nuSTORM decay ring

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Outline

- FFAG Doublet solution
- FFAG Triplet solution
- FoDo solution
- Improvements

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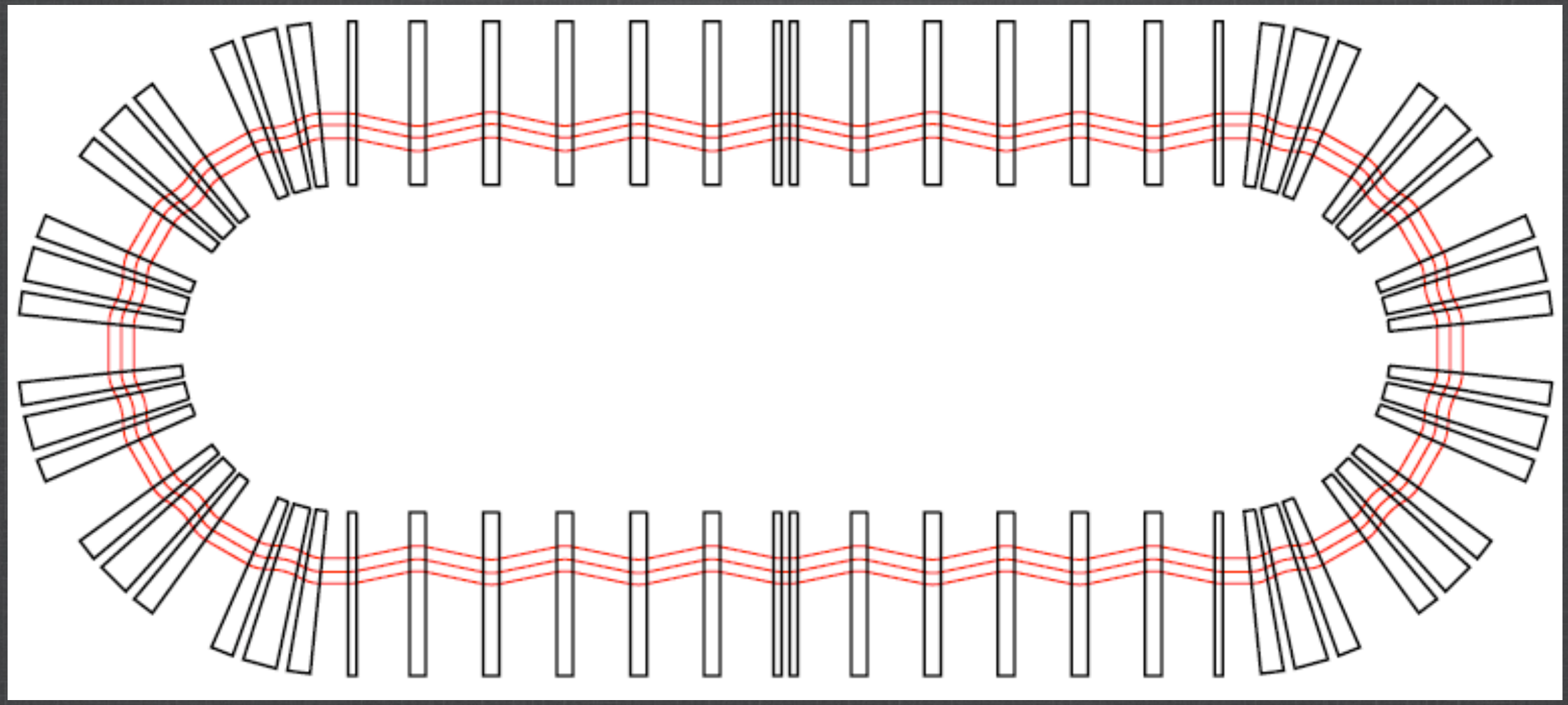
Racetrack FFAG



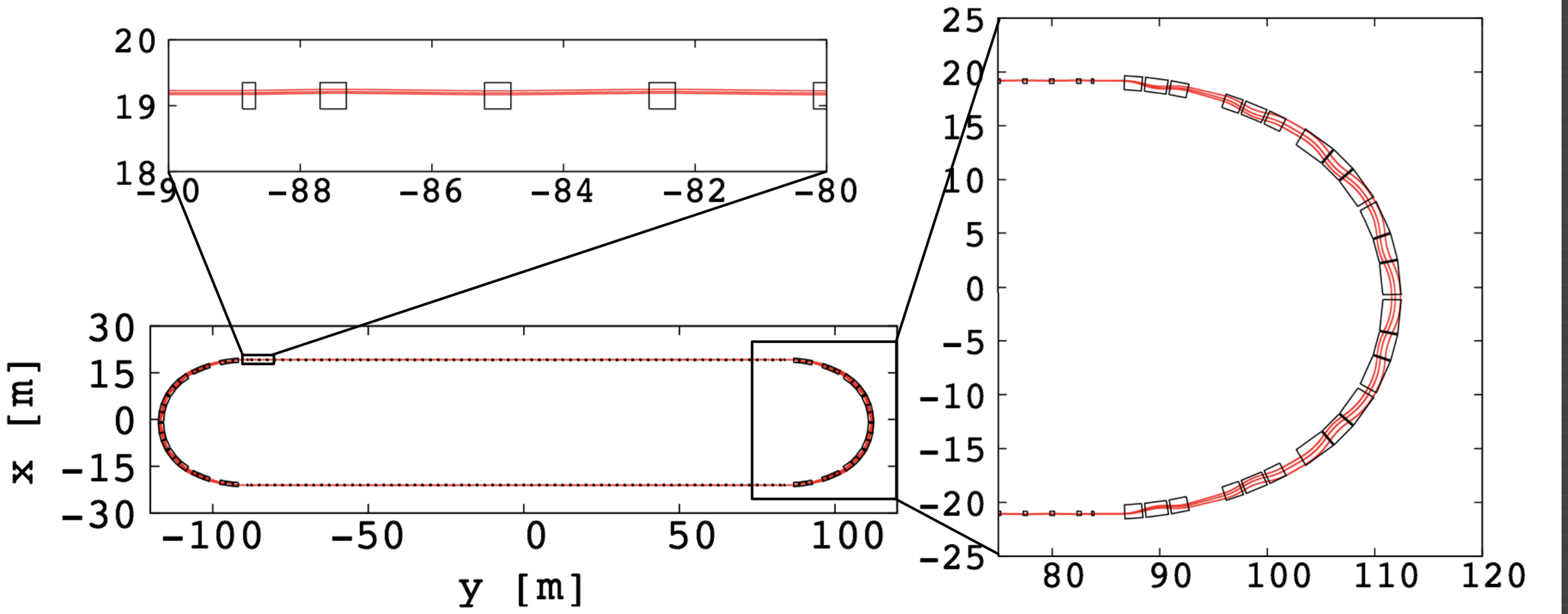
νSTORM Racetrack FFAG

Constraints:

- in the straight part, the scallop must be as small as possible to get the maximum number of neutrinos at the far detector. **15 mrad** has been chosen as the **maximum angle**.
- **Stochastic injection**: in the dispersion matching section, a drift length of ~2.6 m is necessary.
- to keep the ring as small as possible, **SC magnets in the arcs** are considered. **Normal conducting magnets in the straight part** are used.
- **large transverse acceptance** is needed in both planes: 1π mm.rad (2?).

Doublet solution

Straight: **175 m**, maximum scallop angle: **12 mrad**



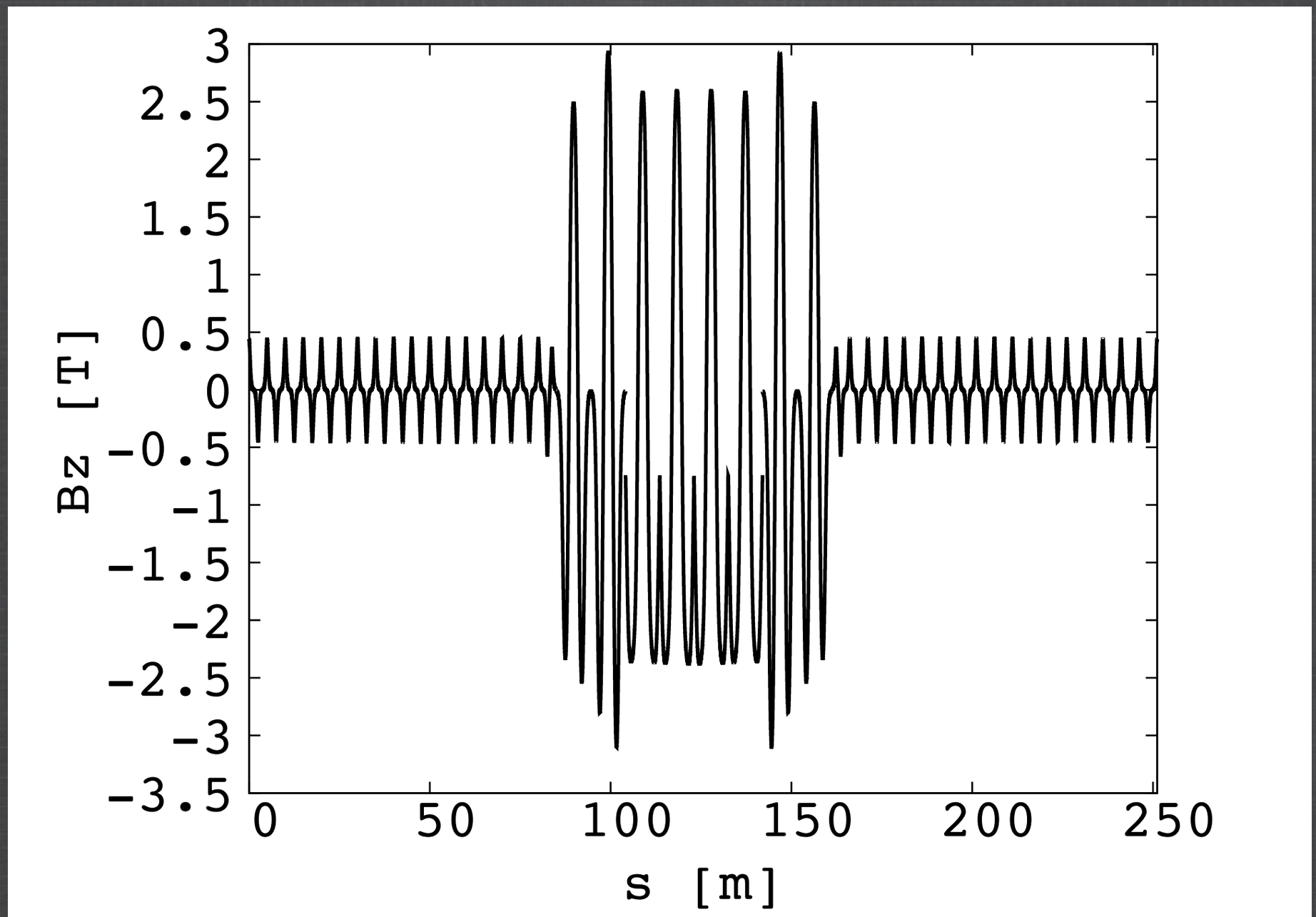
Doublet solution

Cell parameters

	Circular Section	Matching Section	Straight Section
Type	FDF	FDF	Doublet
Cell radius/length [m]	17.6	36.2	5
Opening angle [deg]	30	15	
k-value/m-value	6.043	25.929	5.5 m^{-1}
Packing factor	0.92	0.58	0.16
Maximum magnetic field [T]	2.5	3.3	1.5
horizontal excursion [m]	1.3	1.1	0.4
Full gap height [m]	0.45	0.45	0.45
Average dispersion /cell [m]	2.5	1.3	0.18
Number of cells /ring	4×2	4×2	35×2

