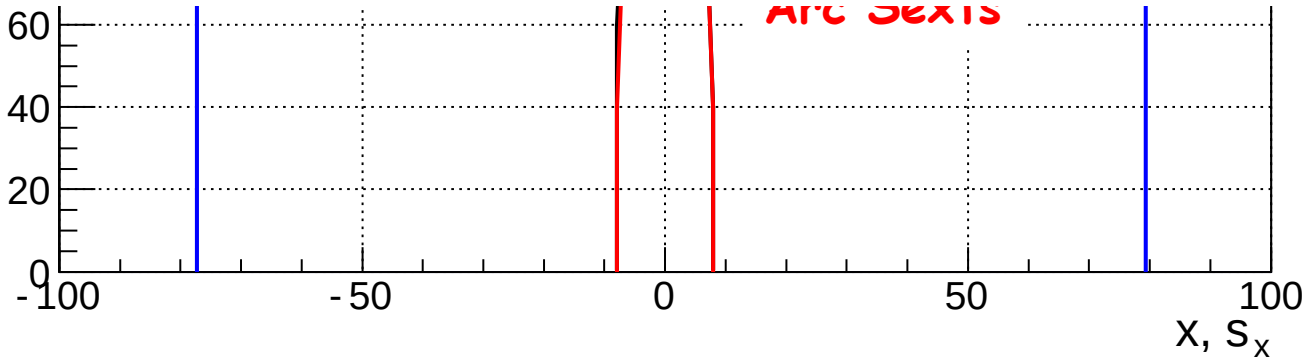
E = 175 GeV, Ex=1.3 nm·rad, 0.2% coupling



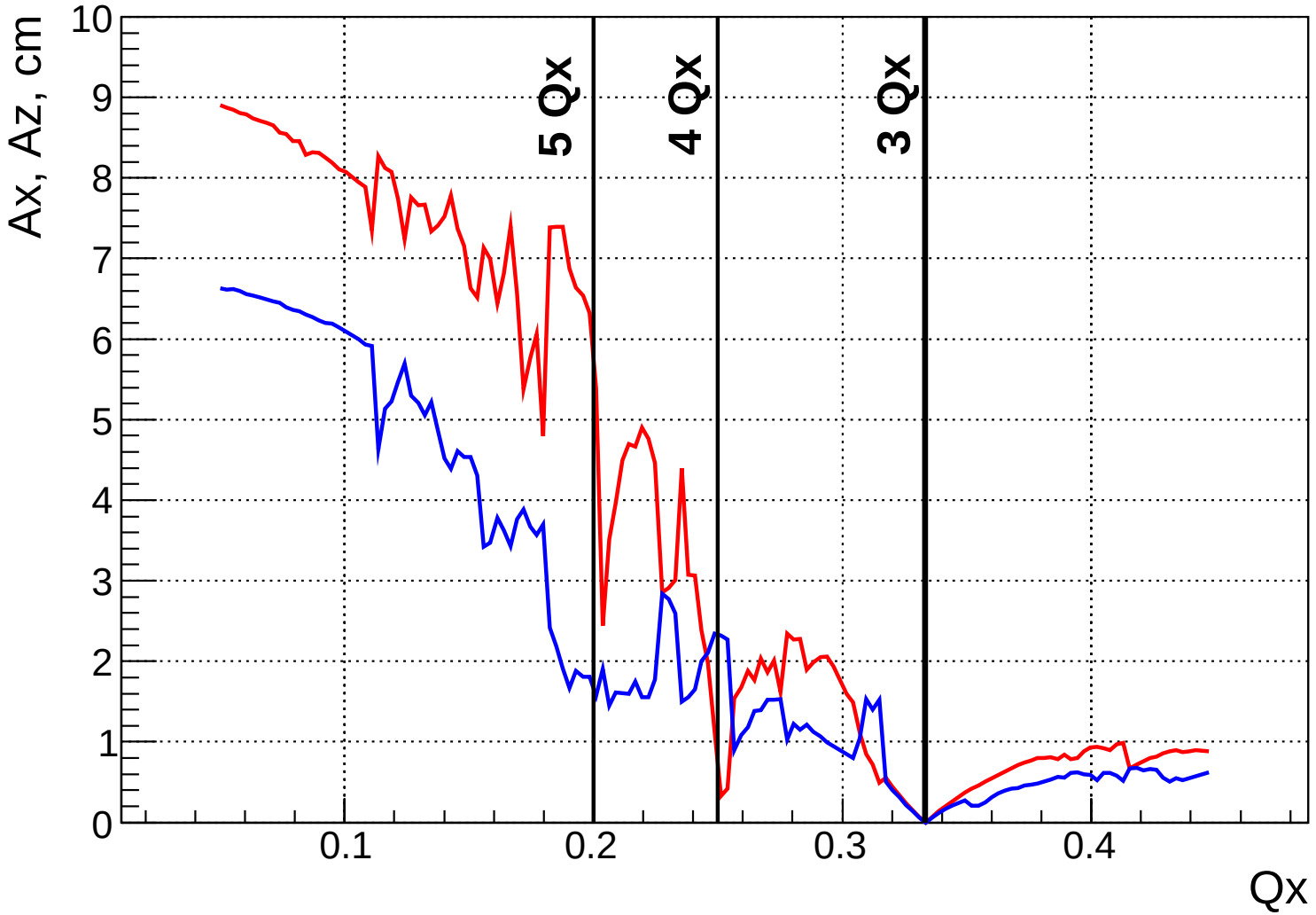
Dynamic Aperture is limited by the Arc's Sexts!

