Advanced Scaling FFAG egg-shape design study for PRISM

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FFAG12 - Nov. 2012

Outline

- "Egg-shape" design parameters
- Linear fringe field fall-offs
- Enge functions field fall-offs
- Conclusion

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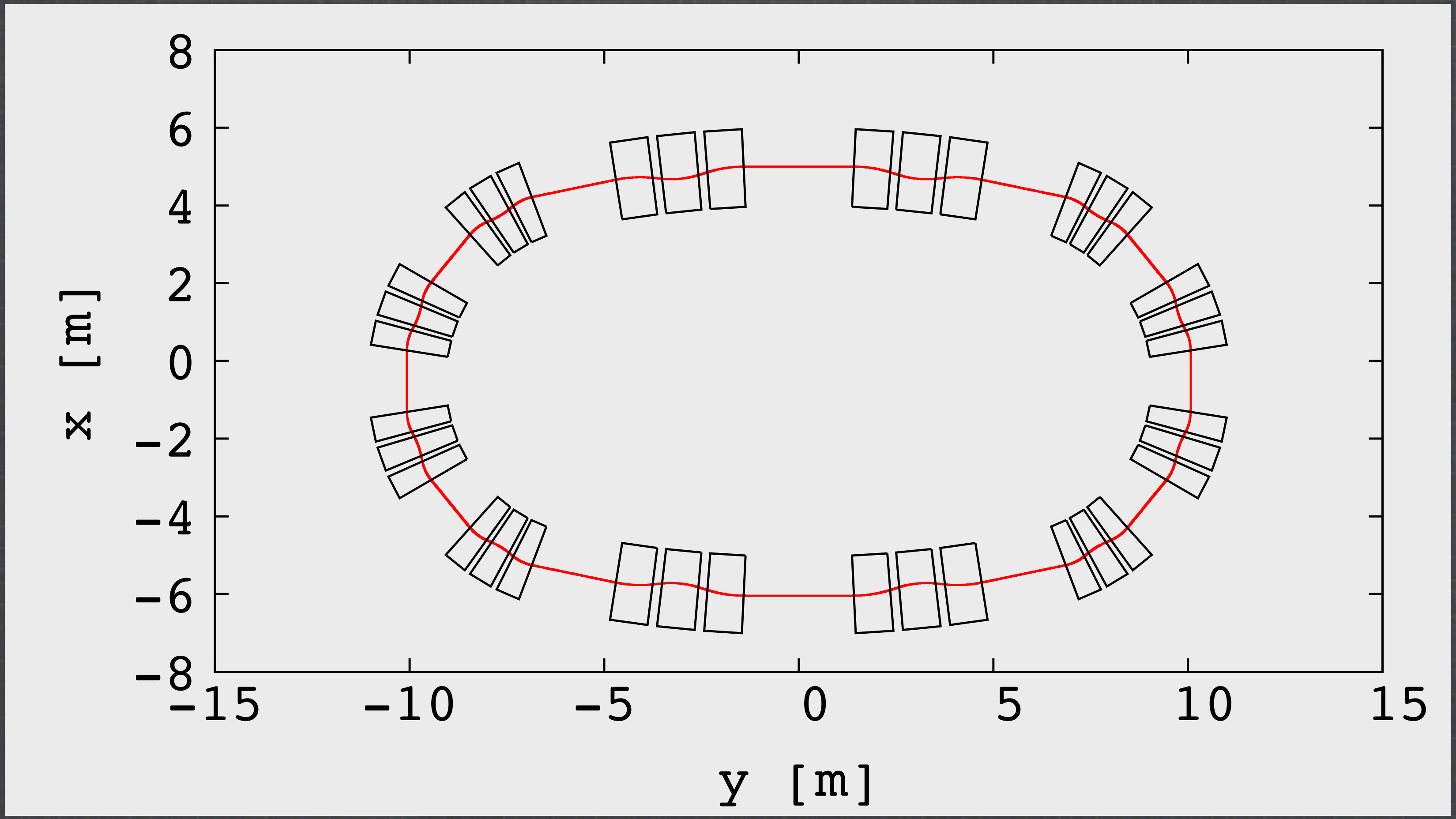
Egg-shape design

