

A CORRECTION SCHEME FOR THE MAGNET IMPERFECTION ON THE CEPC

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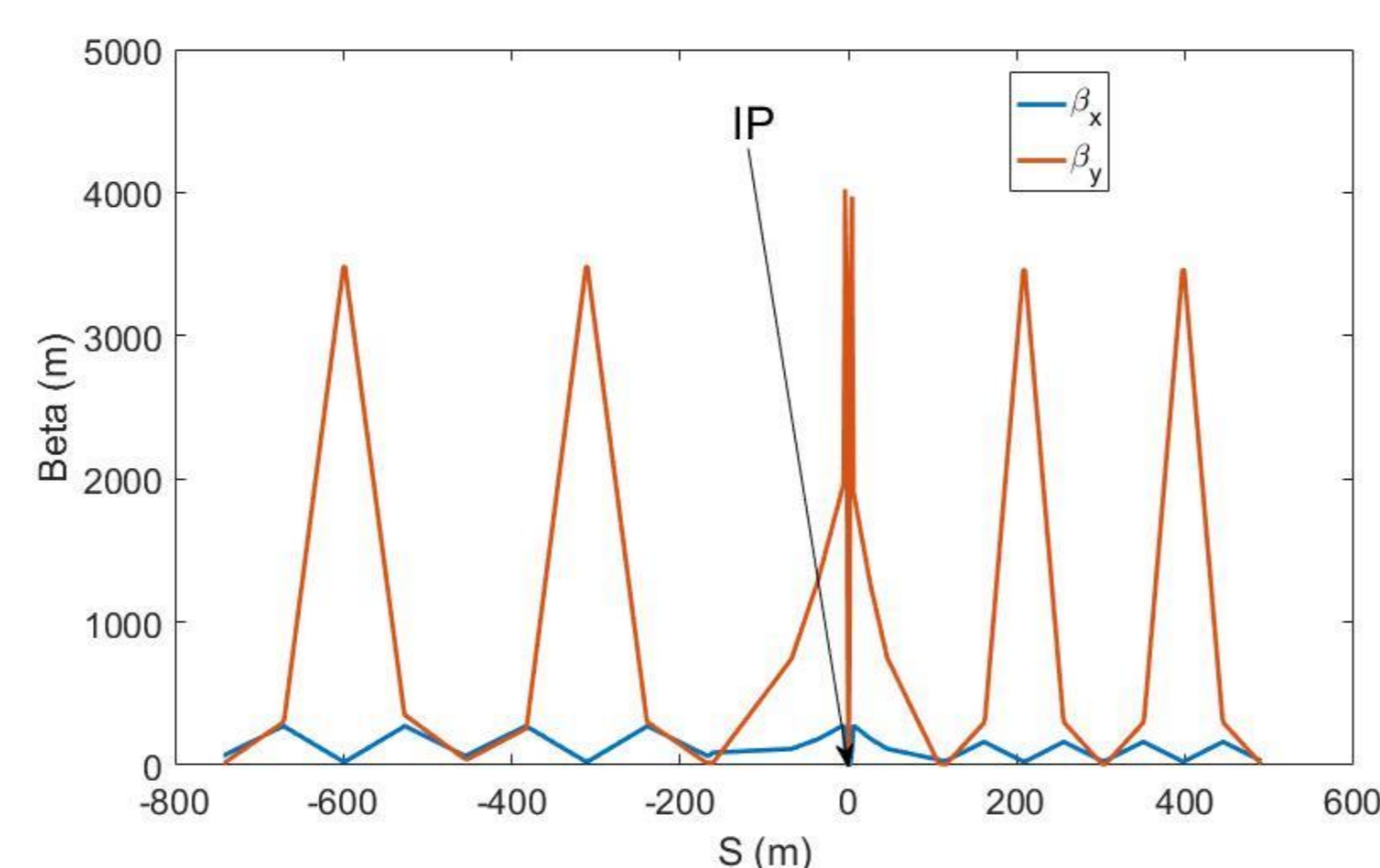
Circular Electron-Positron Collider (CEPC) is a 100 km circumference double-ring Collider, the corresponding lattice has small beta function at the interaction point. The low emittance optics is an enhanced sensitive to the magnet misalignments and field errors. The imperfection will cause the closed orbit distortion (COD) and optics distortion. In this paper we present the correction scheme for these imperfections which includes the closed orbit correction, the dispersion correction, the beta function correction and the betatron coupling correction. The scheme of the correction and the resulting performance are discussed.

