Review of FCC-ee Crab Waist Option
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Dynamic Aperture and Momentum Acceptance of FCCee

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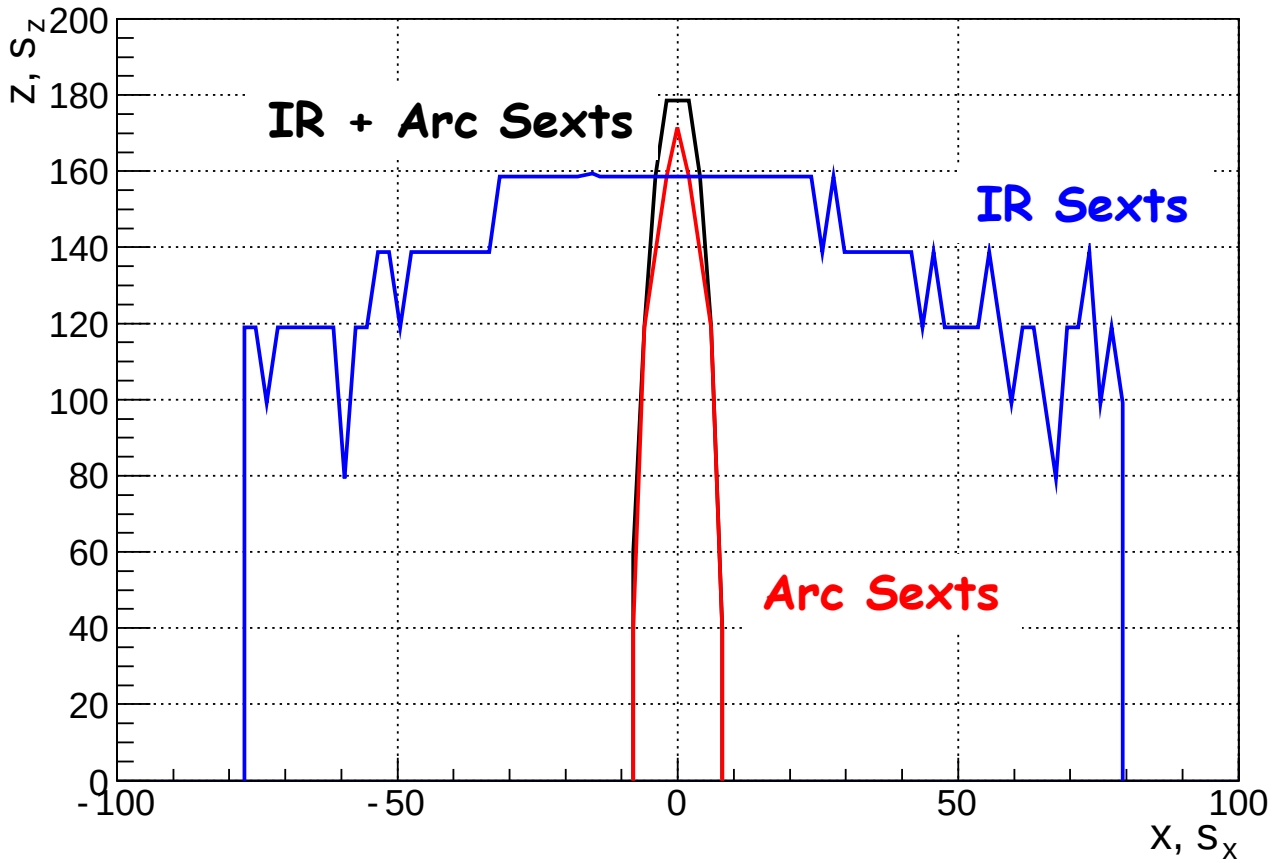
Version 6.14.3