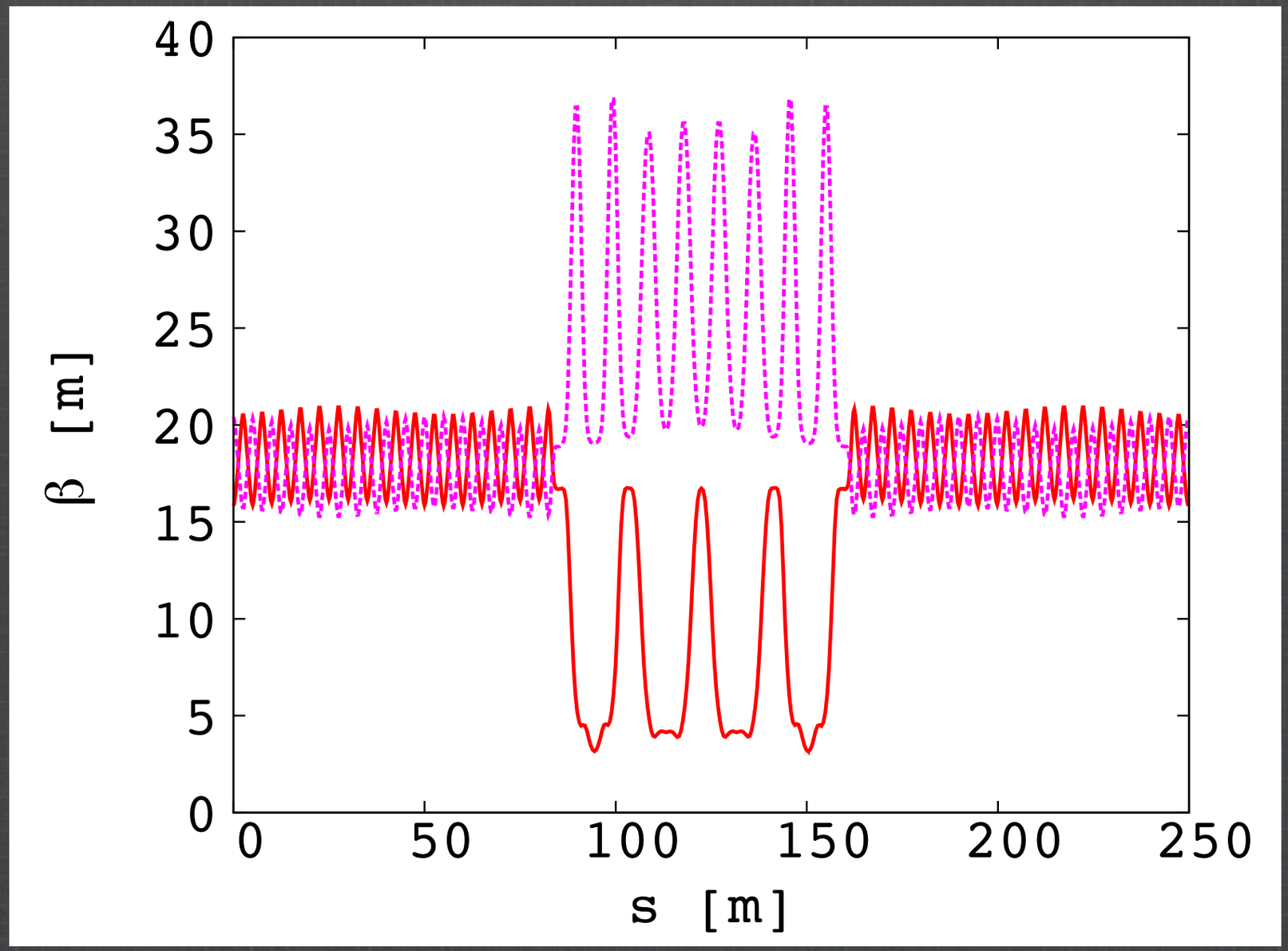
Doublet solution

Magnetic field for P_{max} (+16%)



Doublet solution

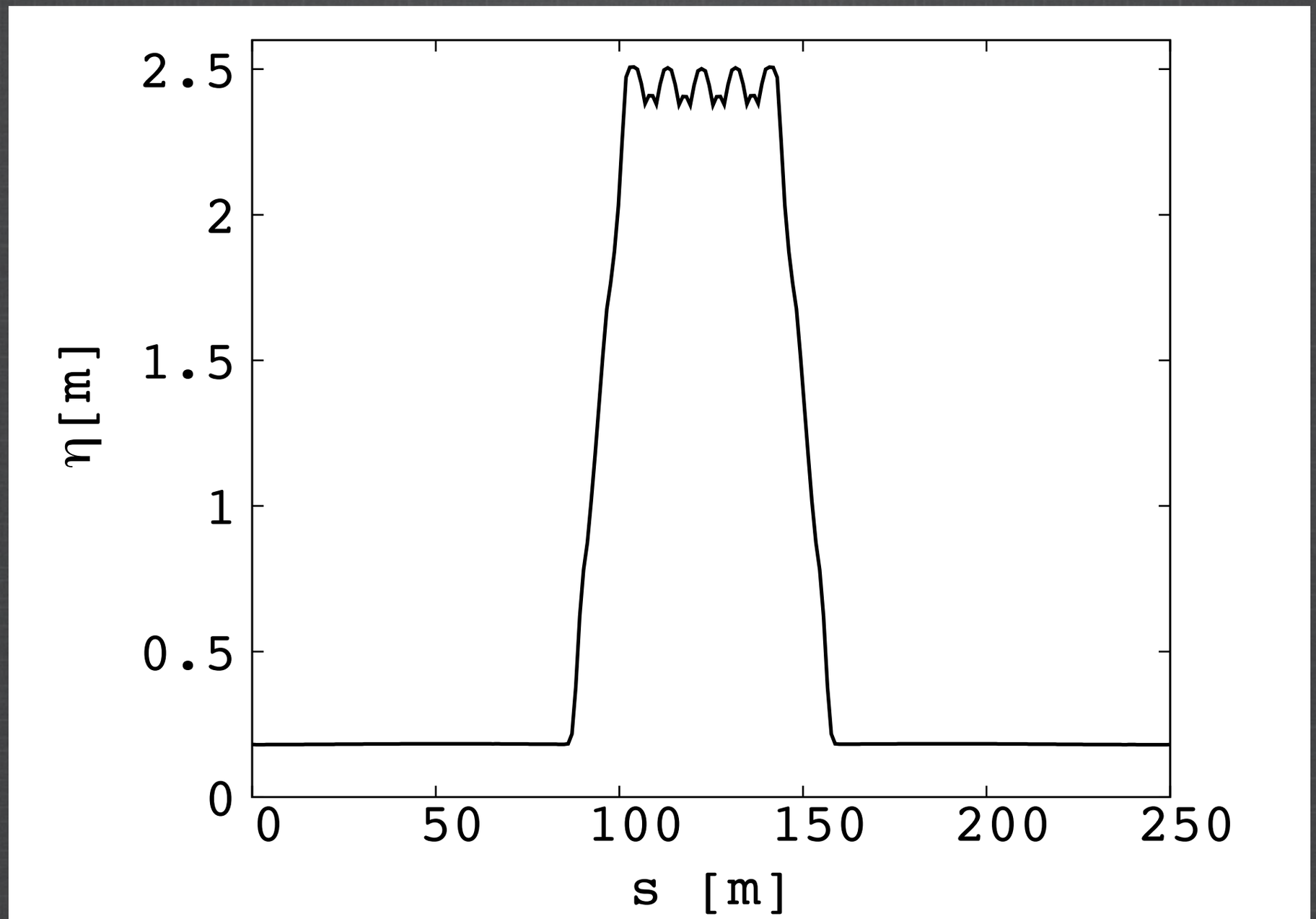
Beta-functions at matching momentum



Horizontal (plain red) and vertical (dotted purple) betafunctions for half of the ring.