FODO Horizontal Phase Advance is 0.25

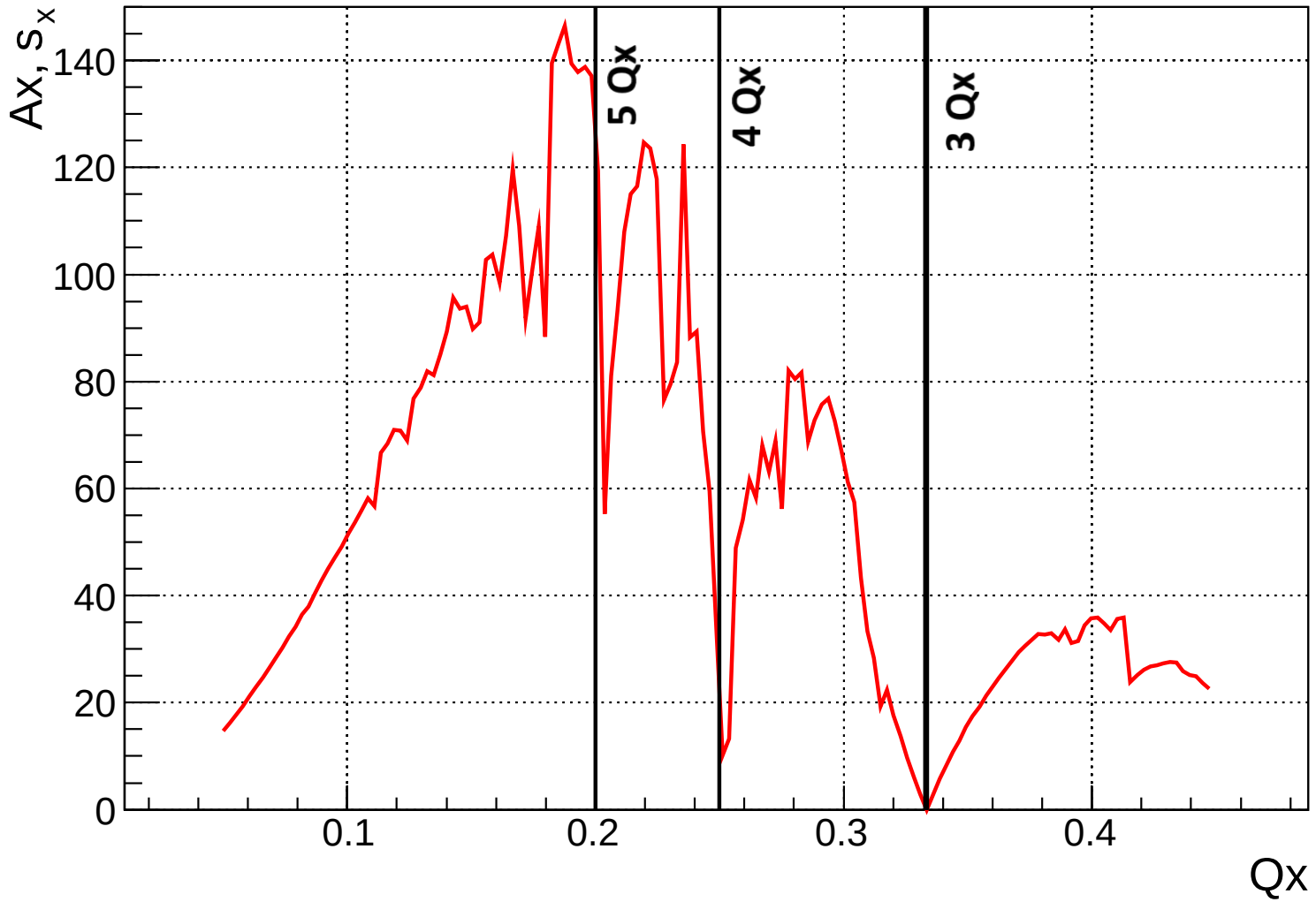
135 cells with resonance condition 4 Qx = 1



