

Tolerance study for magnet and alignment errors and corresponding corrections

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Content



- IARC 2022 comments
- The progress of error correction
- Summary and to do list

IARC2022 comments

- 3. Improve DA with errors, including multipole-field errors in the IR quadrupoles, and increase the number of seeds examined;
- 4. Improve the correction of machine errors for beta-beating;

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	0.02%
Sextupole	0.10	0.10	0.10	

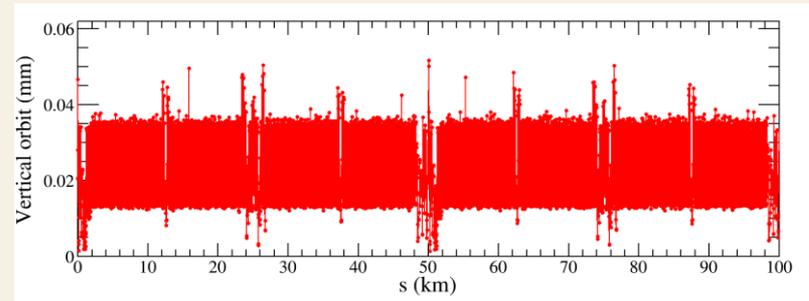
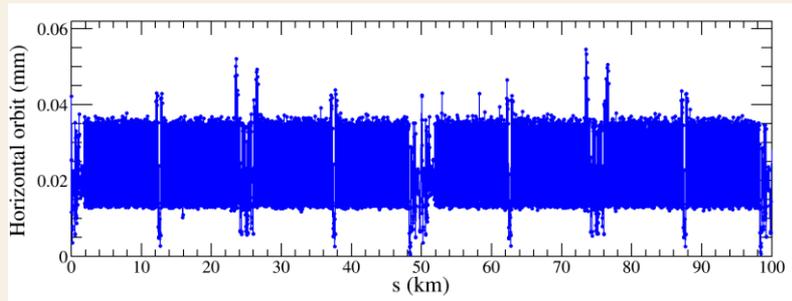
Error definition

- The latest lattice from Yiwei Wang (4 modes) is used;
- The filed errors of IR quadrupole magnets are considered;
- 1000 Higgs lattice seeds are generated for correction;
- The beta-beating correction is optimized;

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COD correction

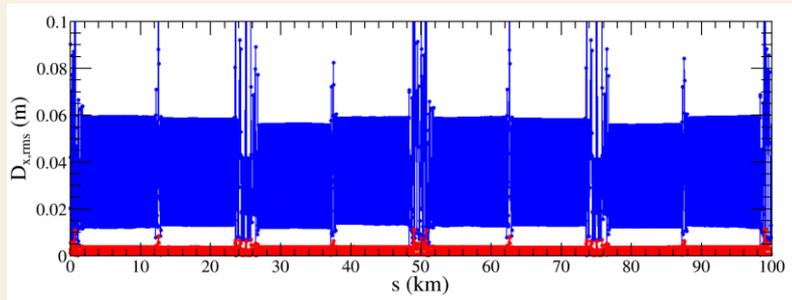
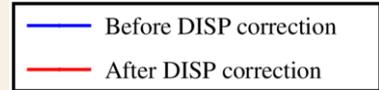
- 3690 BPMs placed at quadrupoles
- 1826 Horizontal correctors placed beside focusing quadrupoles
- 1846 Vertical correctors placed beside defocusing quadrupoles
- Orbit correction is applied using orbit response matrix and SVD method.



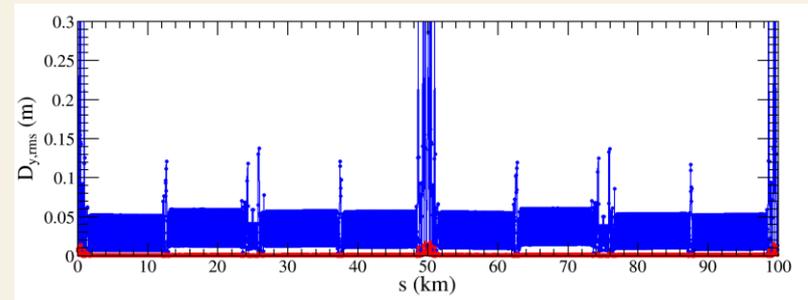
$$RMS_{COD} < 0.05 \text{ mm}$$

- 496 seeds are converged for further correction.