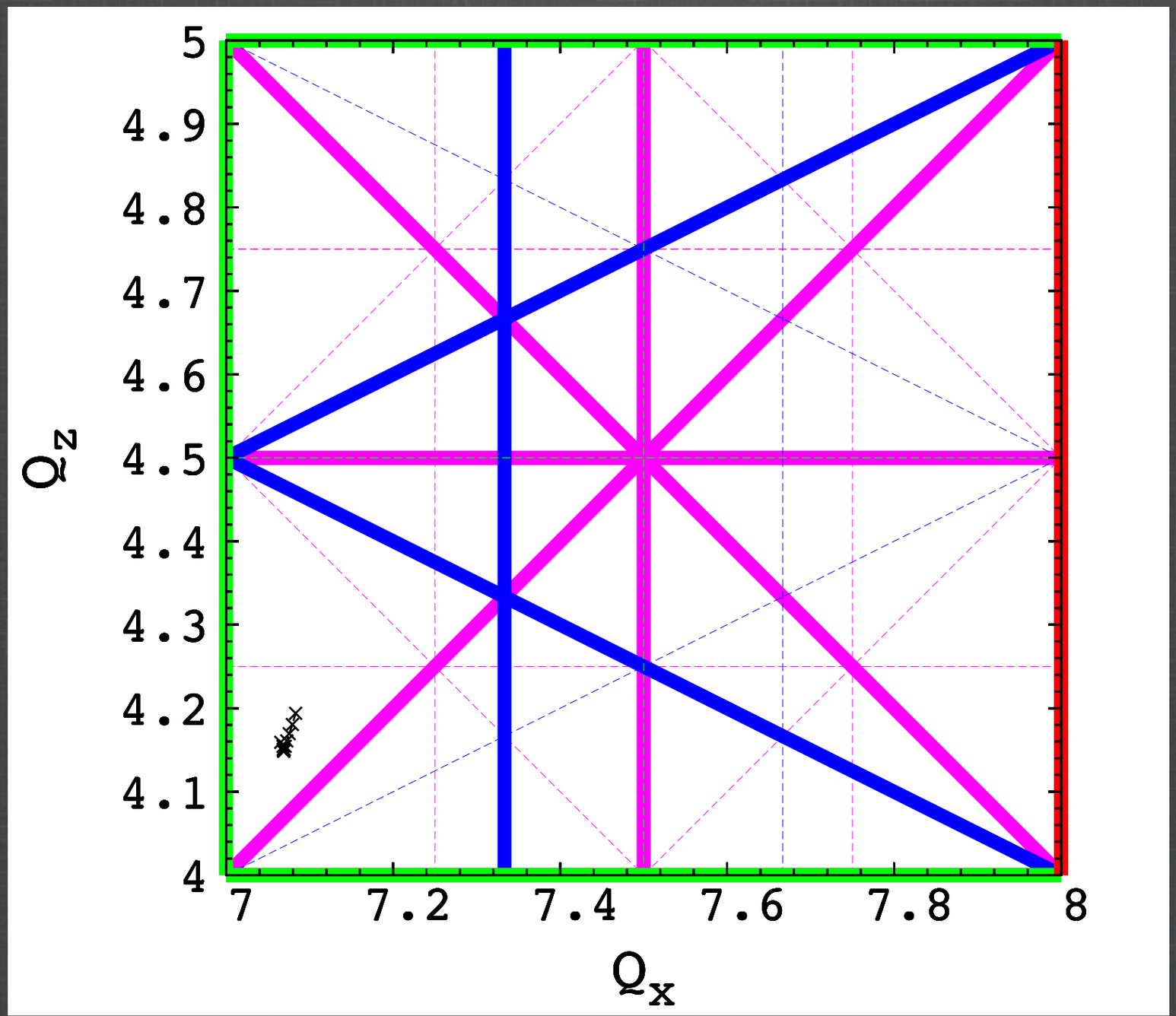
Doublet solution

Dispersion function at matching momentum



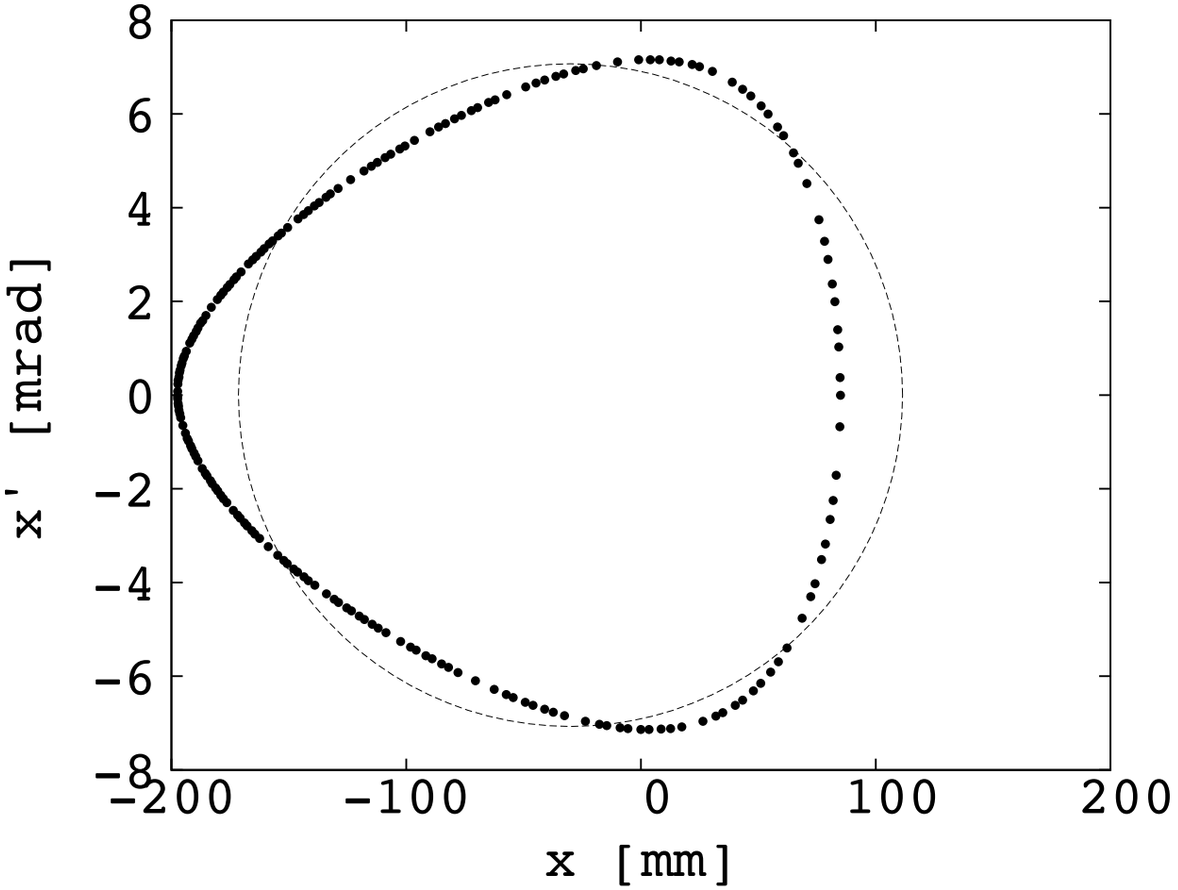
Doublet solution

Tune diagram $\frac{\Delta P}{P} = \pm 16\%$

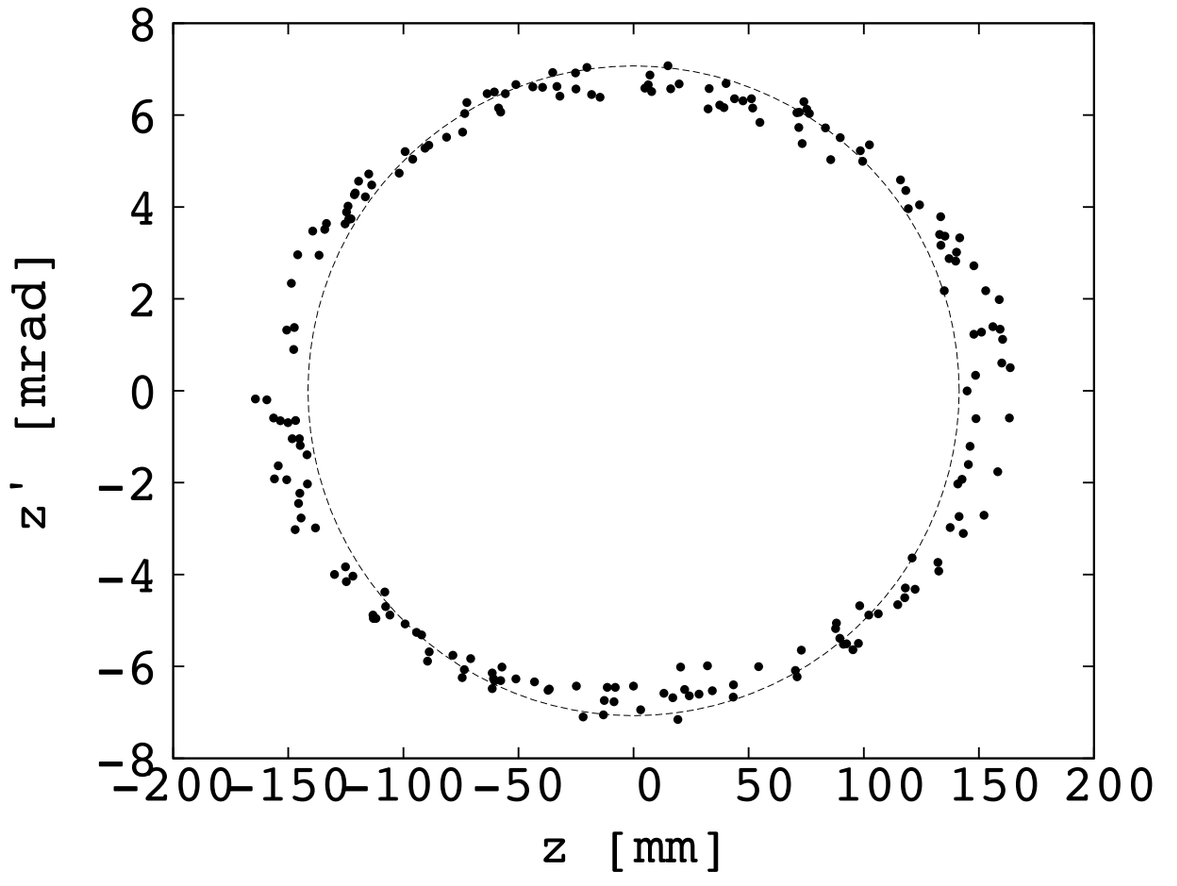


Doublet solution

Transverse acceptance



Maximum horizontal stable amplitude over 100 turns



Maximum vertical stable amplitude over 100 turns

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Motivations

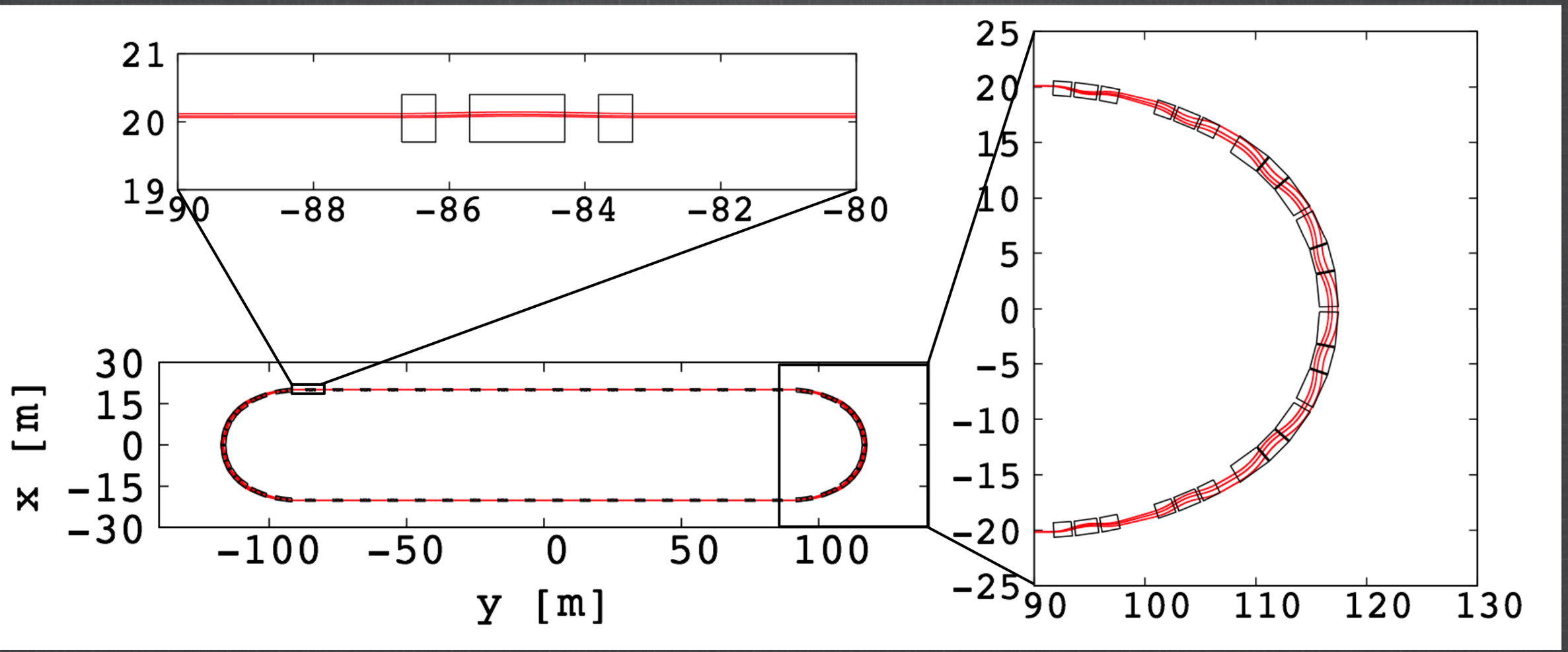
1300 km decay scenario incompatible with scallop of the closed orbit.

Doublet in the straight section cannot be used.

→ Triplet in the straight section.