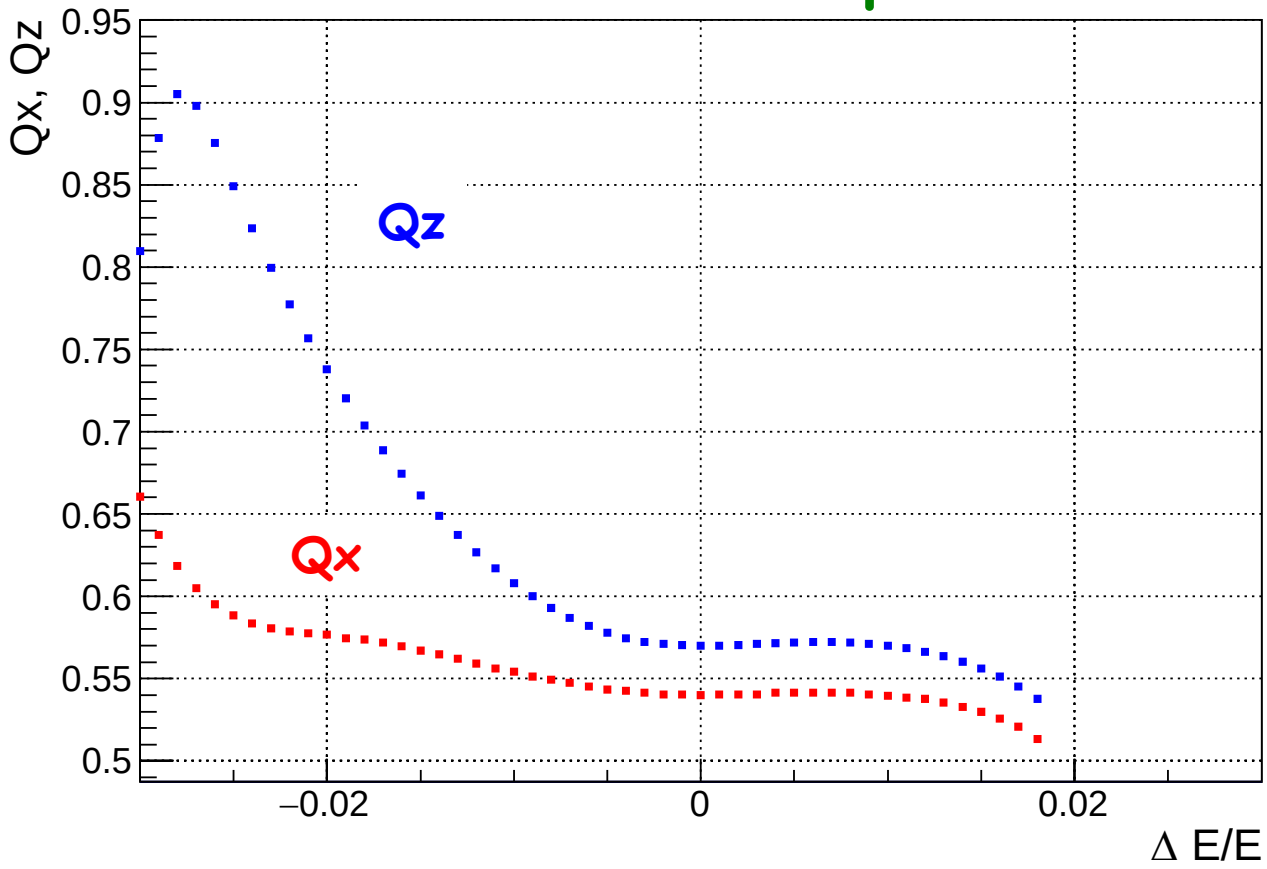
1000 turns without damping



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

Version 6.14.3

1024 turns without damping, rf off
small betatron amplitudes



Version 16.14.3

- Symmetric FODO cell
- FODO phase advance
  - dQx = 0.25 → 0.22, dQz=0.1667
- I-transformation for RF-section, telescope transformation for IP-section
- Optimization DA & EA by IR's sexts
  - Main sexts MSY1, MSY3 & MSX1, MSX3
  - Comp sexts MSY2, MSY4 & MSX2, MSX4
  - Chrom sexts MSY5 & MSX5
- Only two sext families in arcs MSF & MSD

Optimal phase advance between arcs

Telescope Transformation
dQx=n, dQz=n

I Transformation
dQx=n, dQz=n

$$M = \begin{vmatrix} \sqrt{\beta_1/\beta_2} & 0 \\ 0 & \sqrt{\beta_1/\beta_2} \end{vmatrix}$$