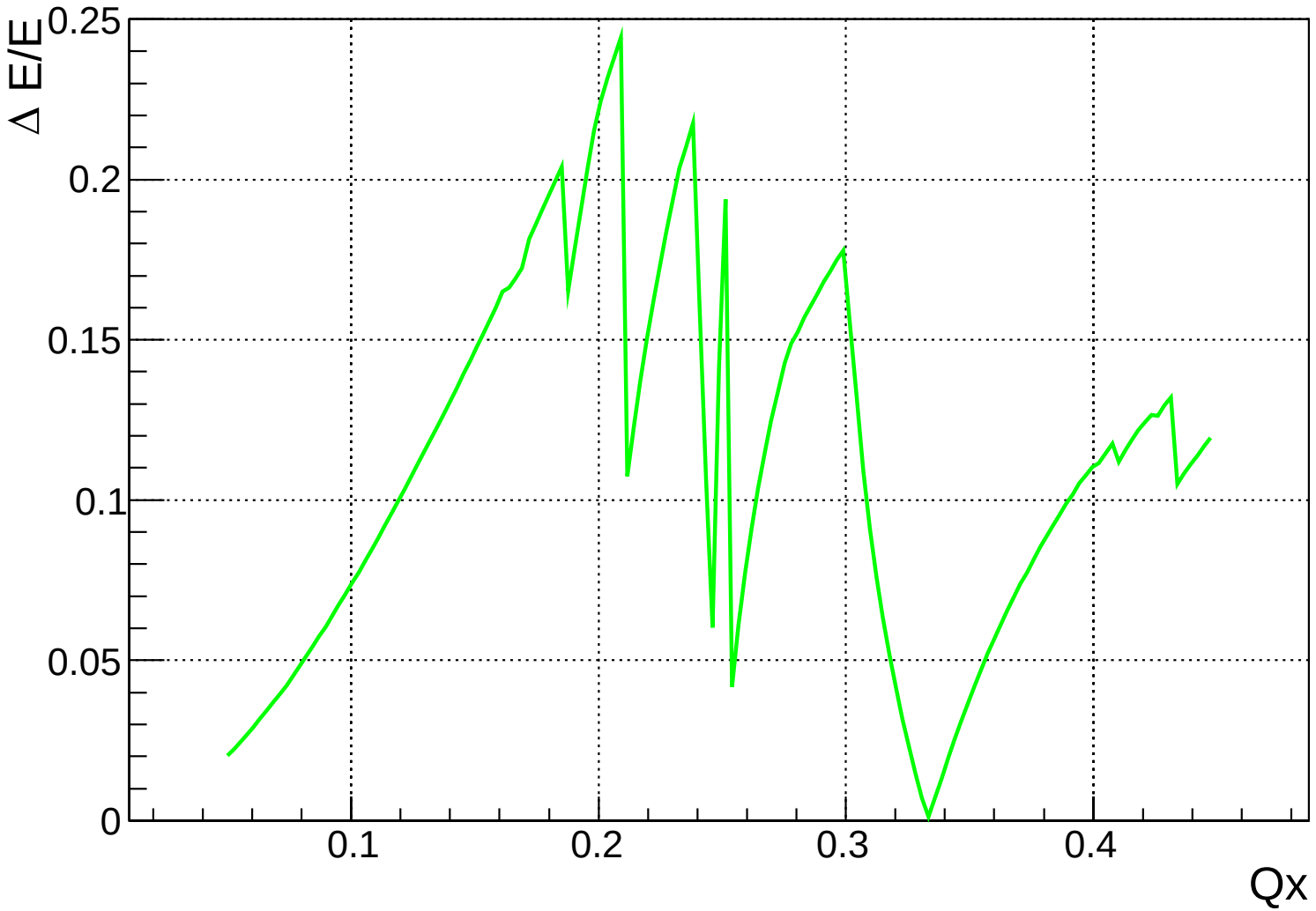
FODO DA vs Phase Advance



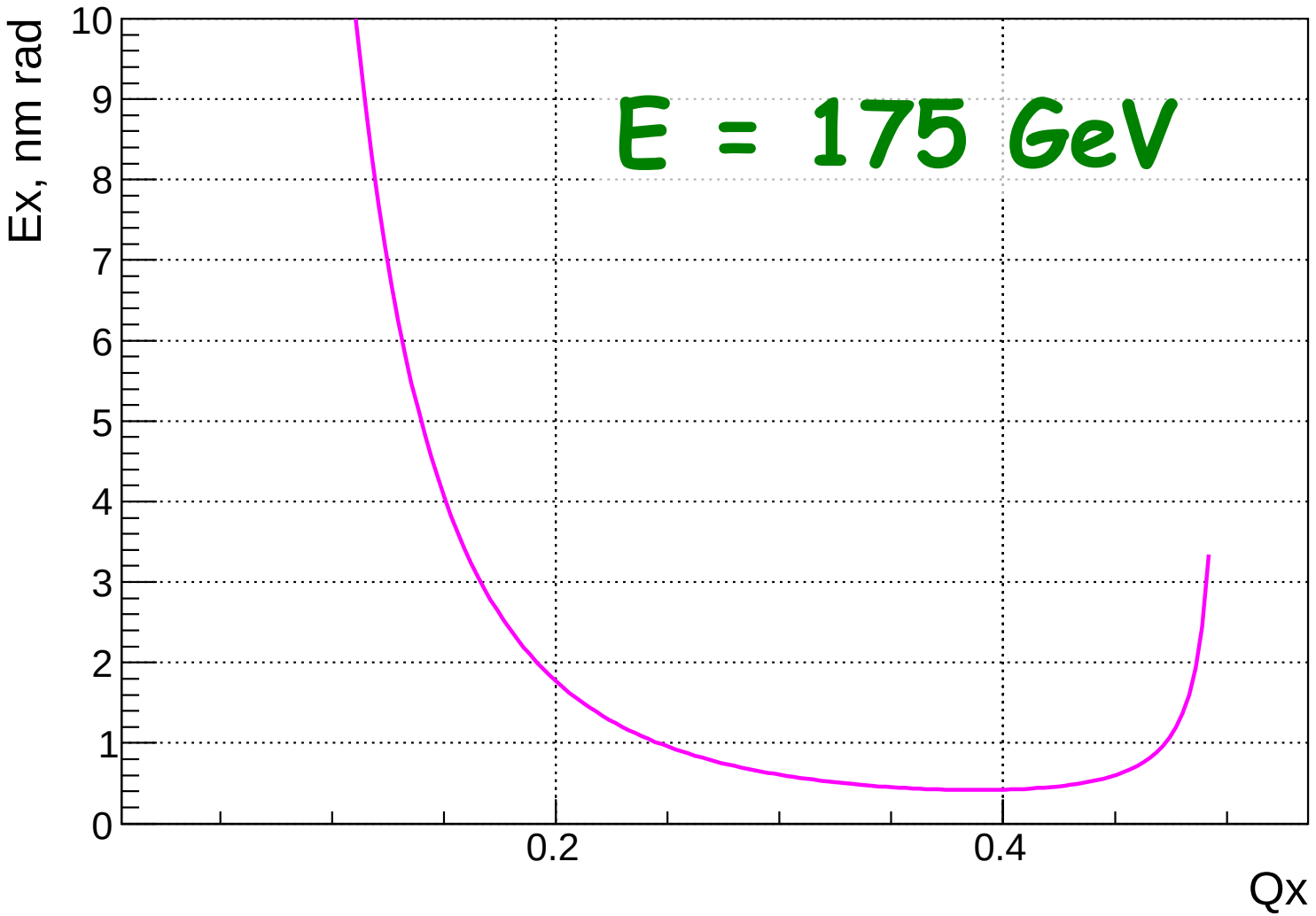
FODO DA vs Phase Advance



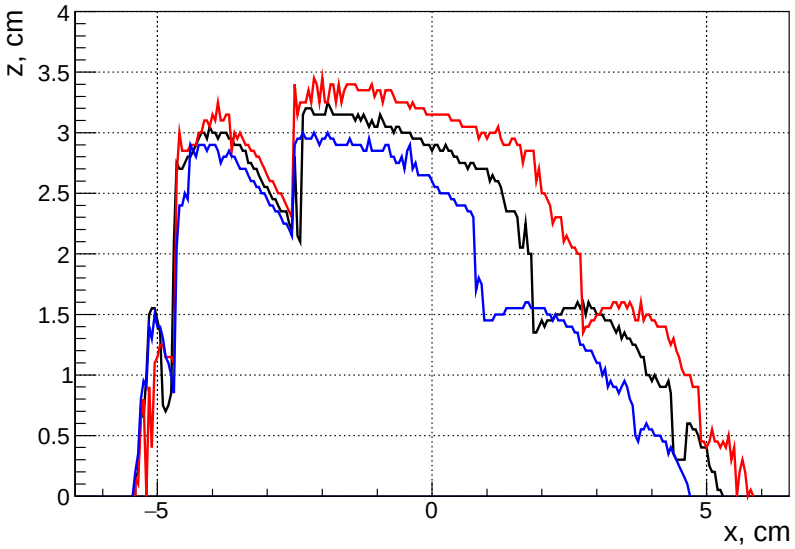
FODO Energy Acceptance



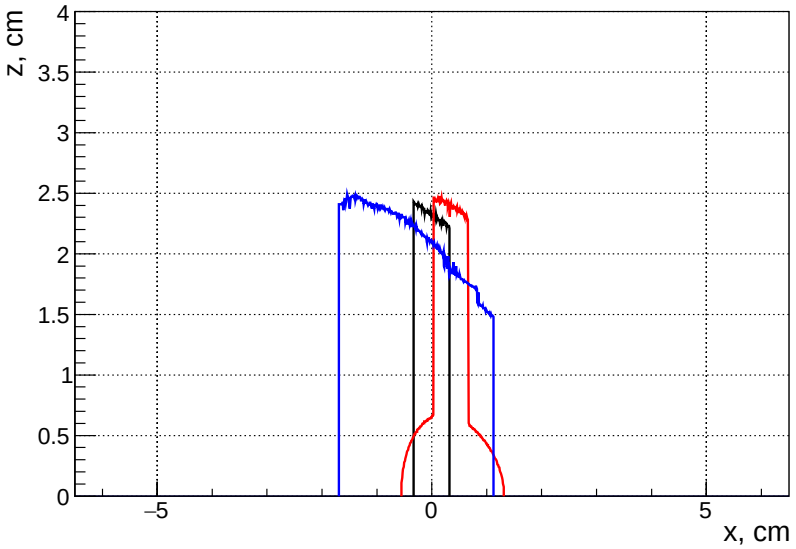