Triplet solution

Straight: **180 m**, maximum scallop angle: **24 mrad**



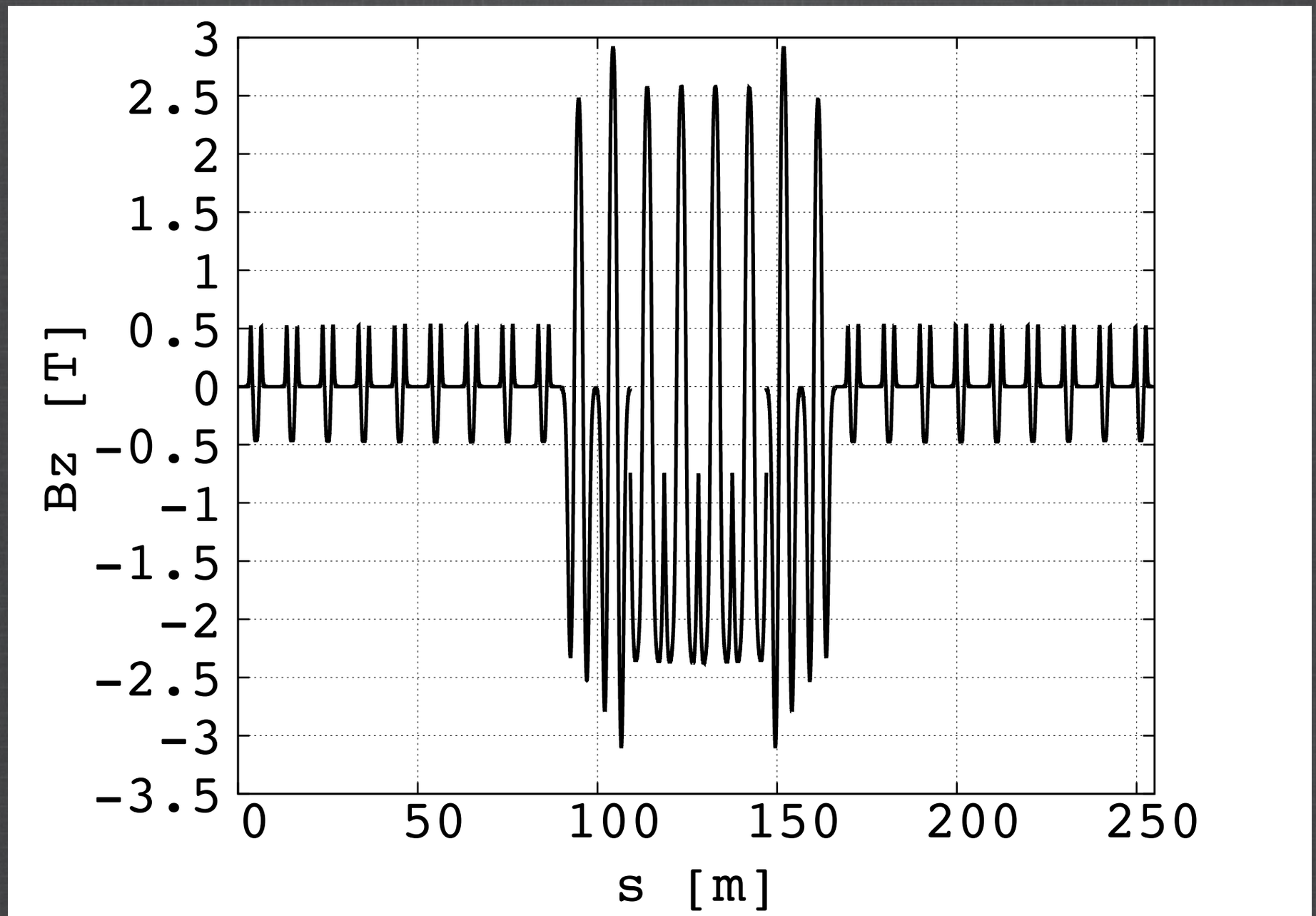
Triplet solution

Cell parameters

	Circular Section	Matching Section	Straight Section
Type	FDF	FDF	DFD
Cell radius/length [m]	17.6	36.2	10
Opening angle [deg]	30	15	
k-value/m-value	6.057	26.	5.5 m^{-1}
Packing factor	0.92	0.58	0.24
Maximum magnetic field [T]	2.5	3.3	1.5
horizontal excursion [m]	1.3	1.1	0.6
Full gap height [m]	0.45	0.45	0.45
Average dispersion /cell [m]	2.5	1.3	0.18
Number of cells /ring	4×2	4×2	36×2

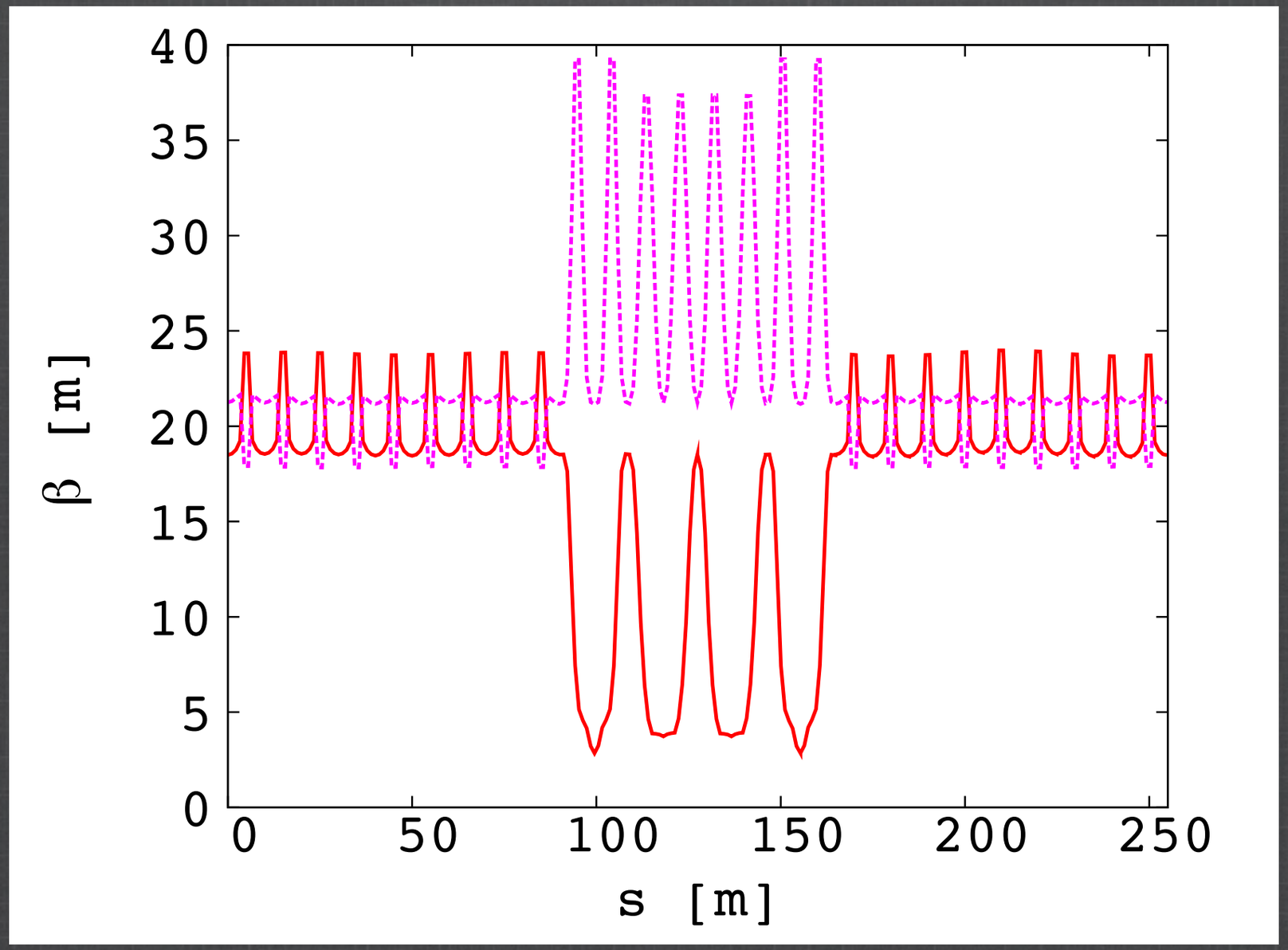
Triplet solution

Magnetic field for P_{max} (+16%)



