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FCC HEB imperfections

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Outline

- Impact of mis-alignment errors on the HEB ring
- Impact of linear field errors on the HEB ring
- Impact of multipole errors on the HEB ring

Linear Errors (fields and mis-alignment)

Tessa Charles FCCIS workshop Nov2021

Type	Δx (μm)	Δy (μm)	ΔS (μm)	ΔTheta (μrad)	ΔPhi (μrad)	ΔPsi (μrad)	Field Errors
Arc quad*	50	50	100	150	100	300	$\Delta k/k = 2\times10^{-4}$
Arc sext*	50	50	100	150	100	300	$\Delta k/k = 2\times10^{-4}$
Dip	1000	1000		1000		300	$\Delta k/k = 1\times10^{-4}$
Girders	150	150		1000			
BPM**						100	

* relative to the girder
** relative to the quadrupole

As first approximation we took Δx_tot = Δx_gird + Δx_quad randomly distributed values for all the quantities (example: x,y offsets of the quadrupoles = 200 μm)

On 10 seeds statistics we get always unstable optics!

Main Linear field errors (b1, b2) only

Main quadupoles :

b2 = 2×10^{-4} relative random error

Main Dipoles:

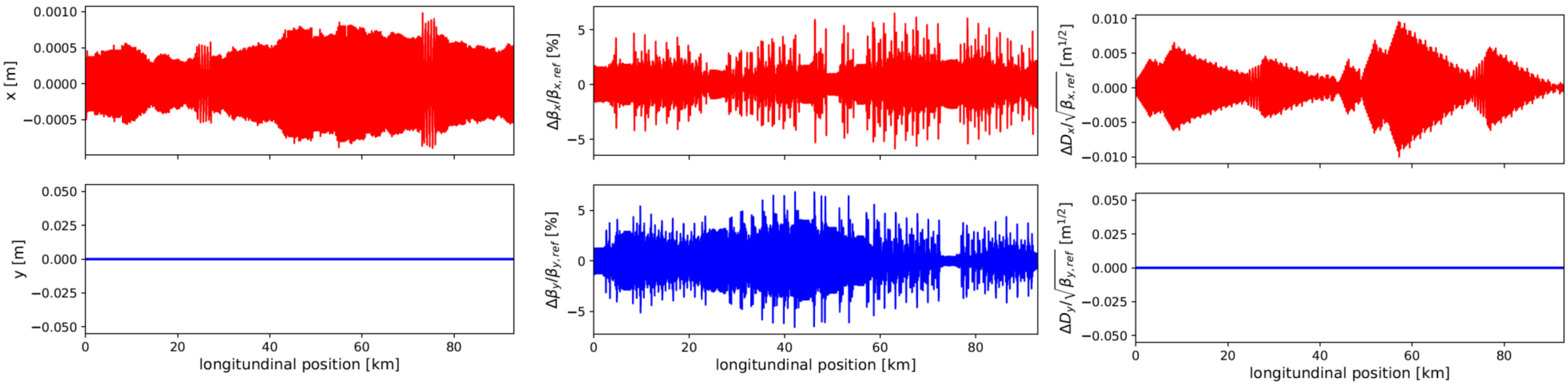
b1 = 1×10^{-4} relative random error

b2 = -1×10^{-4} relative systematic error + 10% random component

Courtesy of F. Zimmermann and Jie Gao

Without orbit, beta-beating and dispersion correction:

orbit | beta-beating | normalized-dispersion



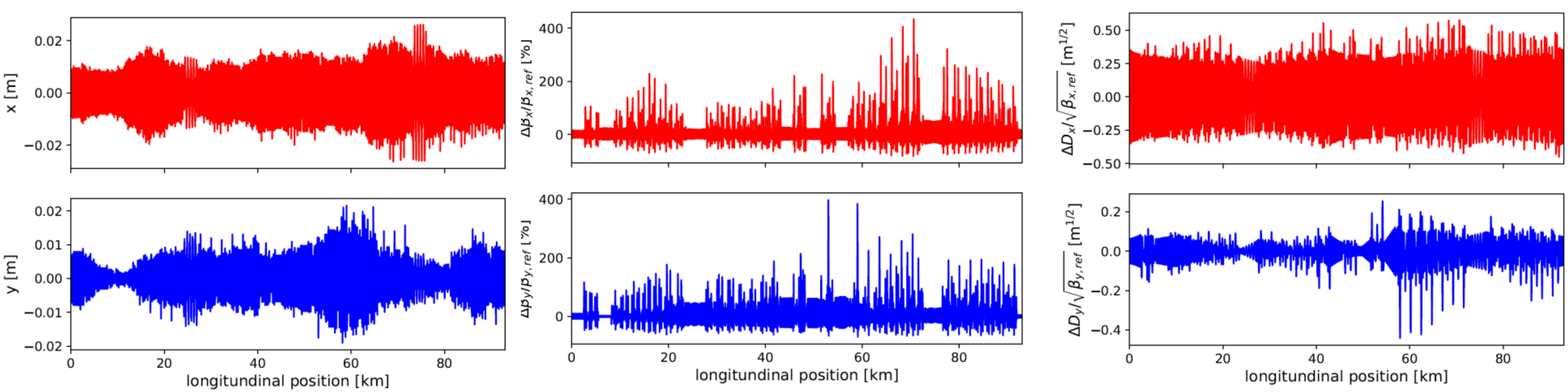
100 μm random quadrupole offset only (x,y)