FODO Emittance vs Phase Advance



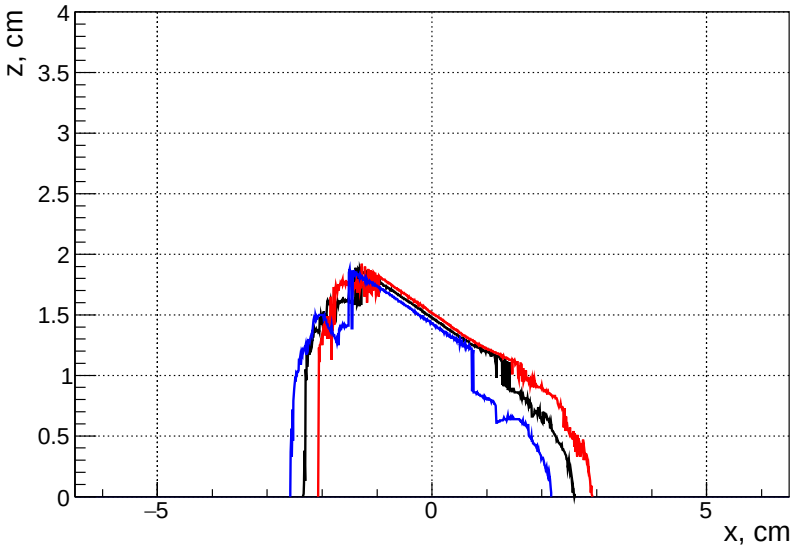
Qx=0.22, Ex=1.35 nm·rad



Qx=0.25, Ex=0.96 nm·rad



Qx=0.28, Ex=0.72 nm·rad

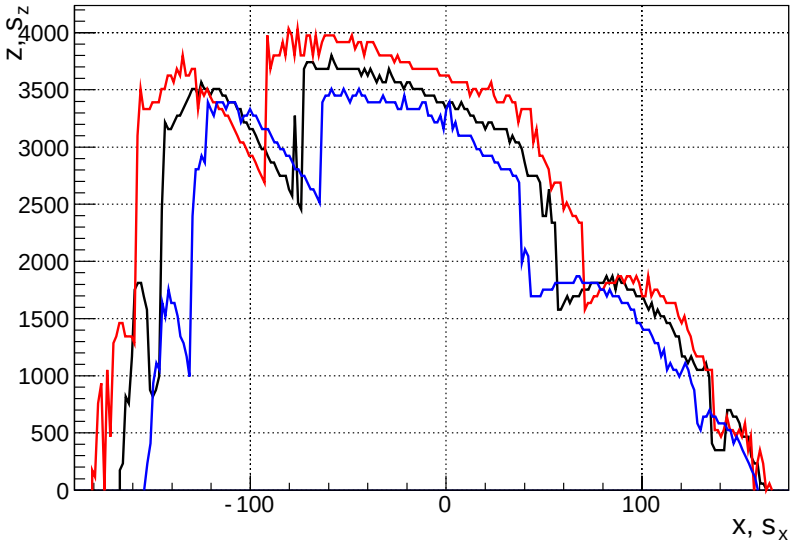


ΔE/E = -3%