- Total tune for 1/4 Ring

  $Qx = 2\,Nx_{IR} + 2\,Nx_{RF} + 3 \cdot 132\,dQx_{FODO}$

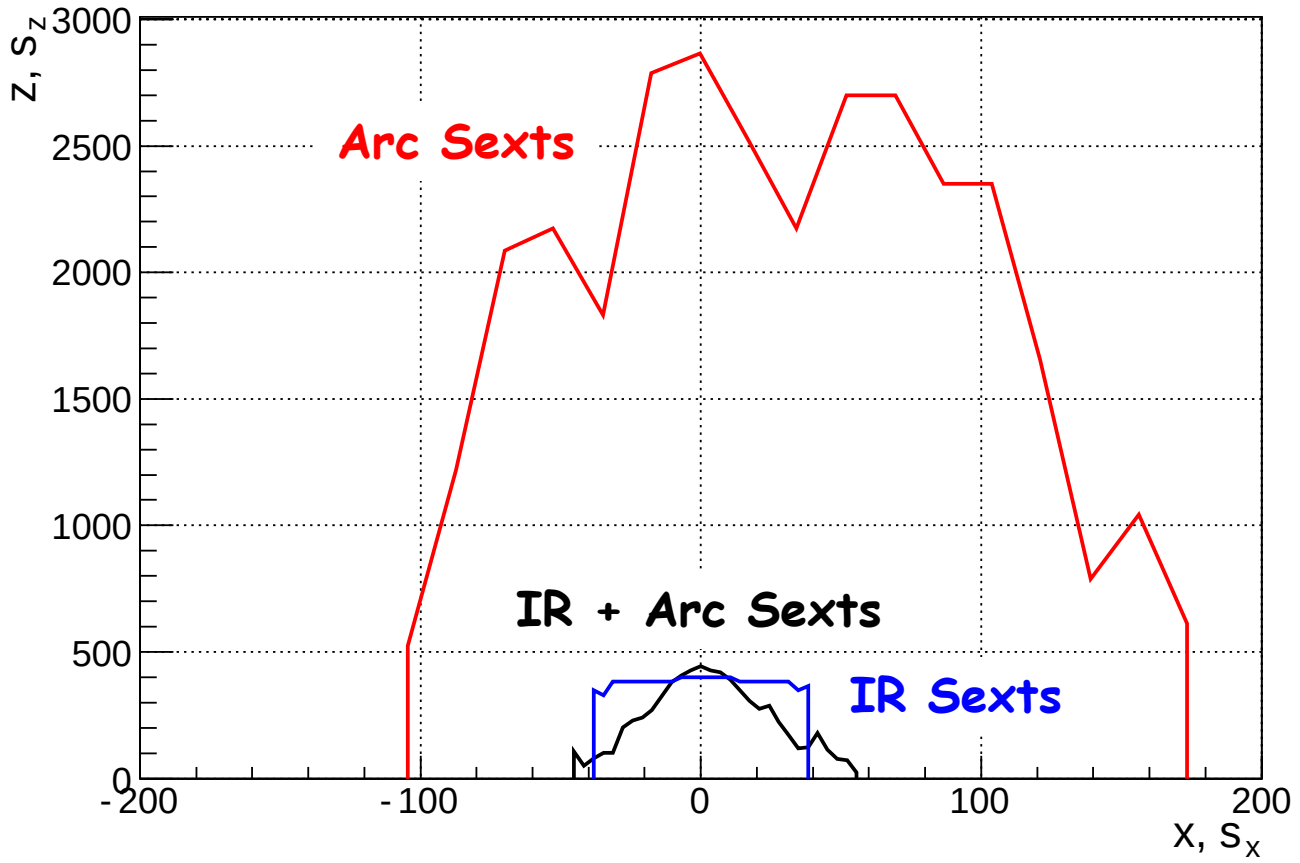
  $Qz = 2\,Nz_{IR} + 2\,Nz_{RF} + 3 \cdot 132\,dQz_{FODO}$
- Fractional tune will be determined by dQ_{FODO}
- Variation of the total tunes and the emittance by dQ_{FODO}

Parameters

Version	6.14.3	16.14.3	Units
Energy	175		GeV
Length	24.656	24.987	km
Tunes	124.54/87.57	110.54/87.57	
Natural chroms	-154.6/-826.5	-138.8/-828.4	
Emittance	1.28	1.66	nm·rad
Energy spread	$1.60 \cdot 10^{-3}$	$1.62 \cdot 10^{-3}$	
Compaction factor	$5.82 \cdot 10^{-6}$	$7.11 \cdot 10^{-6}$	