Triplet solution

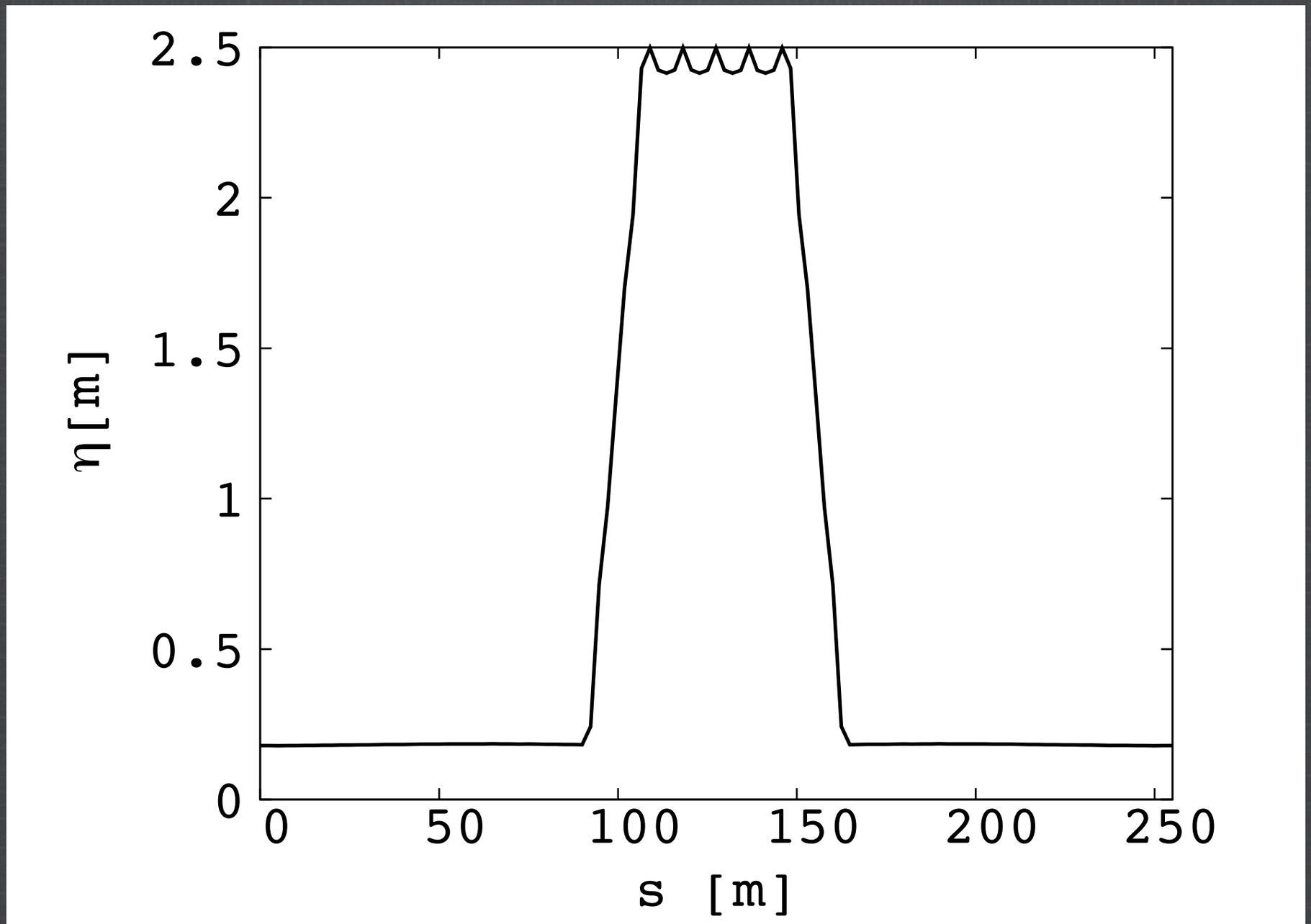
Beta-functions at matching momentum



Horizontal (plain red) and vertical (dotted purple) betafunctions for half of the ring.