Introduction

- The error correction is based on CEPC CDR lattice.
- Small emittance ratio (0.2%) and small beta functions.
- Dynamics aperture (DA) requirements: $8\sigma_x \times 15\sigma_y$ & 0.0135 (on-axis injection).

E=120GeV
 $v_x=363.11$
 $v_y=365.22$

$\beta_x^* = 0.36\text{m}$
 $\beta_y^* = 0.0015\text{m}$
 $\beta_{x,max}=599\text{m}$
 $\beta_{y,max}=4023\text{m}$
 $\epsilon_x = 1.21\text{nm}$



Tolerance and imperfection

Component	Δx (mm)	Δy (mm)	$\Delta\theta_z$ (mrad)	Field error
Dipole	0.10	0.10	0.10	0.01%
Arc Quadrupole	0.10	0.10	0.10	0.02%
IR Quadrupole	0.10	0.10	0.10	
Sextupole	0.10	0.10	0.10	

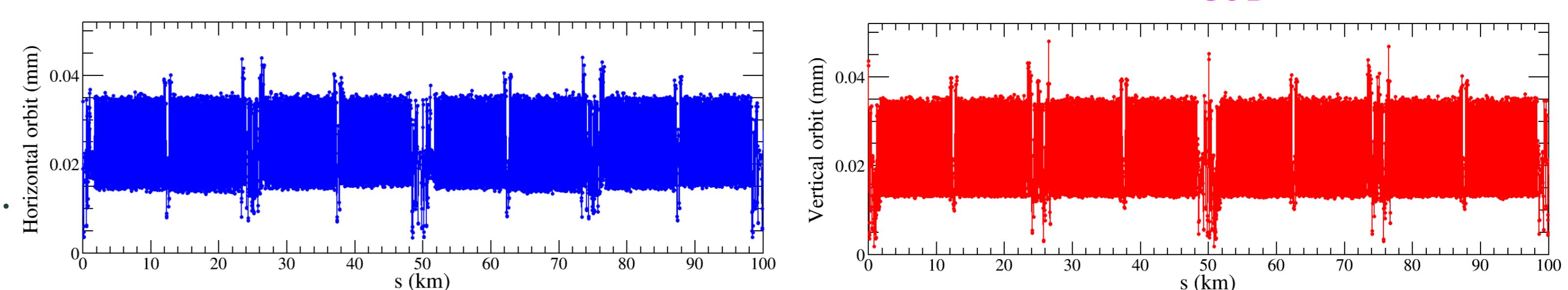
- The lattice with small beta function is very sensitive to FF misalignments;
- Small vertical dispersion and the coupling correction are necessary;

The correction scheme

- COD correction:
 - Horizontal correctors placed beside focusing quadrupoles (~1500)
 - Vertical correctors placed beside defocusing quadrupoles (~1500)
 - BPMs placed at quadrupoles (~1500, 4 per betatron wave)
 - Turn off the sextupoles and perform the COD correction
 - Turn on the sextupoles and repeat the COD correction
- Dispersion correction
 - Based on Dispersion free steering principle [1]
- Beta beating correction
 - Correct the beta functions with sextupoles on
 - Based on AT LOCO
 - Fit the dispersion at the same time
- Coupling and vertical dispersion correction (Local coupling parameter correction)
- 1000 lattice seeds are generated for error correction
- The detail correction algorithm and formula are described in detail elsewhere [2]