Dynamic Aperture

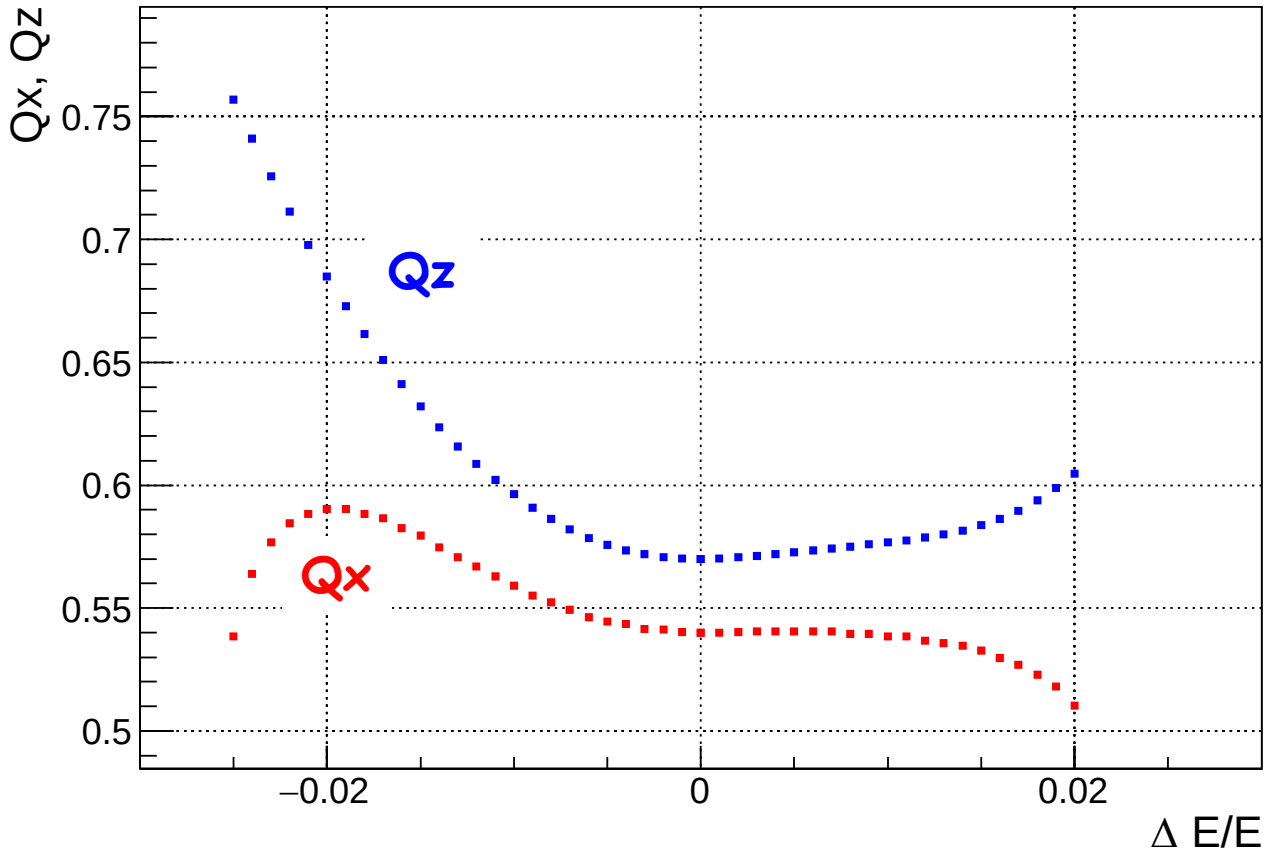
1000 turns without damping



E = 175 GeV, Ex=1.7 nm·rad, 0.2% coupling

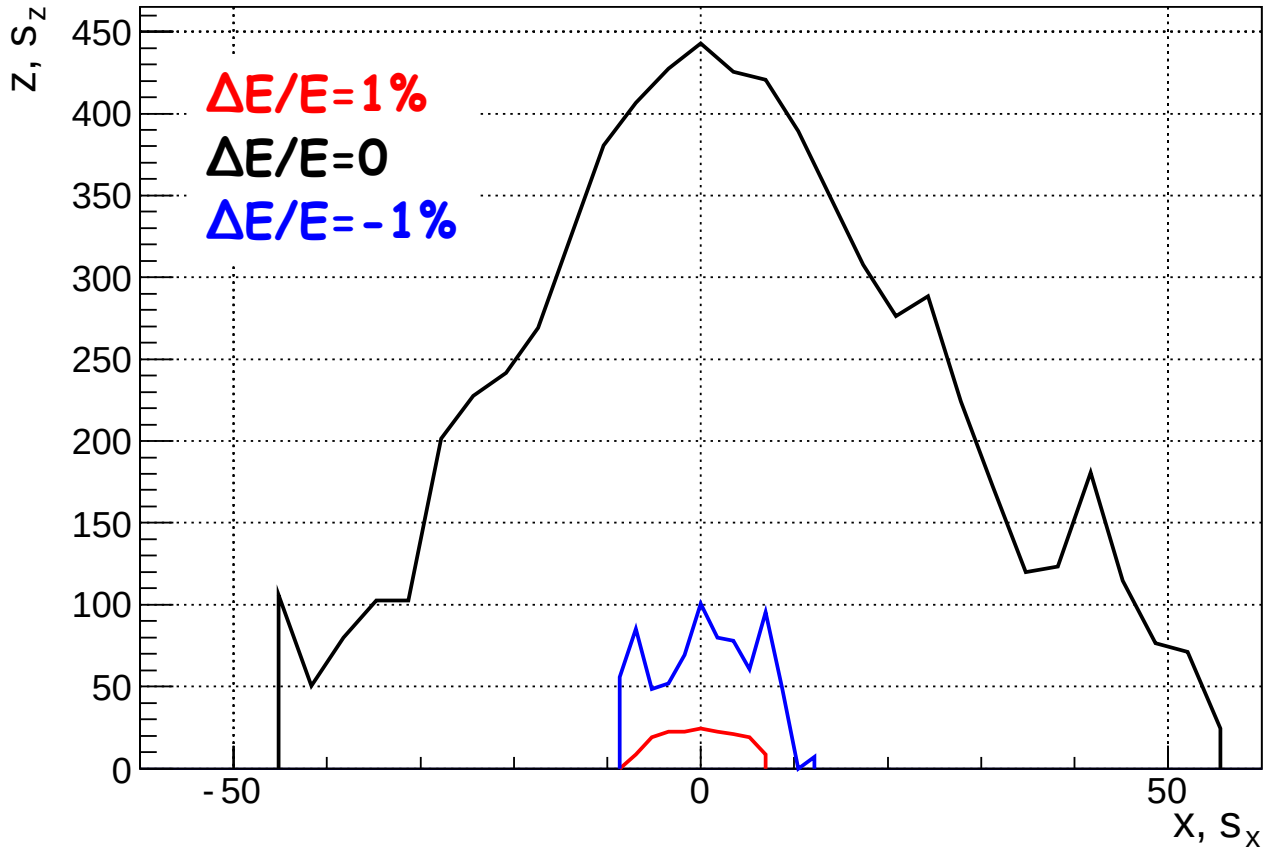
Energy Acceptance

1024 turns without damping, rf off
small betatron amplitudes



Off Energy Dynamic Aperture