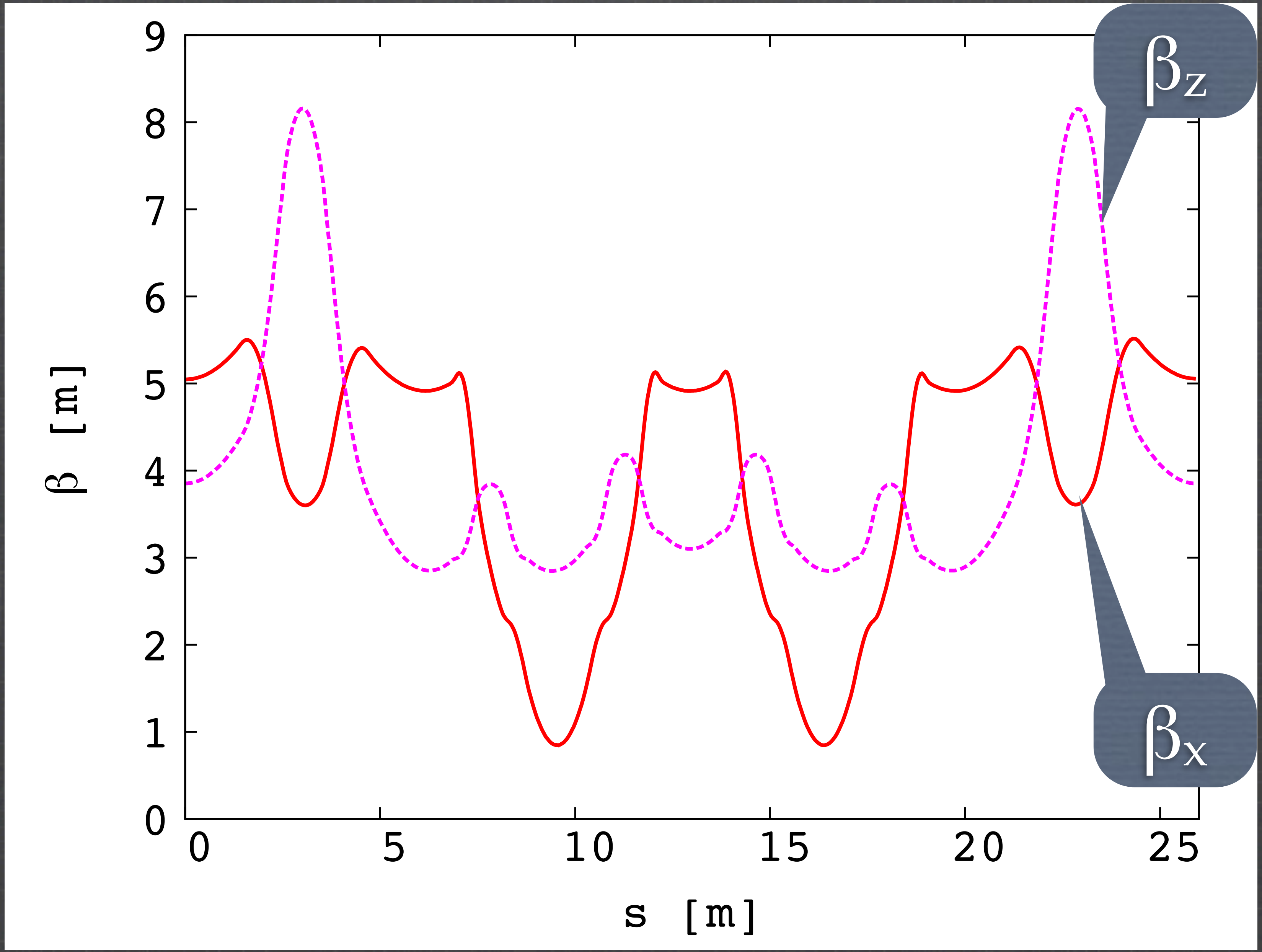
Small Bending cell FDF triplet	
k-value	3.82
total bending angle	39.15 deg.
Average radius	5 m
Phase advances:	
Horizontal μ_x	90 deg.
Vertical μ_z	60 deg.
Dispersion	1 m

Large Bending cell FDF triplet	
k-value	28.9503
total bending angle	11.7 deg.
Average radius	30 m
Phase advances:	
Horizontal μ_x	75 deg.
Vertical μ_z	81 deg.
Dispersion	1 m



Betafunctions

Horizontal (plain red) and vertical (dotted purple) betafunctions of half the ring in egg-shape PRISM