Dispersion correction



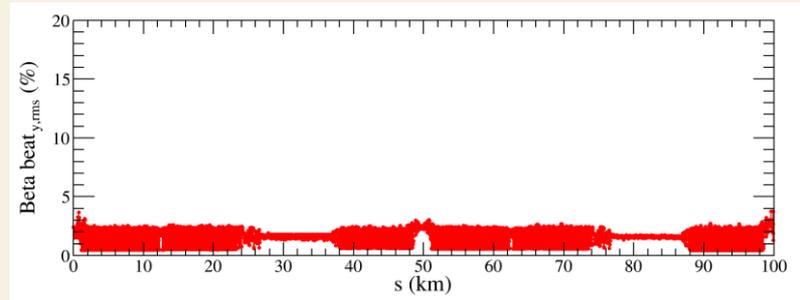
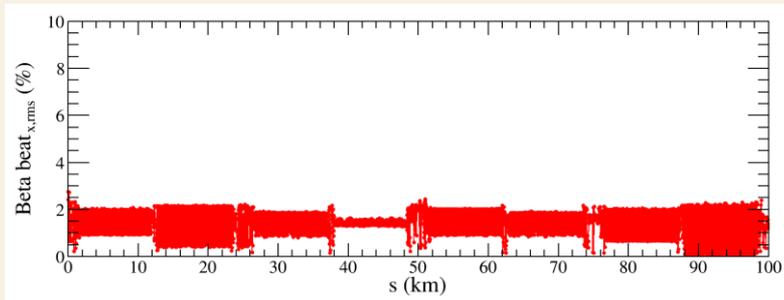
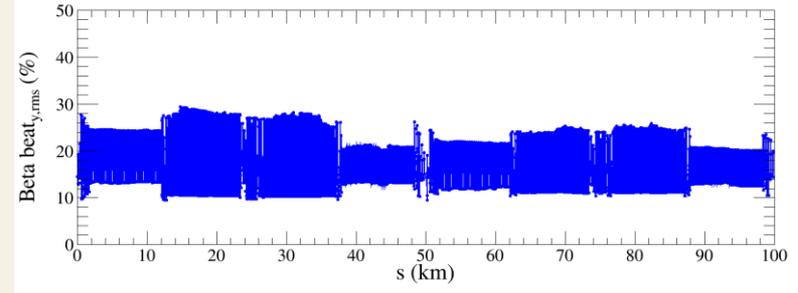
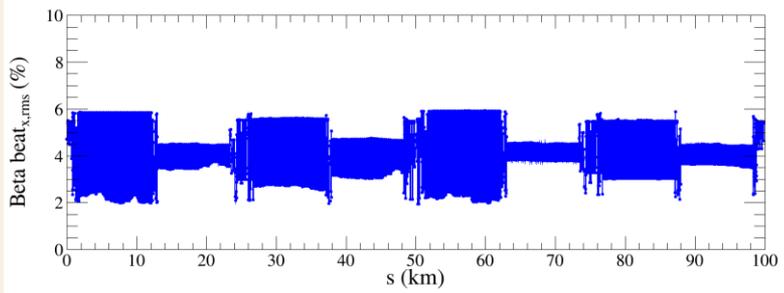
$\Delta D_{x,rms}$ decreased from 29.0 mm to 1.9 mm