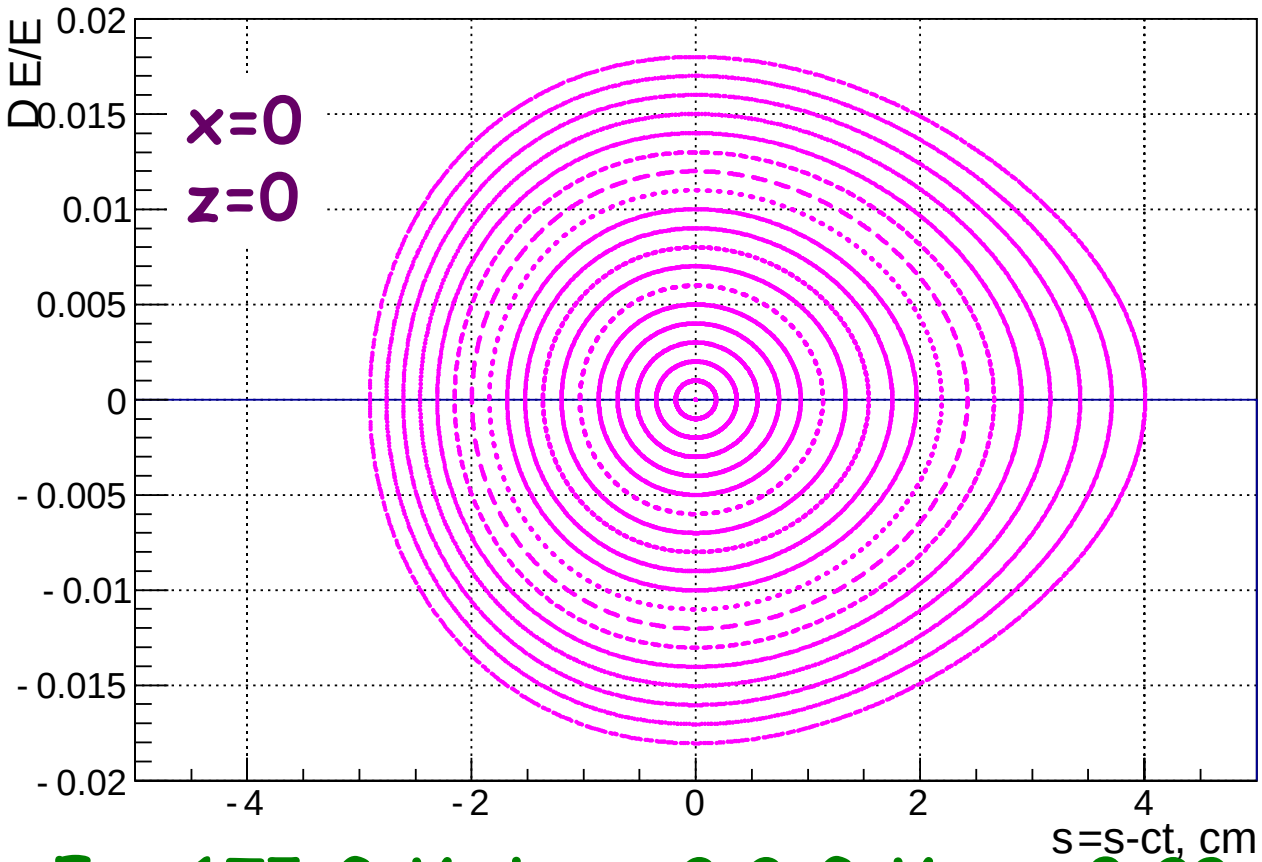
1000 turns without damping, rf off



E = 175 GeV, Ex=1.7 nm·rad, 0.2% coupling

Energy Acceptance

1000 turns without damping, rf on

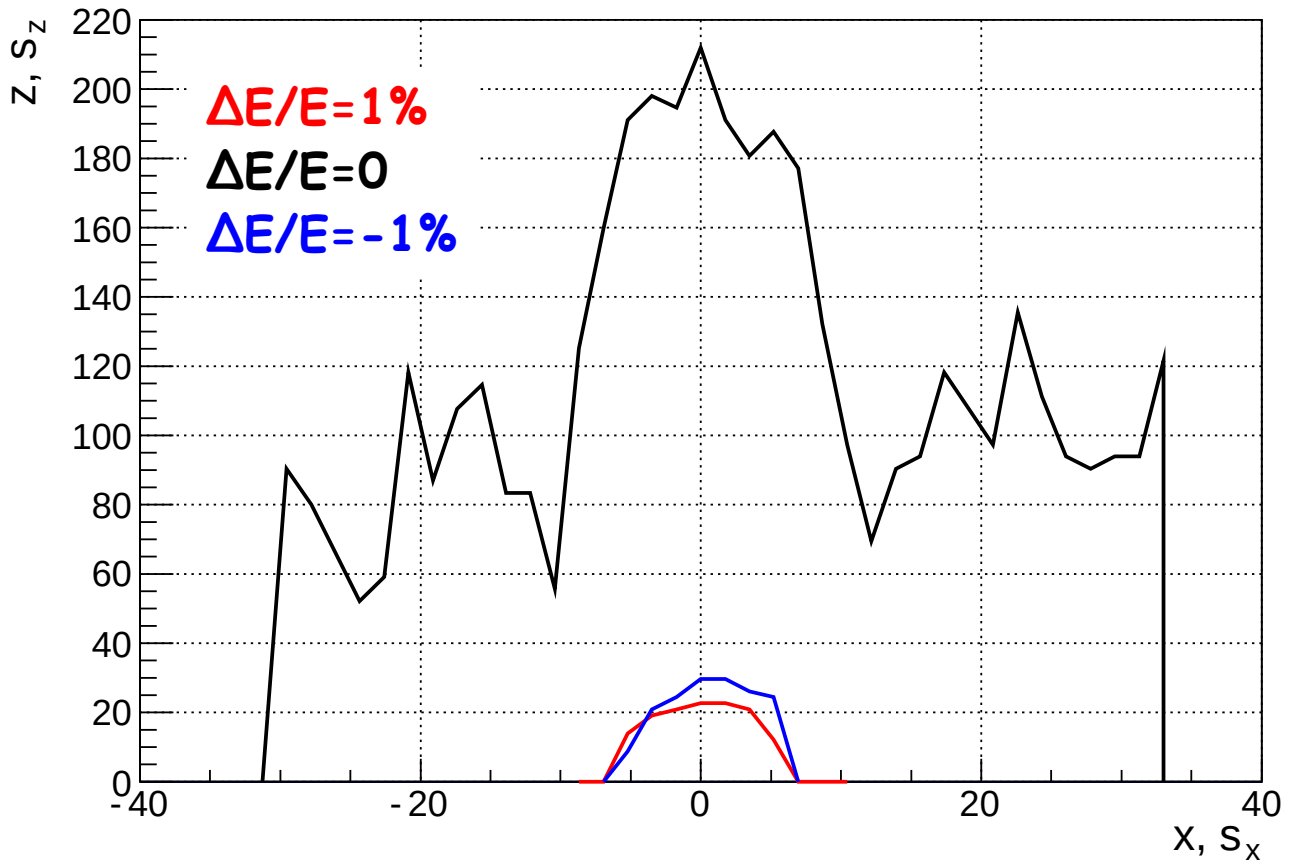


E = 175 GeV, Loss=2.2 GeV, σ_s=0.29 cm

Frf=500 MHz, Urf=120x20 MV, ϕ_{rf}=112.6°, Qs=0.0158