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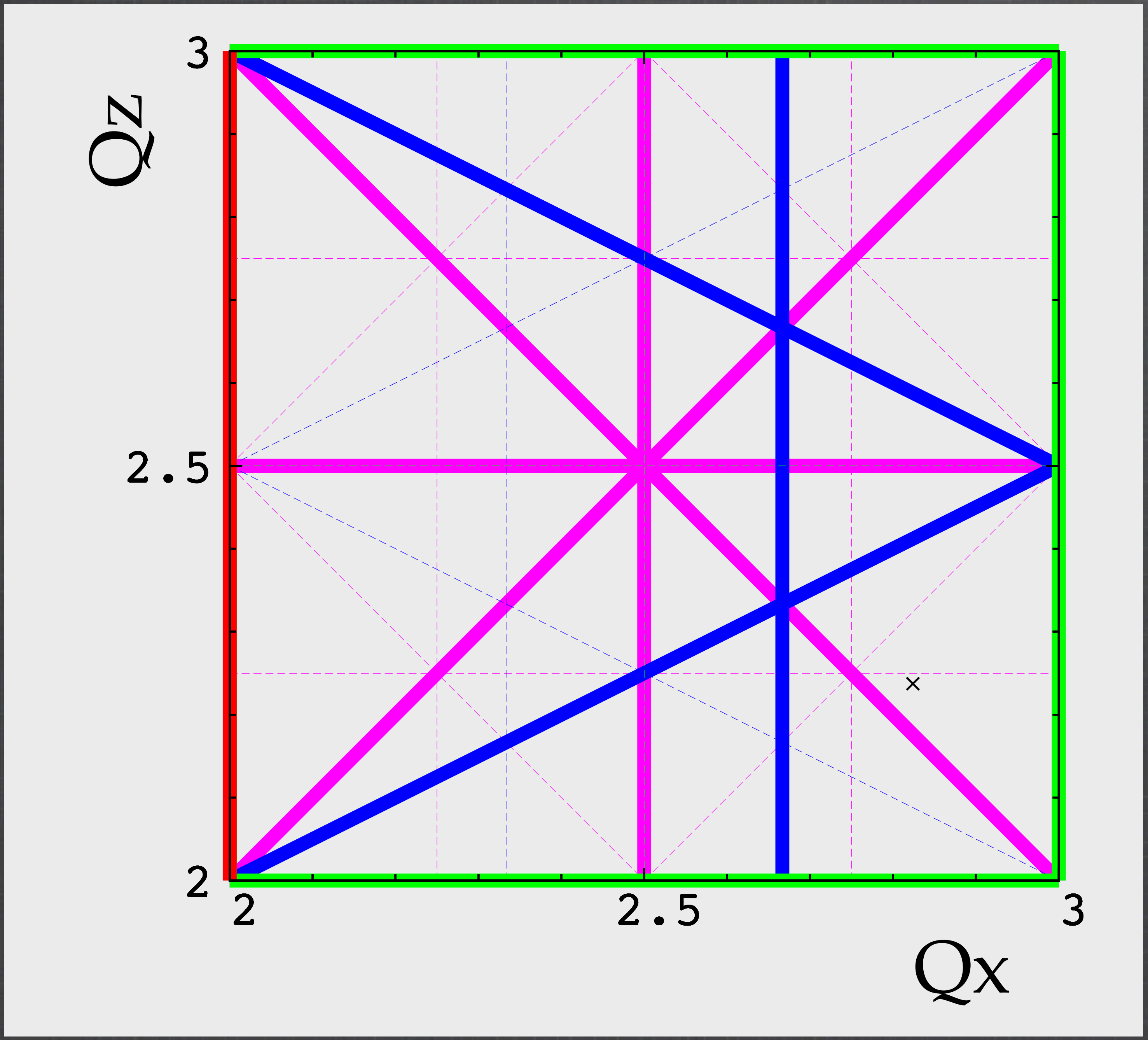
Tune point



Working point of the ring in the tune diagram. Integer (red), quadrupole (green), sextupole (blue) and octopole (purple) normal resonances are plotted.

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Linear fringe field fall-offs

- To simulate fringe fields, linear fall-offs are used first.

$$B_z(r,\theta) = B_0\,\mathcal{F}(\theta)\,\left(\frac{r}{r_0}\right)^k$$

$$\begin{cases} \mathcal{F} = \dfrac{\theta - \Theta_{EFB_{en}} + \Theta_{FE_{en}}}{2\Theta_{FE_{en}}},\ \text{for } \Theta_{EFB_{en}} - \Theta_{FE_{en}} \leq \theta < \Theta_{EFB_{en}} + \Theta_{FE_{en}} \\ \mathcal{F} = 1,\ \text{for } \Theta_{EFB_{en}} + \Theta_{FE_{en}} \leq \theta < \Theta_{EFB_{ex}} - \Theta_{FE_{ex}} \\ \mathcal{F} = 1 - \dfrac{\theta - \Theta_{EFB_{ex}} + \Theta_{FE_{ex}}}{2\Theta_{FE_{ex}}},\ \text{for } \Theta_{EFB_{en}} + \Theta_{FE_{en}} \leq \theta < \Theta_{EFB_{ex}} - \Theta_{FE_{ex}} \\ \mathcal{F} = 0,\ \text{for } \theta < \Theta_{EFB_{en}} - \Theta_{FE_{en}} \text{ or } \theta \geq \Theta_{EFB_{ex}} - \Theta_{FE_{ex}}, \end{cases}$$

- 1st order interpolation off the mid-plane.