$\Delta D_{y,rms}$ decreased from 35.3 mm to 1.1 mm

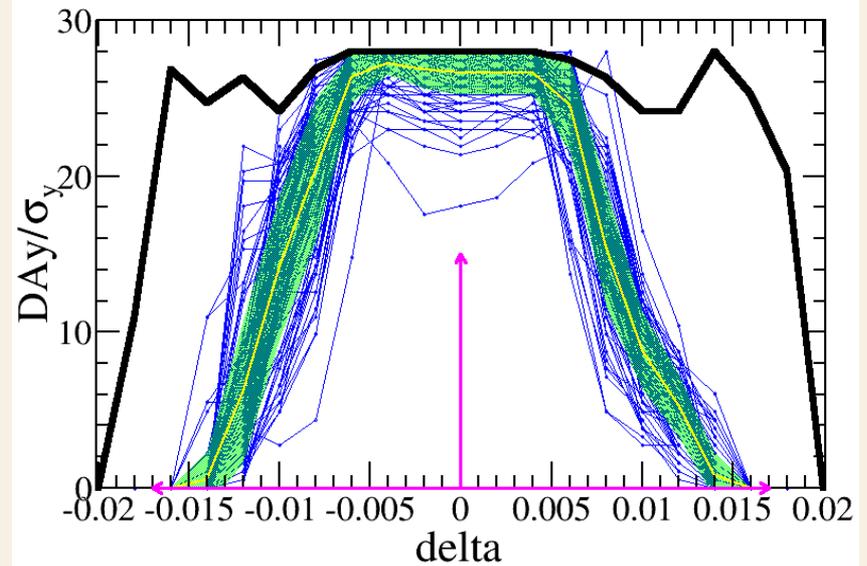
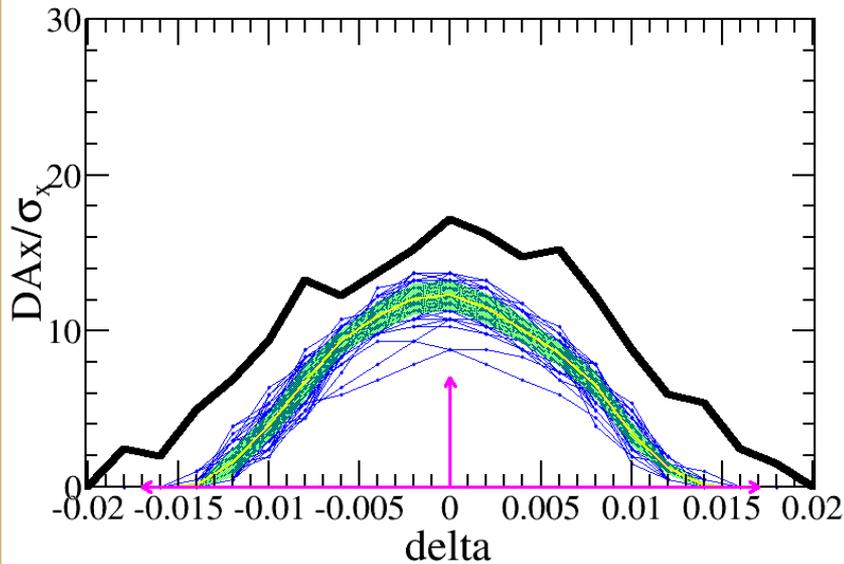
➤ 491 seeds are converged for further correction.

Beta-beating correction



- Scan the BPM numbers, correctors and quadrupole magnets used to do the LOCO fitting;
- Coupling correction is performed;
- The beta beating of ~ 100 seeds are decreased to $\sim 3\%$ after correction.

DA results



- The DA with error correction satisfy $7\sigma_x \times 15\sigma_y$ & 0.014.
- The energy acceptance decreased from 1.6% to 1.4% when the field error of IR quadrupoles is considered.

Summary



- Error correction for the latest Higgs lattice is performed;
- The field error of IR quadrupole magnets is considered;
- The beta beating correction is optimized;
- Compared with the previous DA results, the current energy acceptance is decreased, further check and optimization are necessary.