Off Energy Dynamic Aperture

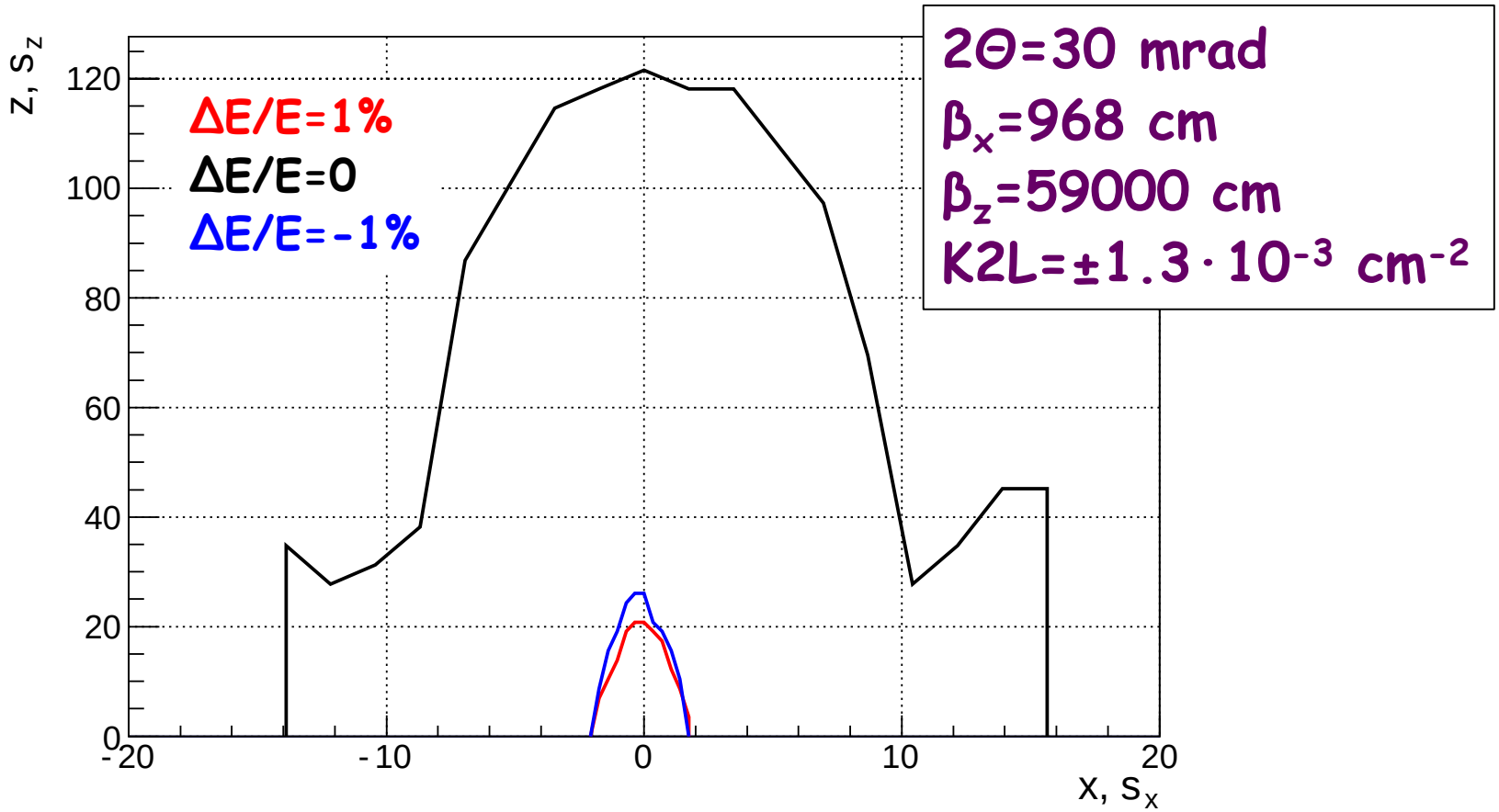
1000 turns without damping, rf on



E = 175 GeV, Ex=1.7 nm·rad, 0.2% coupling

Thin Crab Sexts

1000 turns without damping, rf on



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Thin Crab Sexts