Linear fringe field fall-offs

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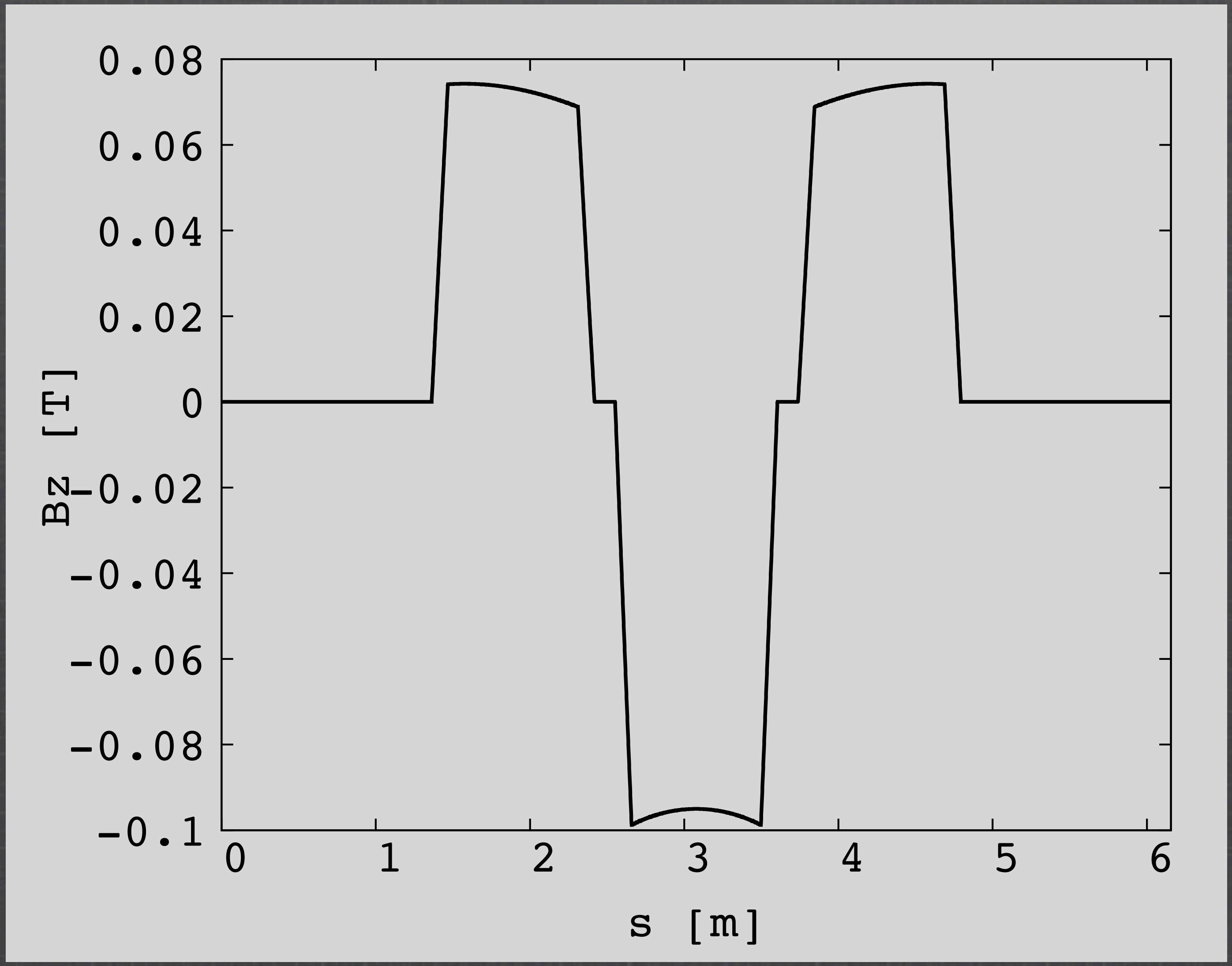
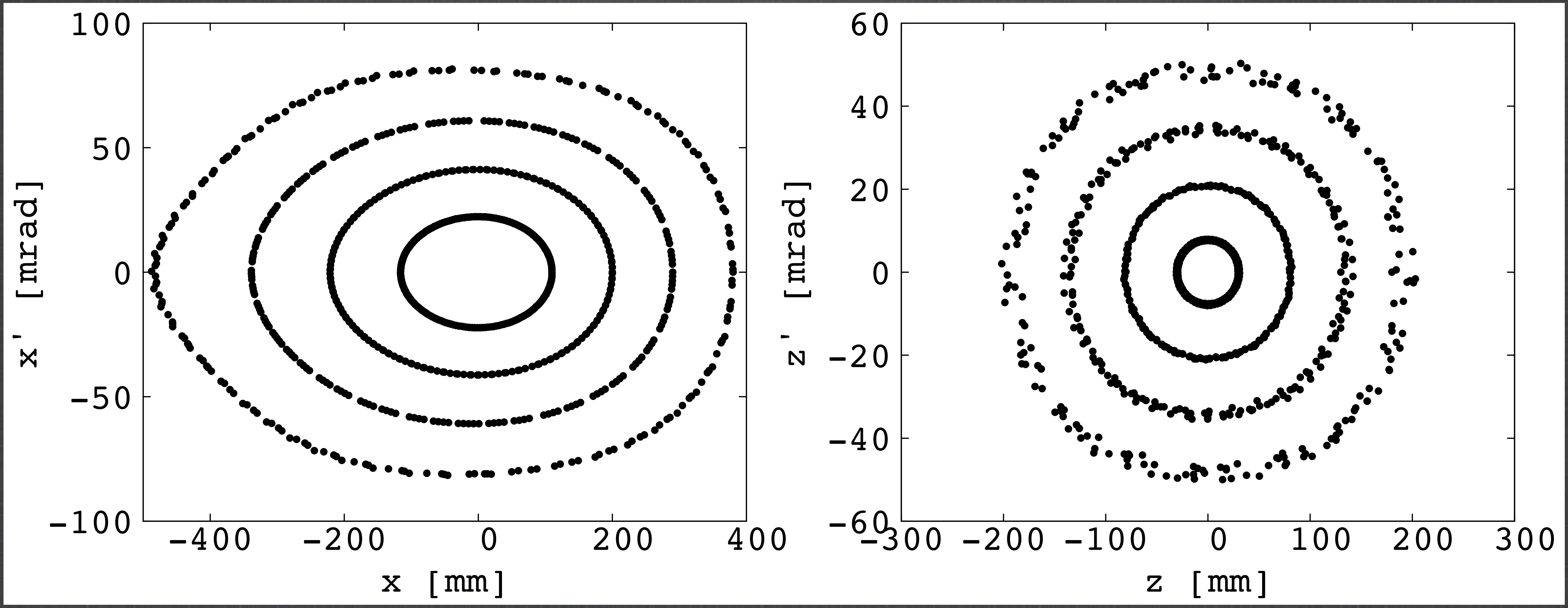


