



Institute of High Energy Physics
Chinese Academy of Sciences

Higher-order field error sensitivity analysis and requirements

BIN WANG

(ON THE BEHALF OF THE CEPC ERROR CORRECTION TEAM)

INSTITUTE OF HIGH ENERGY PHYSICS

2025.05.23





Introduction

- $B_2 \sim B_{10}$ of the Quadrupole is considered. Higgs Lattice with error correction is used.
- Multipole errors in the magnet are calculated on reference radius $R_{\text{ref}} = 12$ mm.
- Using 10^{-6} as the unit, we scan the multipole field errors from 10^{-5} to 10^{-3} .
- The requirement is to preliminarily determine the value at the onset of dynamic aperture reduction.
- The field errors in IR region and arc region are studied independently.

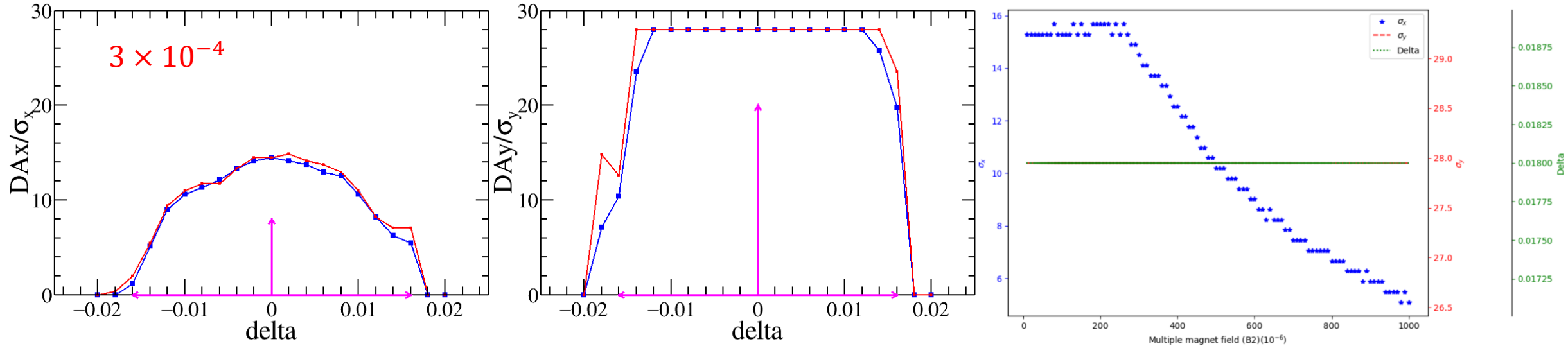
CEPC TDR

Table 5.2.1.3: Multipole field errors (unit: 1×10^{-4}).

Dipole	Quadrupole
$B_1 \leq 2$	
$B_2 \leq 5$	$B_2 \leq 3$
$B_3 \leq 0.2$	$B_3 \leq 2$
$B_4 \leq 0.8$	$B_4 \leq 1$
$B_5 \leq 0.2$	$B_5 \leq 1$
$B_6 \leq 0.8$	$B_6 \leq 0.5$
$B_7 \leq 0.2$	$B_7 \leq 0.5$
$B_8 \leq 0.8$	$B_8 \leq 0.5$
$B_9 \leq 0.2$	$B_9 \leq 0.5$
$B_{10} \leq 0.8$	$B_{10} \leq 0.5$