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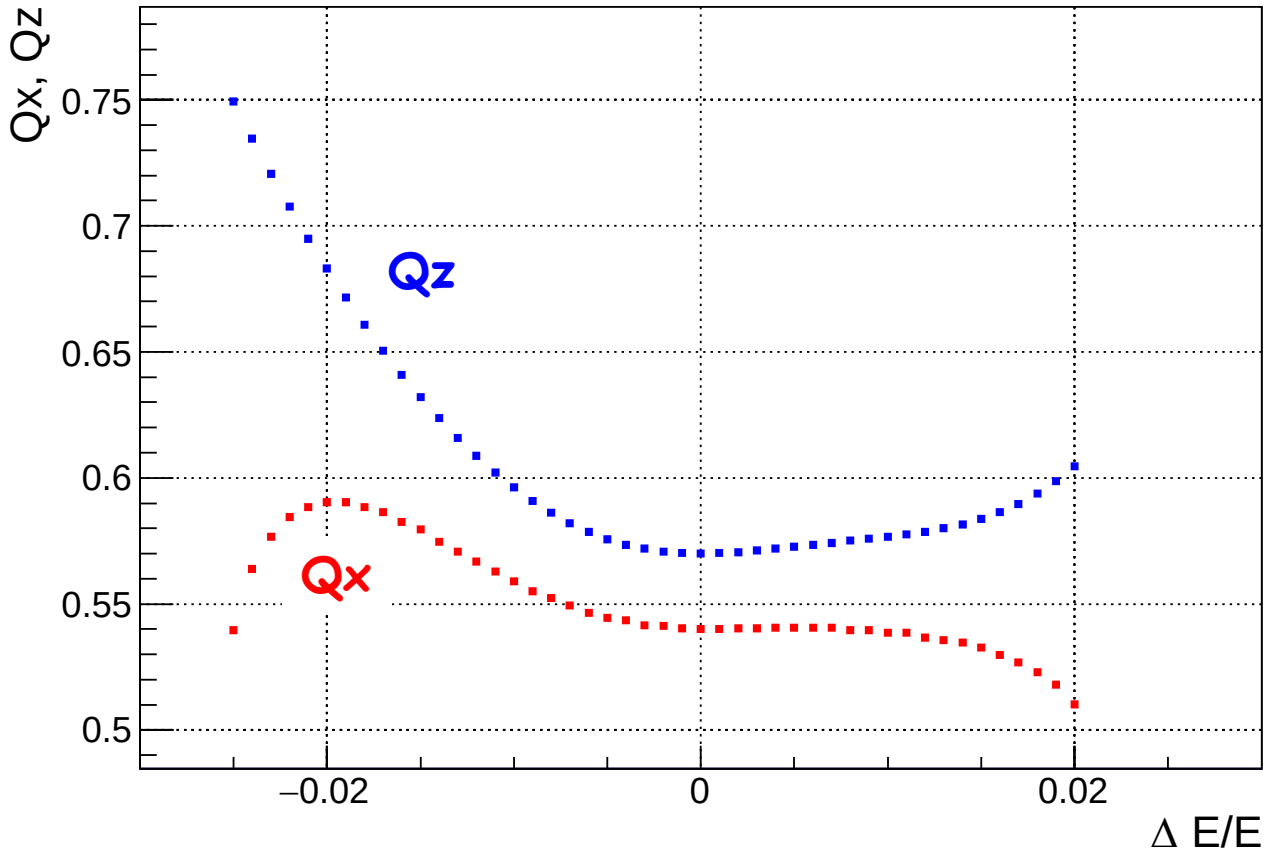

Summary

- Now FODO arcs do not limit DA and MA ($100\sigma_x \times 2500\sigma_z$)
- Strong IR chromatic sextupoles reduce the DA to $50\sigma_x \times 450\sigma_z$
- Crab sextupoles additionally reduce the DA to $14\sigma_x \times 120\sigma_z$ at $\Delta E/E=0\%$ and to unacceptable $5\sigma_x \times 20\sigma_z$ at $\Delta E/E=\pm 1\%$
- Further optimization is necessary

Plans

- Off energy DA optimization
- Simulation with damping
- Introduce kinematic term and quadrupole fringe fields in model
- Crab sextupole study
- Errors & misalignments, etc…