- 1st order interpolation off the mid-plane.

Linear case: Dynamic aperture study

≈40 000 π mm.mrad ≈8 000 π mm.mrad



Horizontal (left) and vertical (right) maximum stable amplitude over 100 turns. Far collimators identify lost particles.

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Enge fringe field fall-offs

- To check validity of dynamic aperture, enge fall-offs are then used.

$$B_z(r,\theta) = B_0\,\mathcal{F}(\theta)\,\left(\frac{r}{r_0}\right)^k$$

$$\mathcal{F}(\theta) = \mathcal{F}_{en}(\theta) \times \mathcal{F}_{ex}(\theta)$$

$$\text{with} \begin{cases} \mathcal{F}_{en}(\theta) = \dfrac{1}{1+e^{C_1(\Theta_{EFB_{en}}-\theta)}}, \\ \mathcal{F}_{ex}(\theta) = \dfrac{1}{1+e^{C_1(\theta-\Theta_{EFB_{ex}})}} \end{cases}$$

- 4^{th} order interpolation off the mid-plane.

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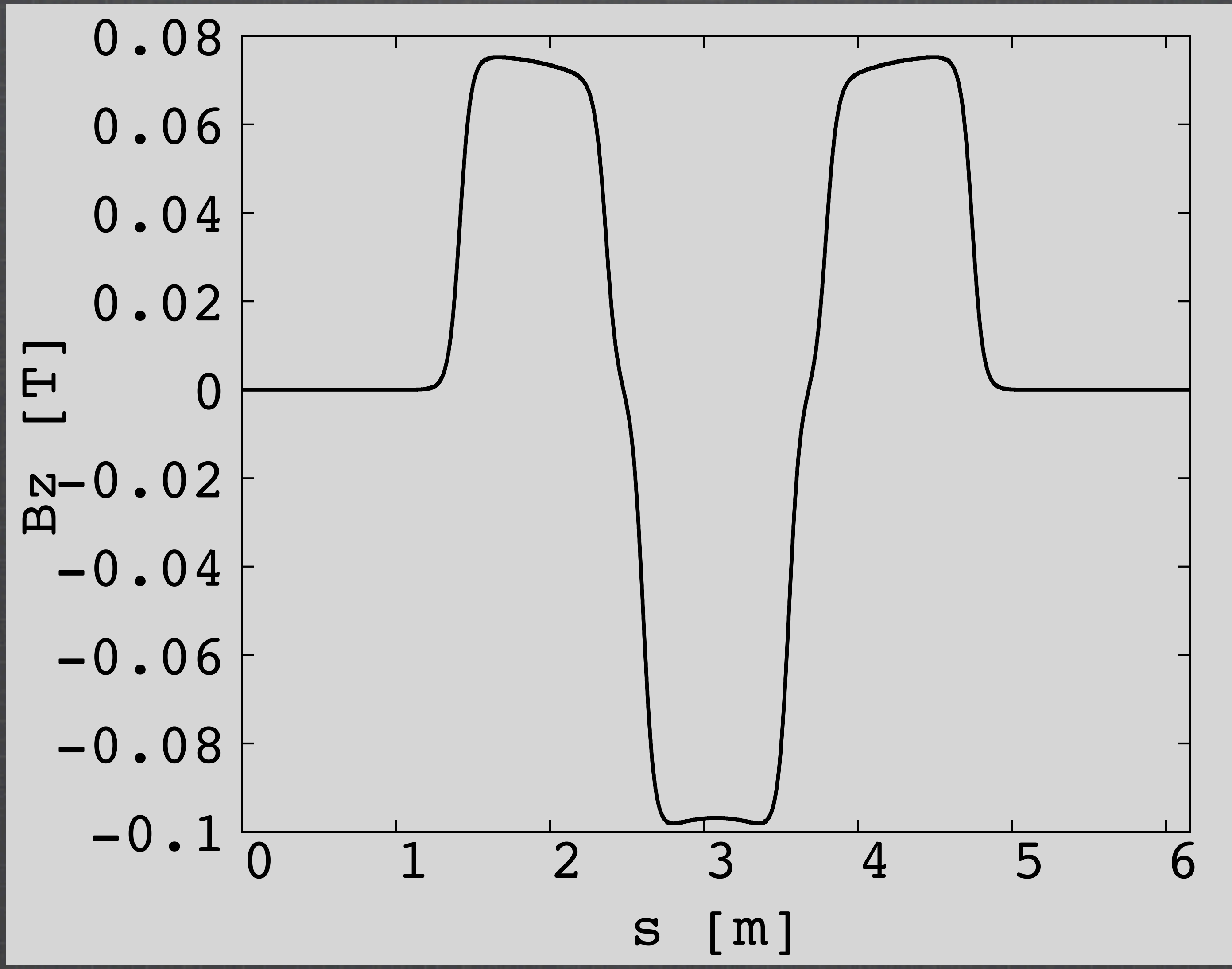