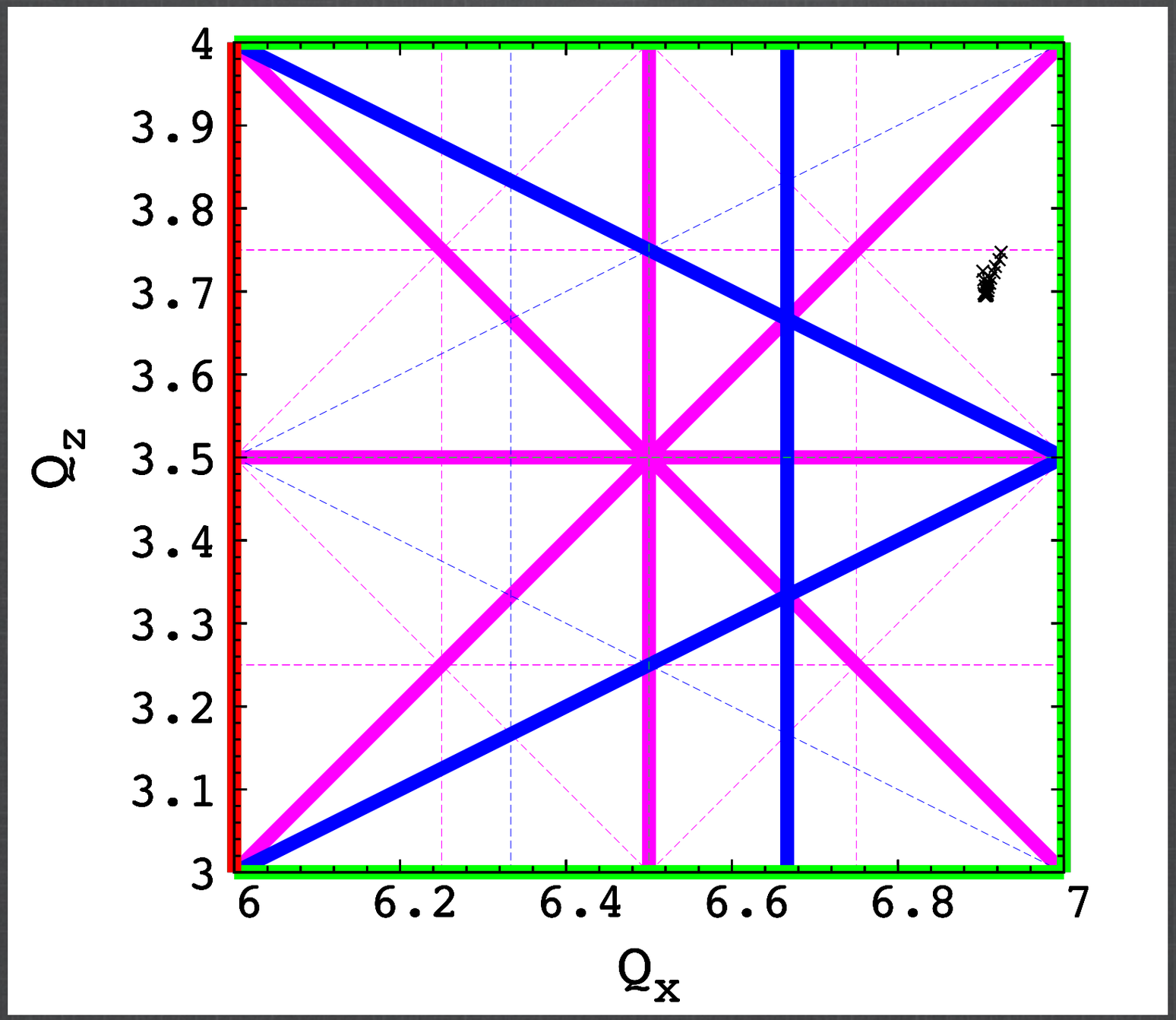
Triplet solution

Dispersion function at matching momentum



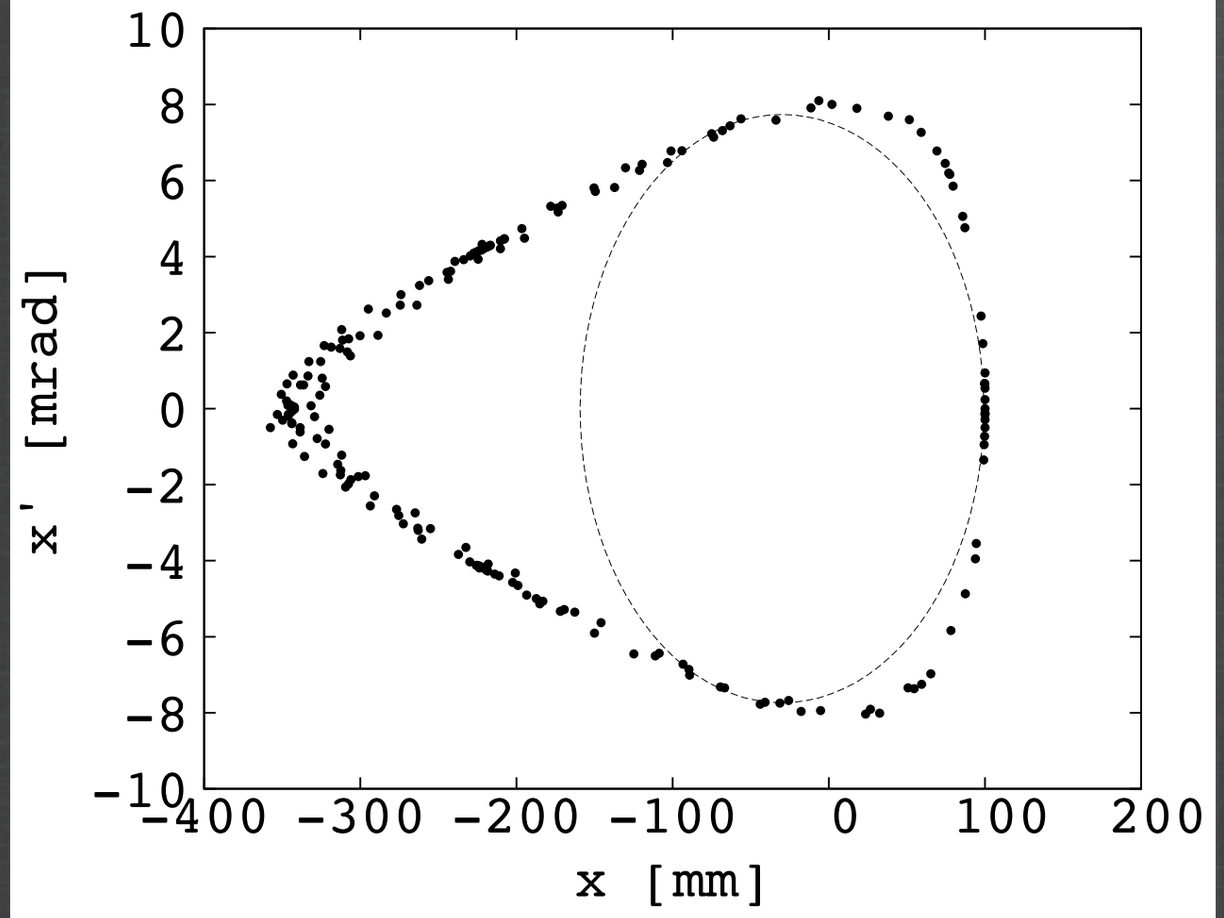
Triplet solution

Tune diagram $\frac{\Delta P}{P} = \pm 16\%$

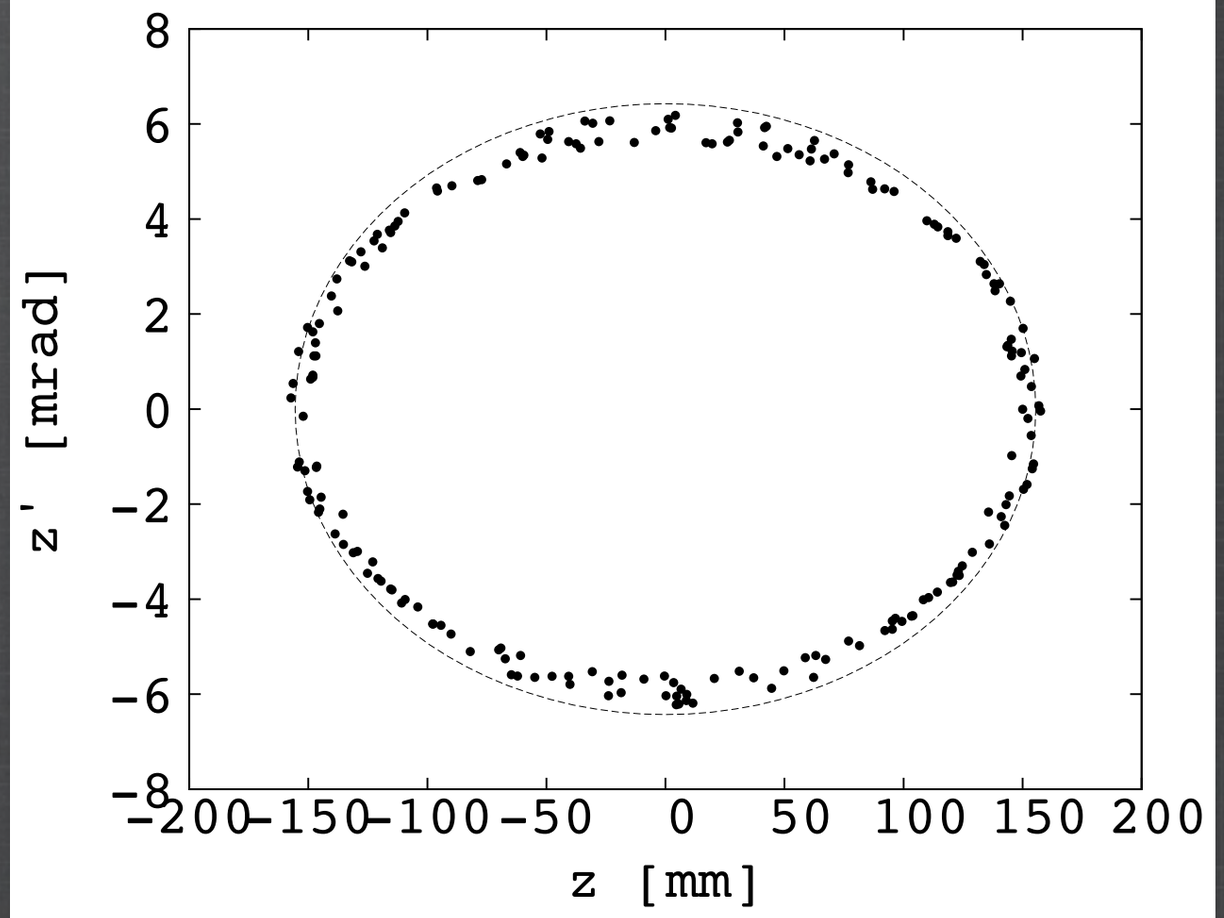


Triplet solution

Transverse acceptance



Maximum horizontal stable amplitude over 100 turns



Maximum vertical stable amplitude over 100 turns

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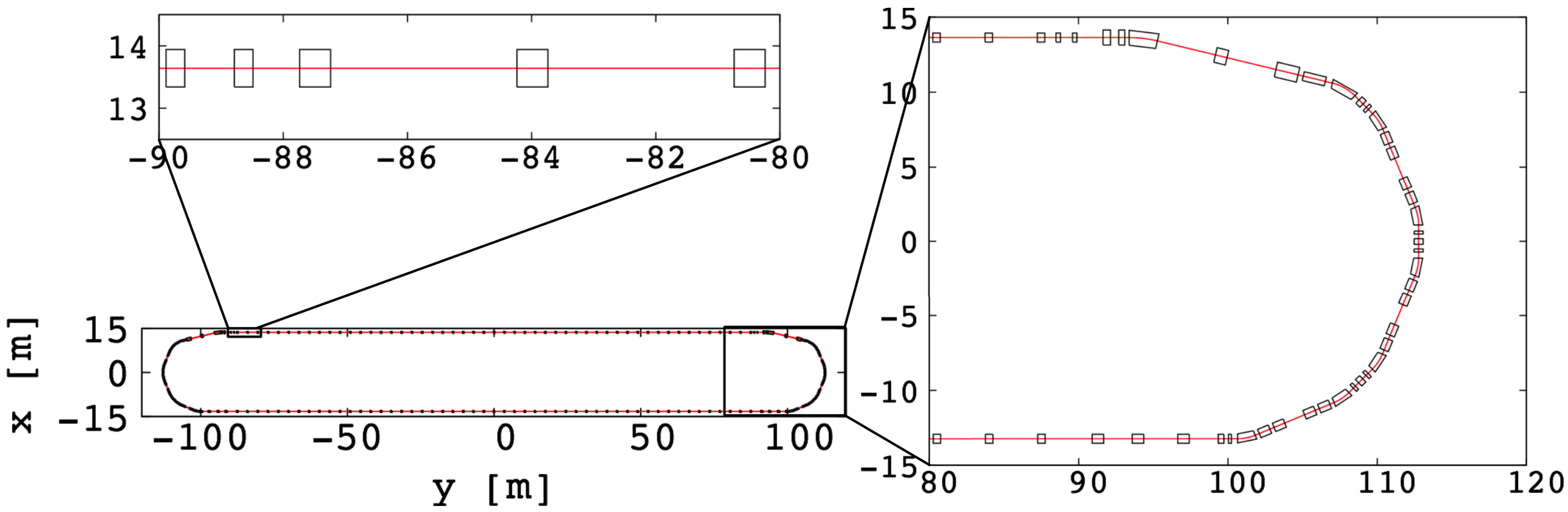
FoDo solution

Lattice parameters

Total circumference	480 m
Length of the decay straight section	184 m
Decay straight section/circumference ratio	38%
Field type	Field model
Fringe field type	Linear
Fringe field length	1 cm
Interpolation off the mid-plane	1^{st} order
Aperture type	rectangular
Stepsize	1 cm
Particle	muon μ^+
Matching momentum p_0	3.8 GeV/c
Minimum momentum p_{min}	3.42 GeV/c (-10%)
Maximum momentum p_{max}	4.18 GeV/c (+10%)
Ring tune point (H/V) at p_0	(9.71, 7.83)