ΔE/E = 0

ΔE/E = +3%

Qx=0.22, Ex=1.35 nm·rad



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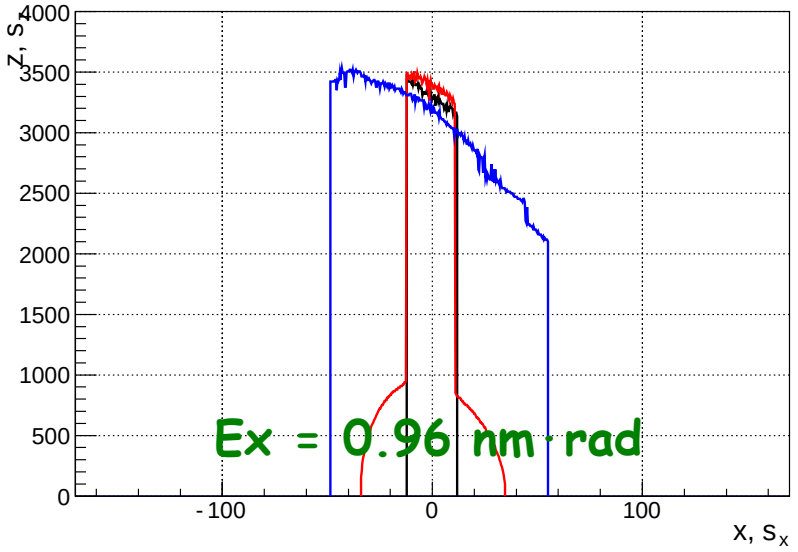

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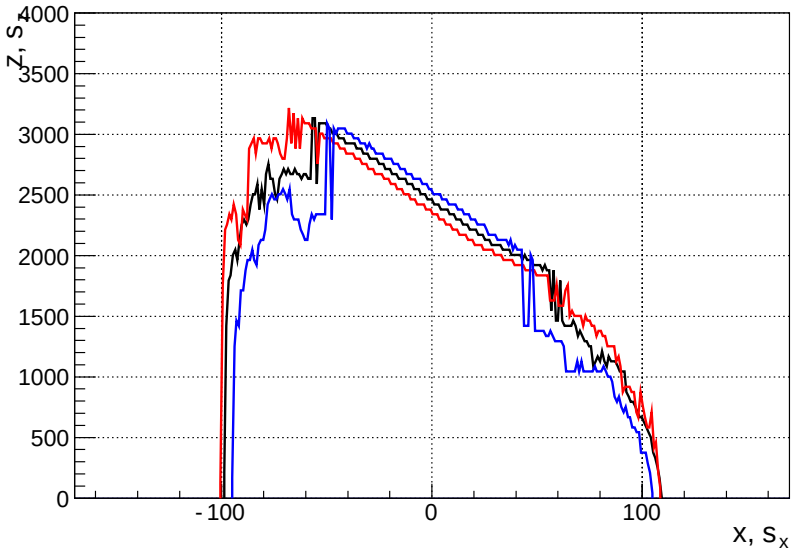

ΔE/E = -3%

ΔE/E = 0

ΔE/E = +3%

Plans

- Choose Optimal Phase Advance in FODO
- Check Dynamic Aperture & Energy Acceptance of the whole Ring w/o Interaction Region
- Choose several Sextupole families in Arcs?
- …