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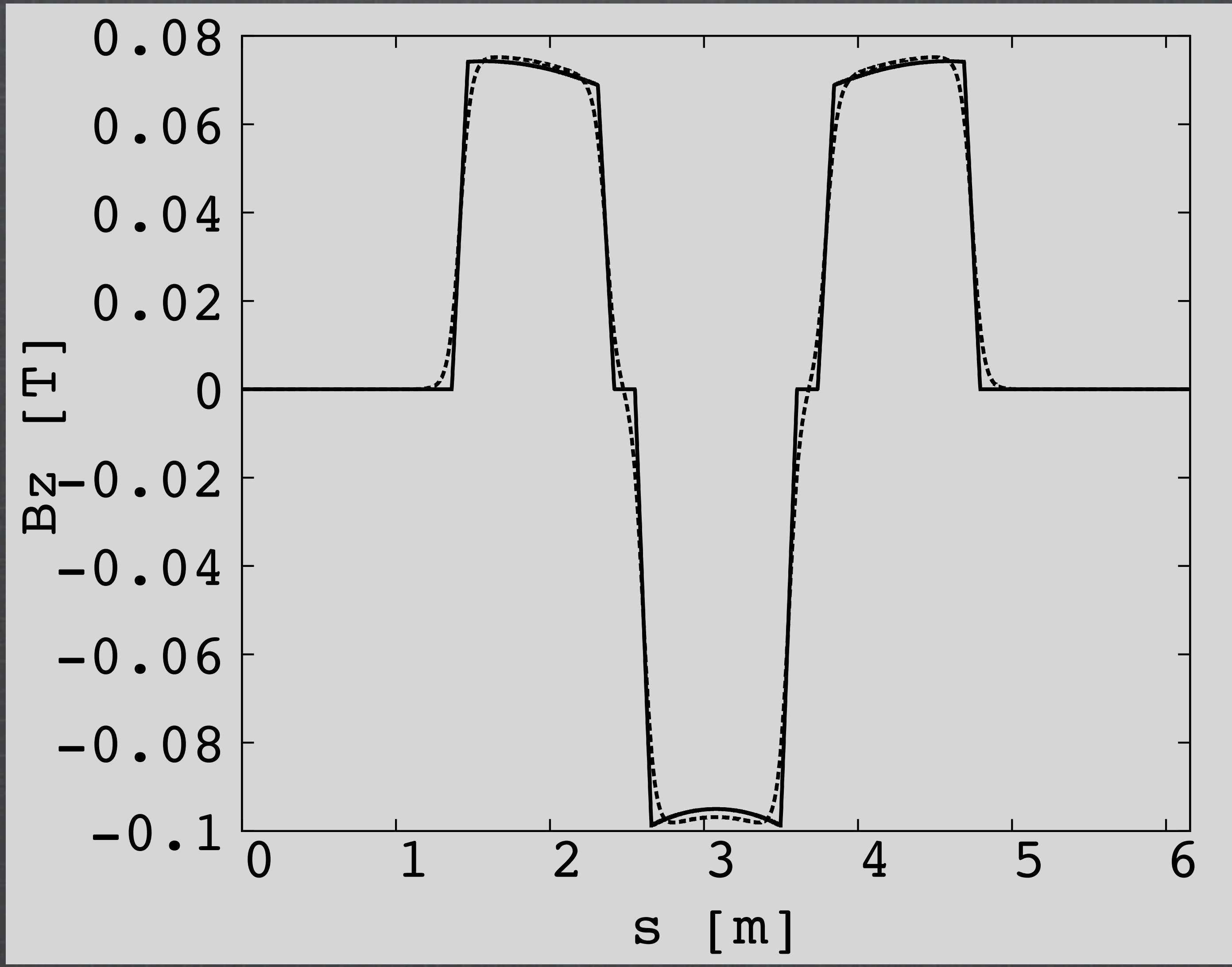