Thank you for
your attention

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Beta-beating correction

Dispersion free steering principle (DFS): θ_c

$$\vec{d} = \begin{pmatrix} (1 - \alpha)\vec{u} \\ \alpha\vec{D}_u \end{pmatrix} \quad M = \begin{pmatrix} (1 - \alpha)A \\ \alpha B \end{pmatrix} \quad \vec{d} + M\vec{\theta} = 0$$

\vec{u} : Orbit vector

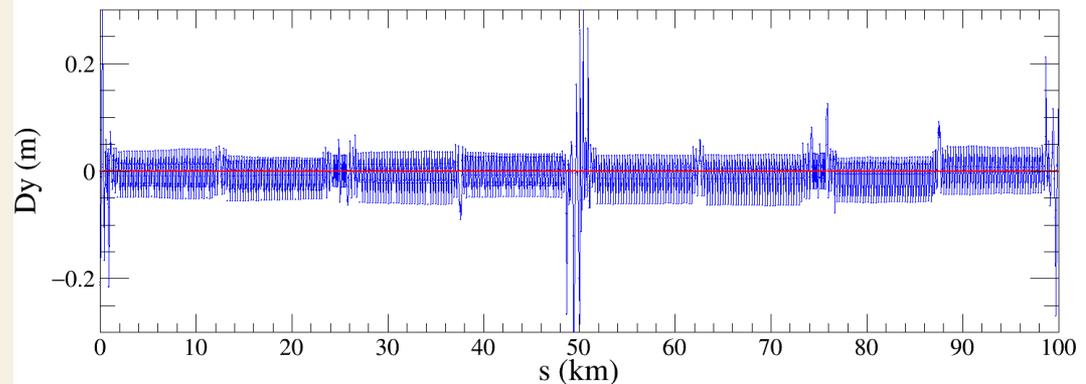
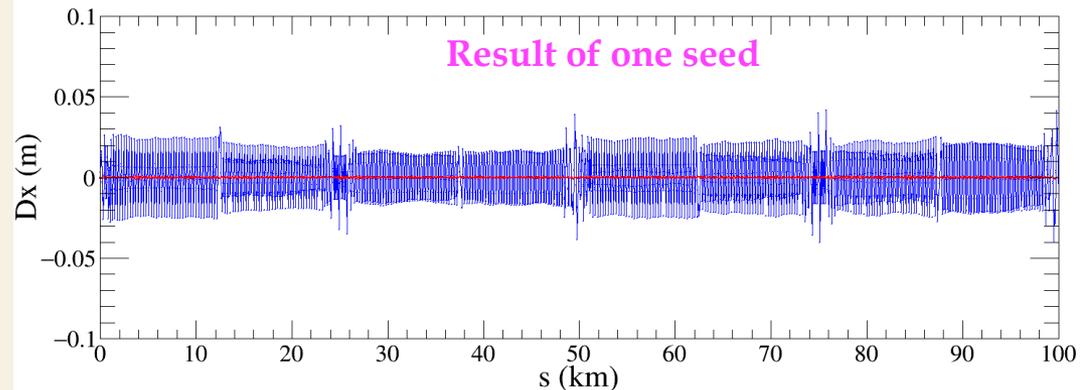
\vec{D}_u : Dispersion vector

$\vec{\theta}$: Corrector strengths vector

α : Weight factor

A : Orbit response matrix

B : Dispersion response matrix



Beta-beating correction

- ◆ Correct the beta functions with sextupoles on.
- ◆ **Based on AT LOCO**: model based correction
 - ◆ Establish lattice model M_{mod} , multi-parameter fit to the orbit response matrix M_{meas} to obtain calibrated model:
$$\chi^2 = \sum_{i,j} \frac{(M_{mod,ij} - M_{meas,ij})^2}{\sigma_i^2} \equiv \sum_{i,j} V_{ij}^2$$
 - ◆ Parameters fitted: K, KS ...
 - ◆ Use calibrated model to perform correction and apply to machine.
 - ◆ Fit the dispersion at the same time.
 - ◆ Application to **correct beta-beating**, **dispersion** and **coupled response matrix**.

Number of BPM: 947 horizontal 947 vertical
Number of CM: 610 horizontal 617 vertical

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Result of one seed