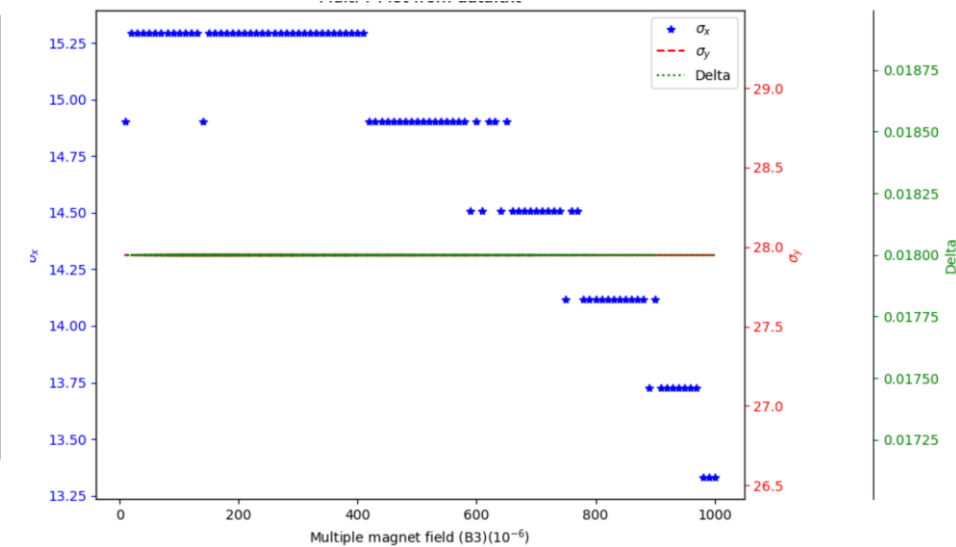
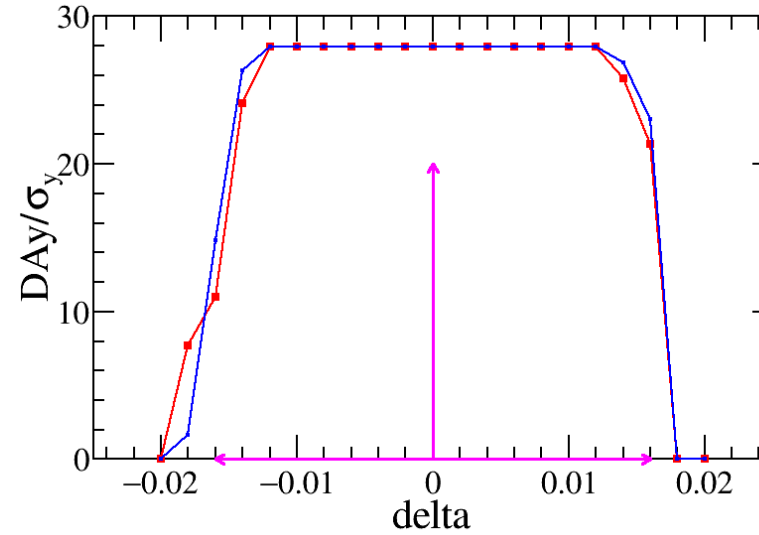
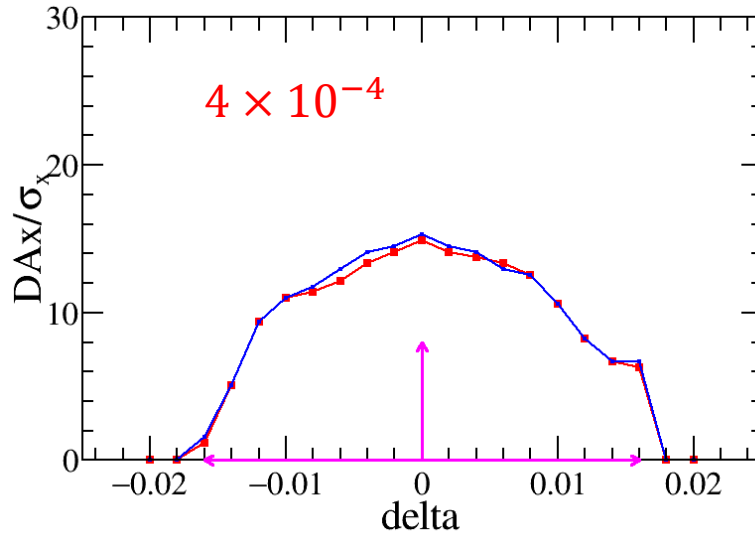
B2 in IR quadrupole



- The red and blue curves show the DAs without and with higher-order field error.
- The scanning results indicate a gradual reduction in horizontal DA with increasing higher-order field errors, while the vertical DA and the momentum acceptance are stable.
- 3×10^{-4} is preliminarily set to the requirement of B2 in the IR quadrupole magnets.