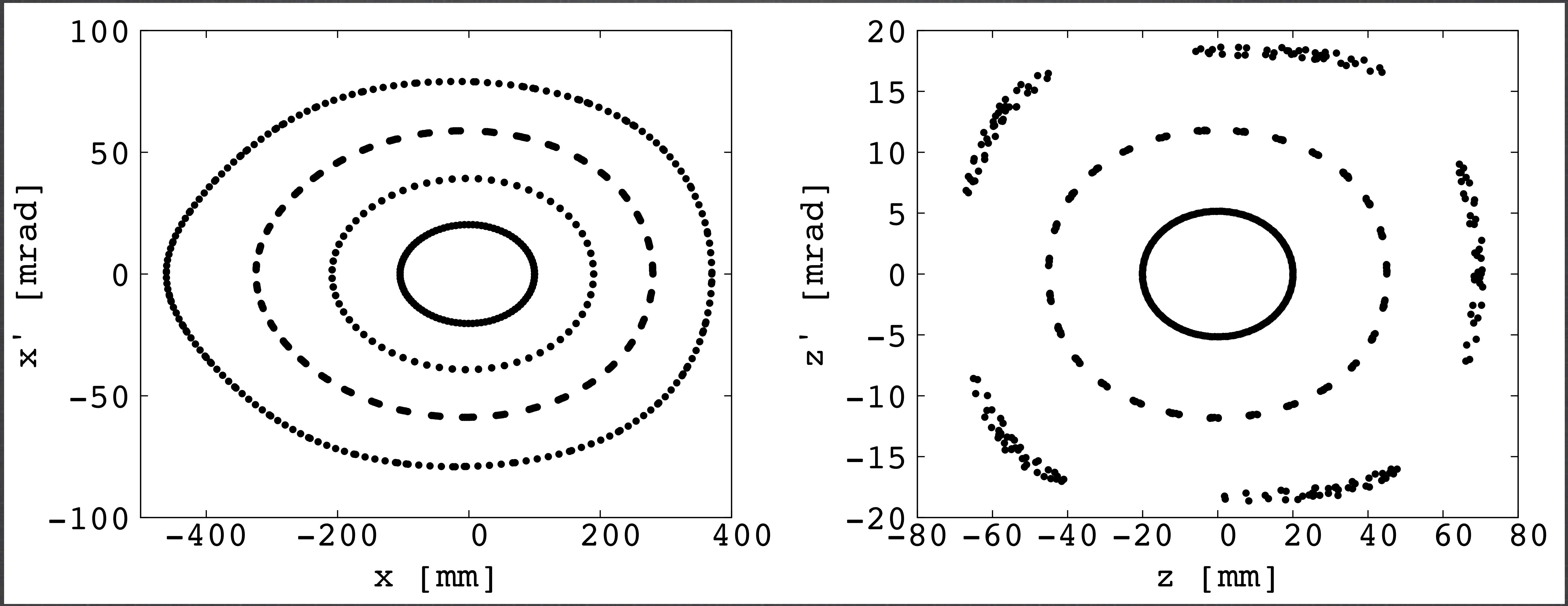


- 4^{th} order interpolation off the mid-plane.