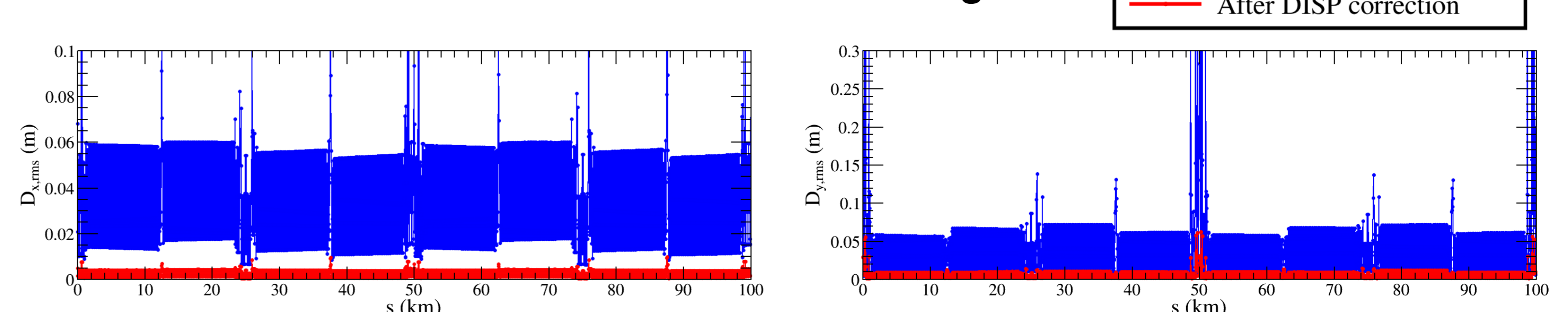
COD correction

955 seeds converged **$RMS_{COD} < 0.05\text{ mm}$**



Dispersion correction

736 seeds converged

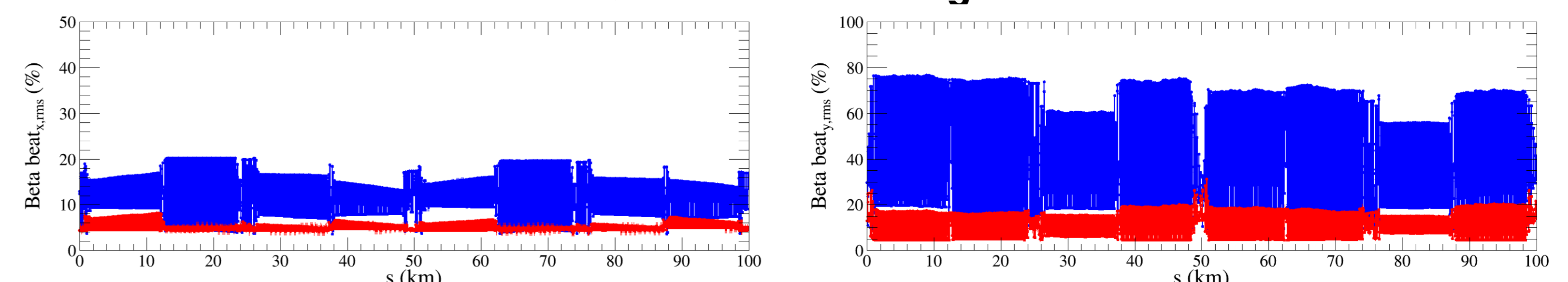


$\Delta D_{x,rms}$ decreased from 31mm to 2.2mm (14 improvement)

$\Delta D_{y,rms}$ decreased from 42.7mm to 5.9mm (7 improvement)