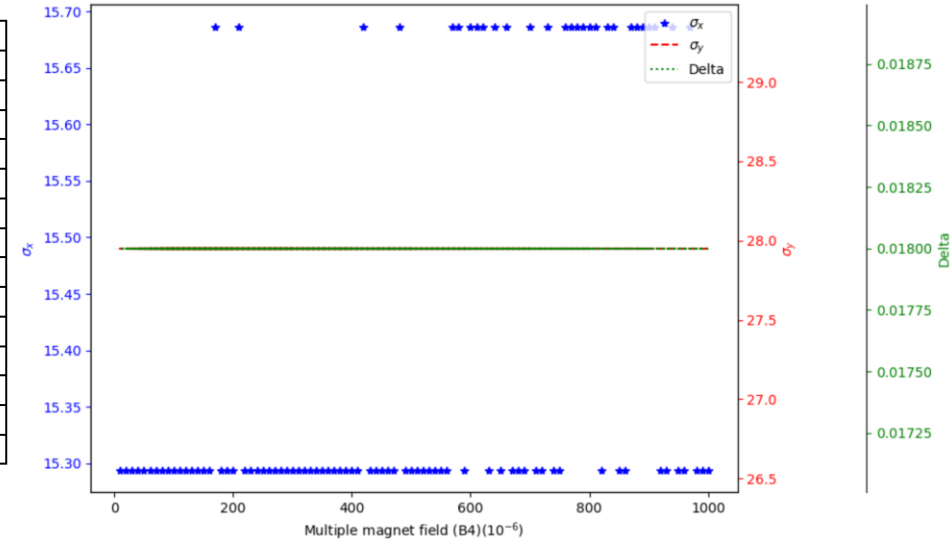
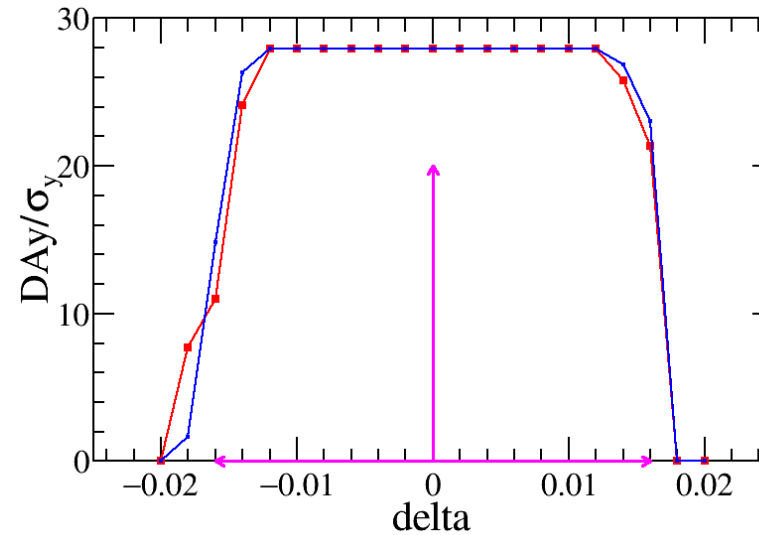
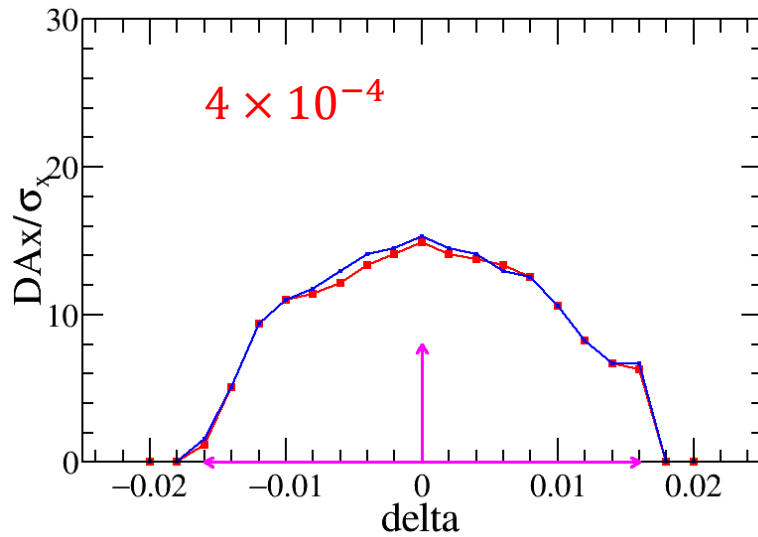
B3 in IR quadrupole



- 4×10^{-4} is preliminarily set to the requirement of B3 in the arc quadrupole magnets.