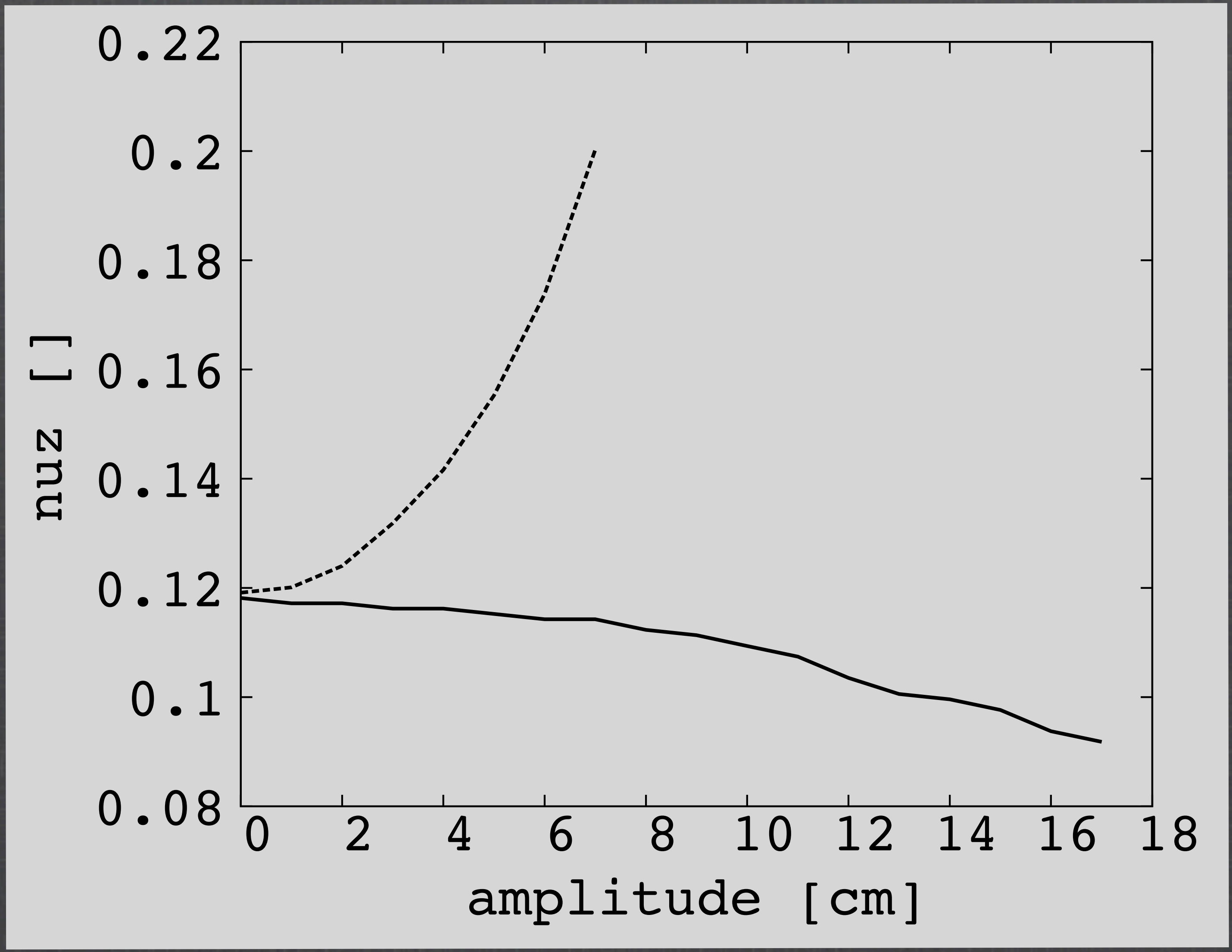
Enge case: Dynamic aperture study

≈40 000 π mm.mrad ≈1 500 π mm.mrad!!!



Horizontal (left) and vertical (right) maximum stable amplitude over 100 turns. Far collimators identify lost particles.

Amplitude dependance of the tune



Fractional part of the vertical tune for half of the ring in the linear case (plain) and in the Enge case (dotted).

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Summary

- Linear and Enge fringe field fall offs have a good agreement for the horizontal dynamic aperture.
- Very different for the vertical dynamic aperture !
- Enge fringe field fall-offs are more realistic, and must then be used for any vertical dynamic aperture study.
- Egg-shape design has a vertical acceptance half of the requirements: back to the first stage of the design.

Thank you for your attention