Beta beating correction

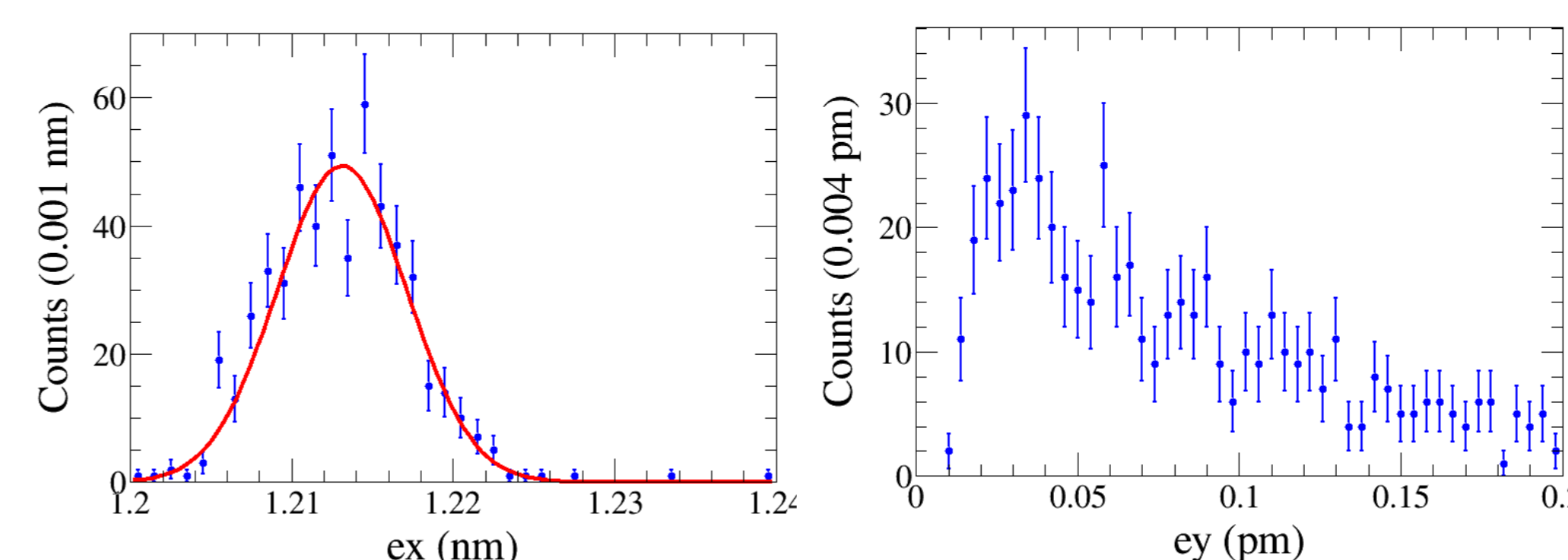
724 seeds converged



$\Delta\beta/\beta_{x,rms}$ decreased from 37.7% to 11.2% (3 improvement)

$\Delta\beta/\beta_{y,rms}$ decreased from 11.7% to 5.1% (2 improvement)

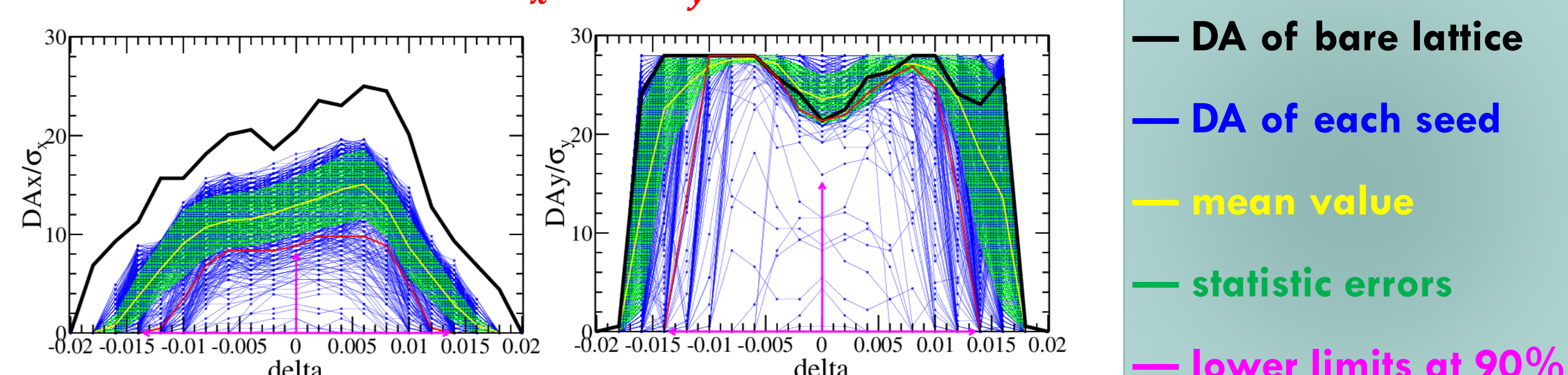
Coupling correction



$e_x = 1.2131 \pm 0.0040\text{ nm}$
 $e_y = 0.0777 \pm 0.0023\text{ pm}$
 $e_y/e_x = (0.0064 \pm 0.0002)\%$

DA results

$9\sigma_x \times 20\sigma_y$ & 0.014



Summary

The CEPC CDR lattice with 100 μm IR quadrupole misalignment is corrected, the passing rates is evaluated to be 72.4%. The DA is satisfy with the design

[1] R. Assmann, et al., "Emittance optimization with dispersion free steering at LEP", Phys. Rev. ST Accel. Beams 3, 121001 (2000).
[2] Bin Wang, "Imperfection and correction for CEPC", in The IAS program on high energy physics (IHEP 2021), 2021.01.19.