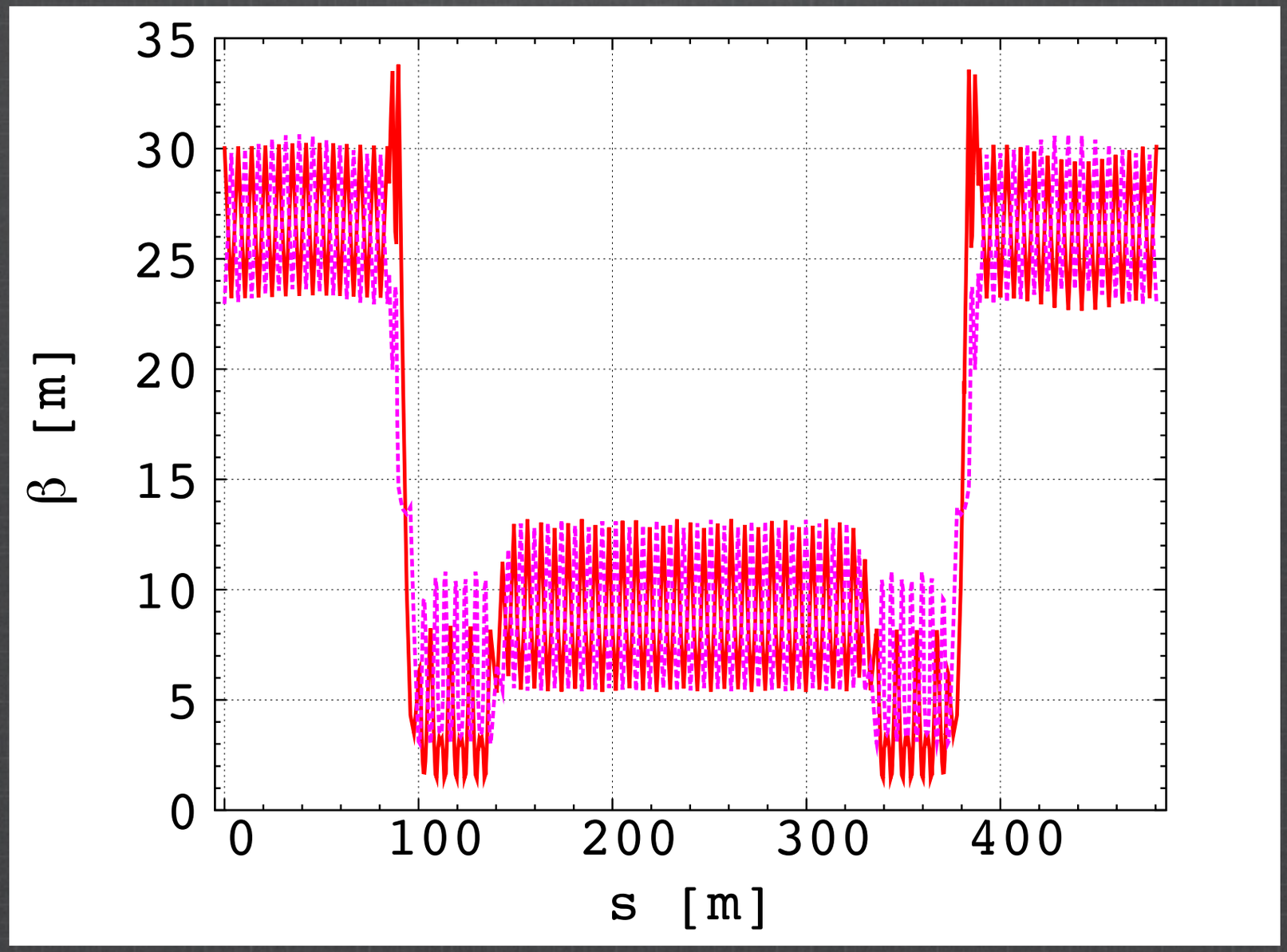
FoDo solution

Straight: **184 m.**



FoDo solution

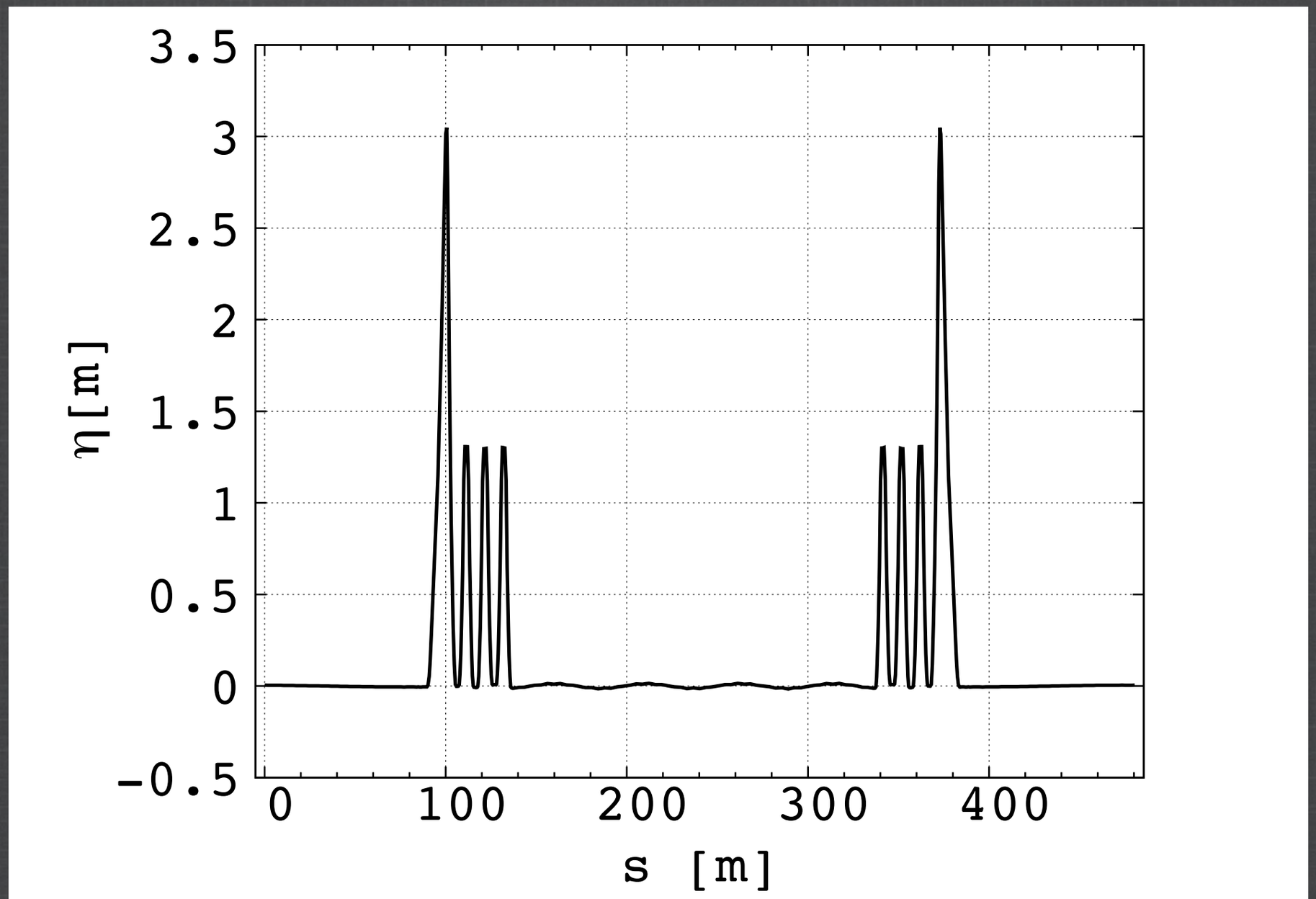
Beta-functions at matching momentum



Horizontal (plain red) and vertical (dotted purple) betafunctions for half of the ring.