Removing all other mis-alignment except for quadrupole offsets
Reducing the randomly distributed offset values to ±3 σ= 100 μm

Type	Δx (μm)	Δy (μm)	ΔS (μm)	ΔTheta (μrad)	ΔPhi (μrad)	ΔPsi (μrad)	Field Errors
Arc quad	100	100					
Arc sext							
Dip							
Girders							
BPM							

Without orbit, beta-beating and dispersion correction:

orbit | beta-beating | normalized-dispersion



Multipoles field errors at injection (> b2)

Static dipole field errors of the CT dipole design at 56Gs considered + 10% random part

Dynamic field effect not taken into account in this simulations: dipole and multipole reproducibility expected to be ≤ **5×10^{-4}**

97km 60°/60° optics

Stable initial action @ 4500 turns (~15% *tx* 20 GeV)

Geometric emittance injected 1.27e-9 nm

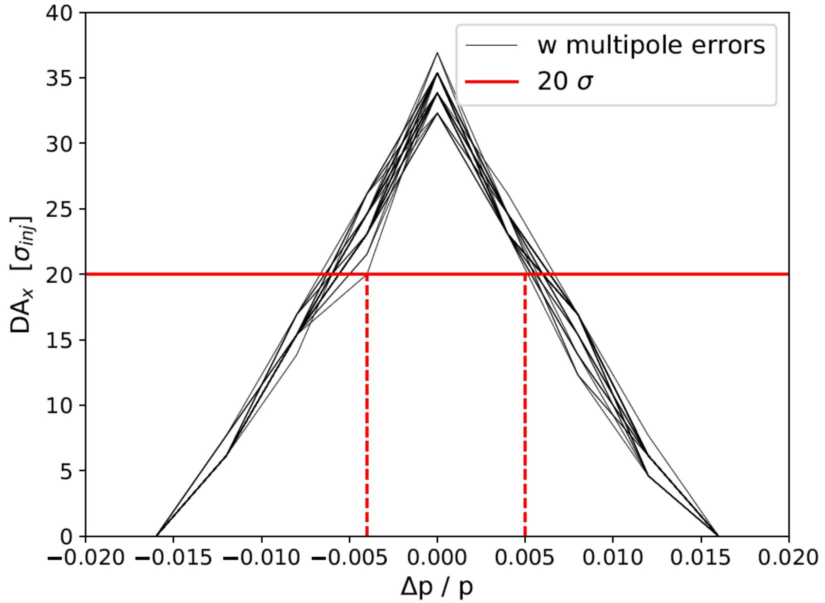
Courtesy of F. Zimmermann and Jie Gao

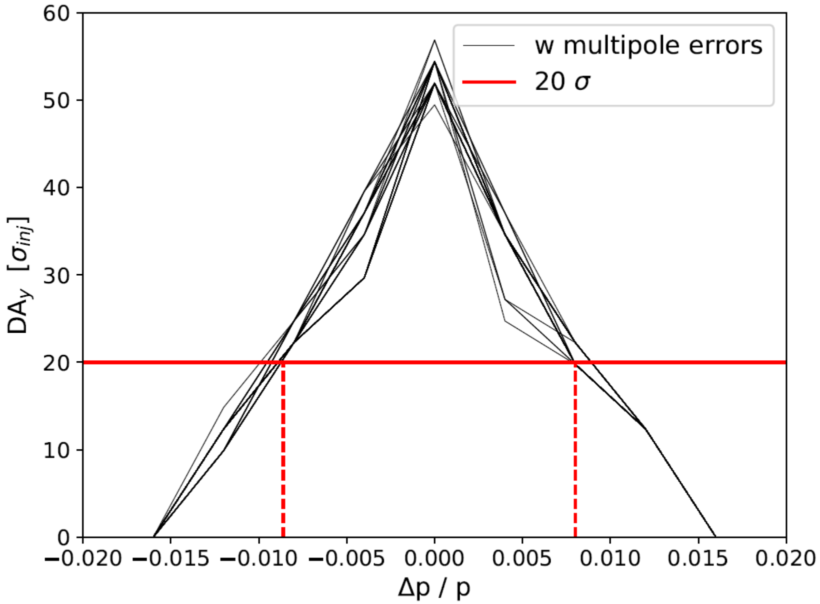
	CT dipole		Iron-core dipole	
GFR=R26	28Gs	56Gs	28Gs	56Gs
B1/B0	-5.20E-04	-1.04E-04	-1.56E-03	-2.60E-04
B2/B0	4.73E-04	5.41E-04	-2.03E-03	-2.03E-04
B3/B0	-7.03E-06	1.05E-04	3.52E-04	1.76E-04
B4/B0	-9.14E-04	-3.66E-04	4.57E-04	-1.83E-04
B5/B0	3.56E-05	-2.38E-05	-2.38E-05	-3.56E-05
B6/B0	6.18E-04	2.16E-04	-3.09E-04	9.27E-05

relative values @ R = 26 mm

60 seeds

MadX Thin-Lens Tracking





Conclusion

- orbit, beta-beating and dispersion correction required for the booster
- coupling correction to still to be seen (target=2×10^{-3} at extraction)
- Impact of linear field errors relative small with respect to mis-alignment
- Impact of multipoles errors at injection on Dynamic Aperture to be follow-up

https://gitlab.cern.ch/fcc-optics/fcc-ee-heb/-/tree/errors