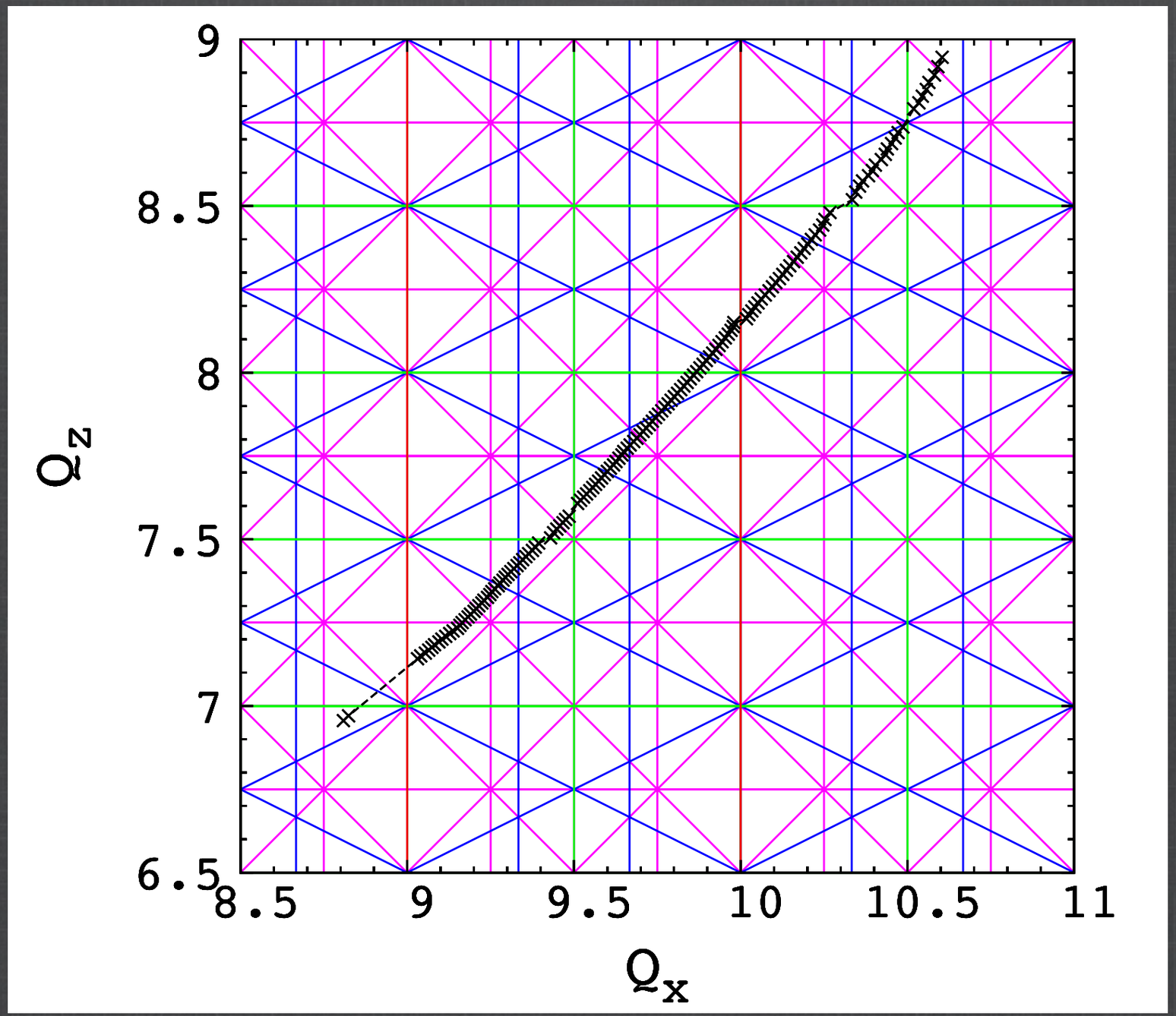
Doublet solution

Dispersion function at matching momentum



FoDo solution

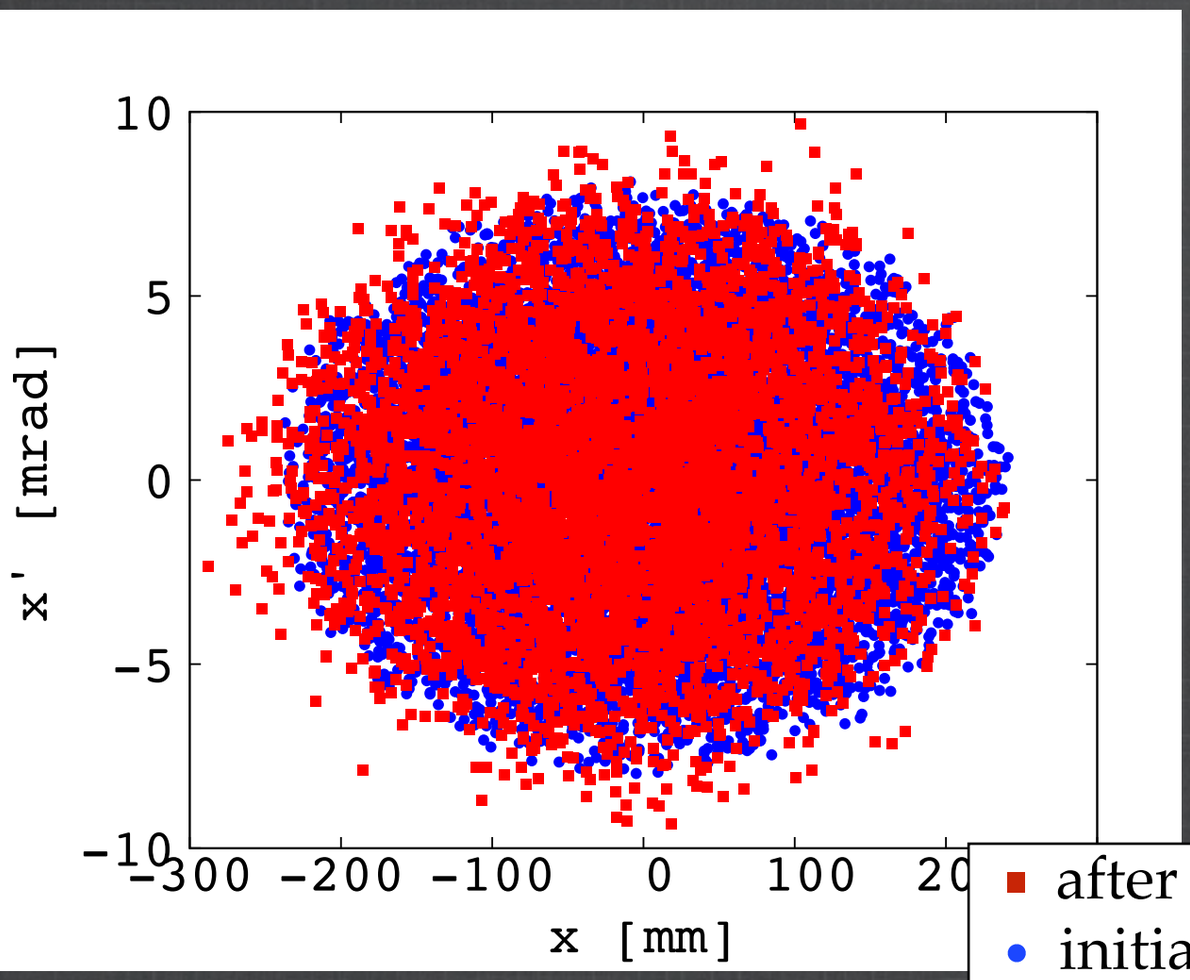
Tune diagram from -8.1% to +9.2% around 3.8 GeV/c



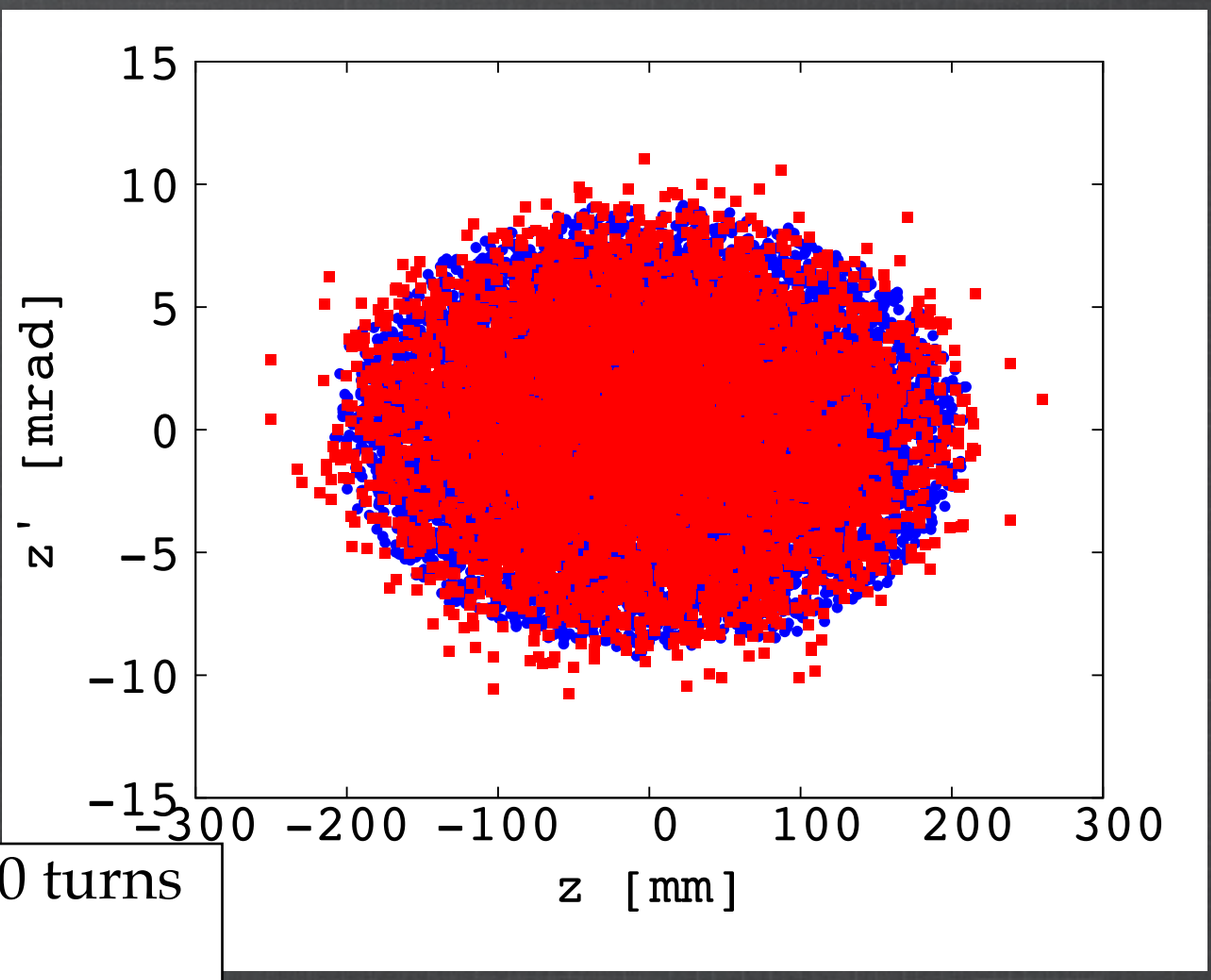
FoDo solution

Transverse acceptance

10 000 particles with a Waterbag distribution. Unnormalized emittances are $2.\pi mm.rad$ in transverse planes.
Momentum uniformly distributed in a longitudinal ellipse around 3.8 GeV/c ±10%.



Horizontal (over 100 turns)
54% survival over 100 turns

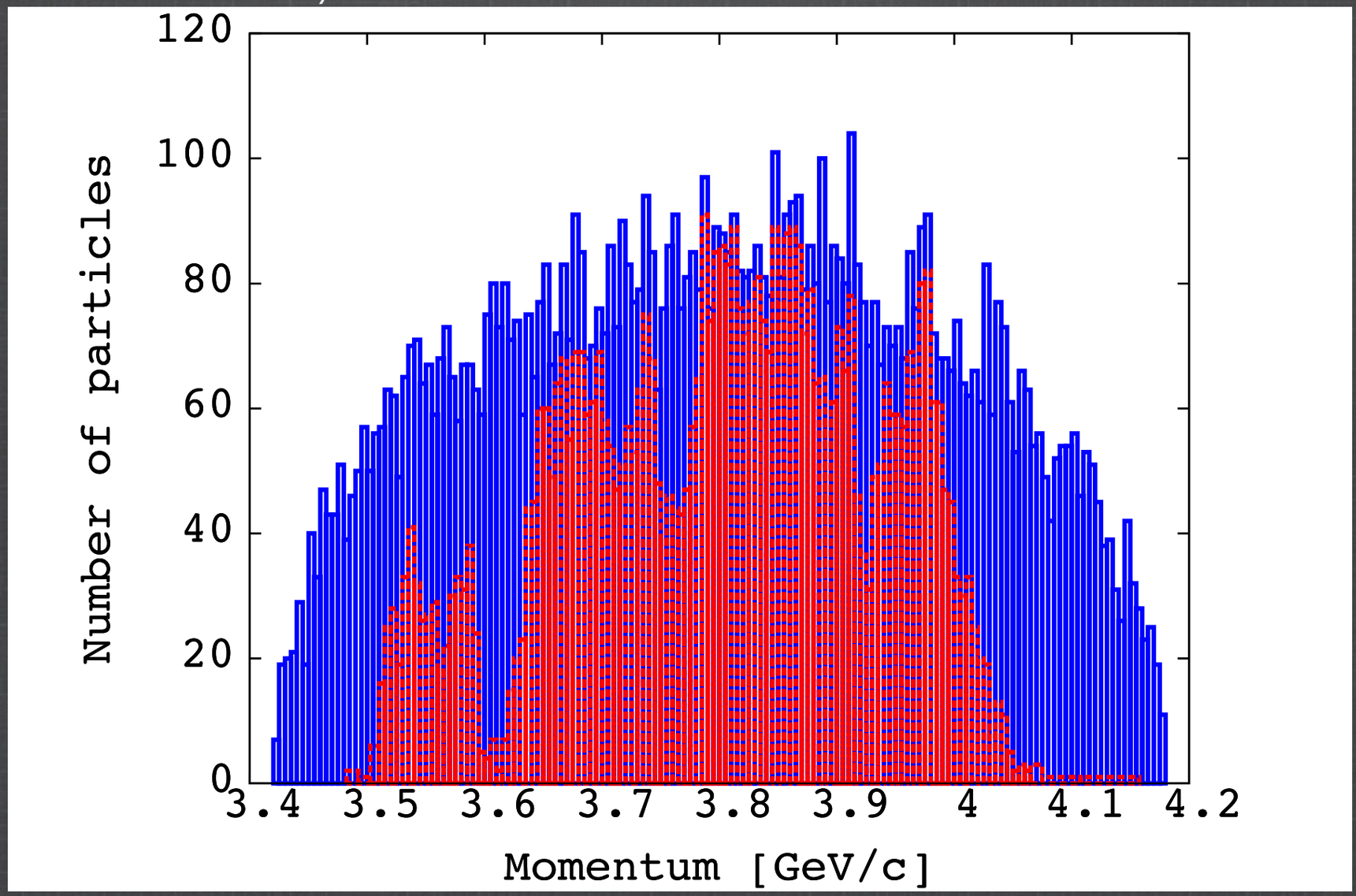


Vertical (over 100 turns)

FoDo solution

Momentum distribution

54% survival over 100 turns



Initial (plain blue) and after 100 turns (dotted red).

(No error in the lattice.)

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Future improvements

- Small scallop angle in the straight for FFAG: reduce the portion of the straight cell with scallop.
- Larger DA for FFAG: smaller gradient (m-value) in the straight section.
- Smaller magnets in the arcs for FFAG: reduce the maximum dispersion (> 1.3 m necessary for injection).
- larger drift space in matching section for easier injection.
- Realistic magnetic field in tracking for FFAG and FoDo (Enge Fringe field fall-offs, no discontinuity).
- Study of tolerance to errors (field error and misalignment) in FFAG and FoDo lattices.

Thank you for your attention