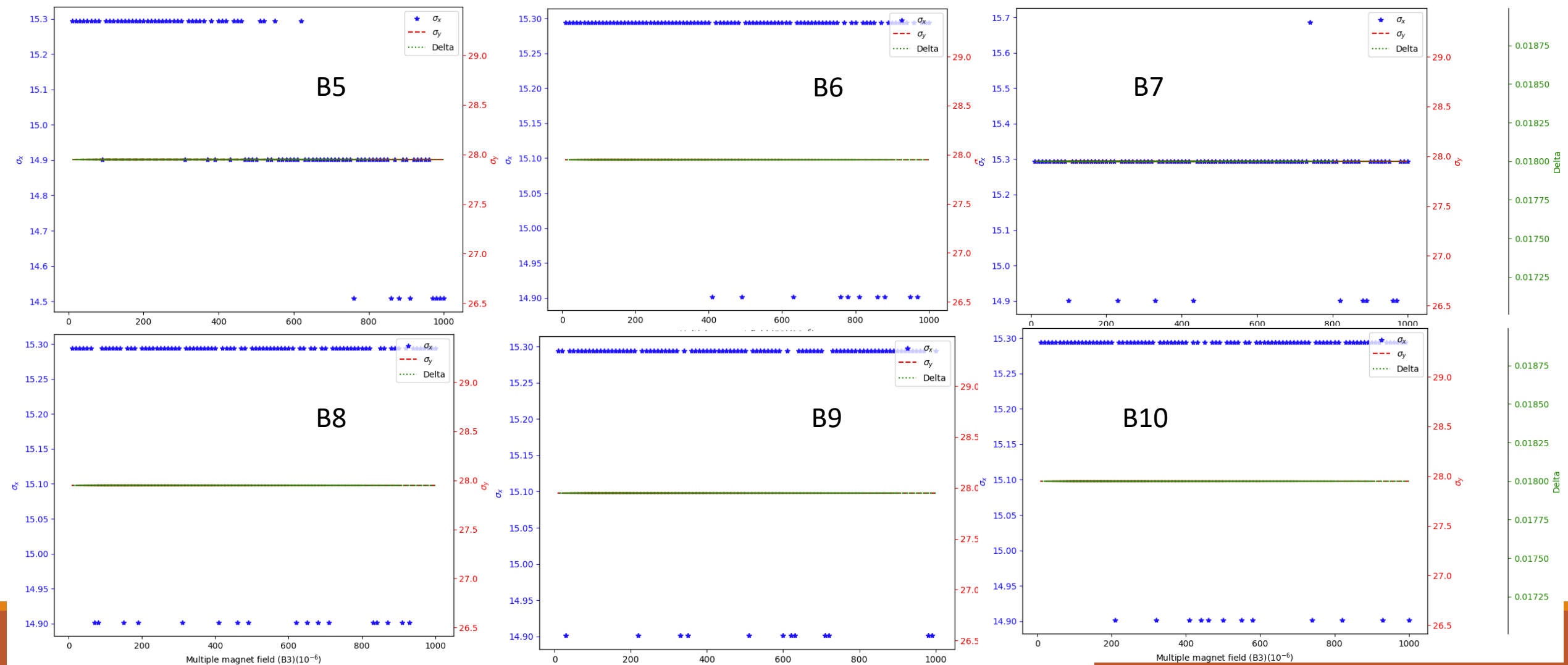
B4 in IR quadrupole



- No obvious DA reduction with adding the B4 – B10 in IR quadrupole.
- By check the detail DA plots, conservatively, 4×10^{-4} is preliminarily set to the requirement of B4 in the arc quadrupole magnets.

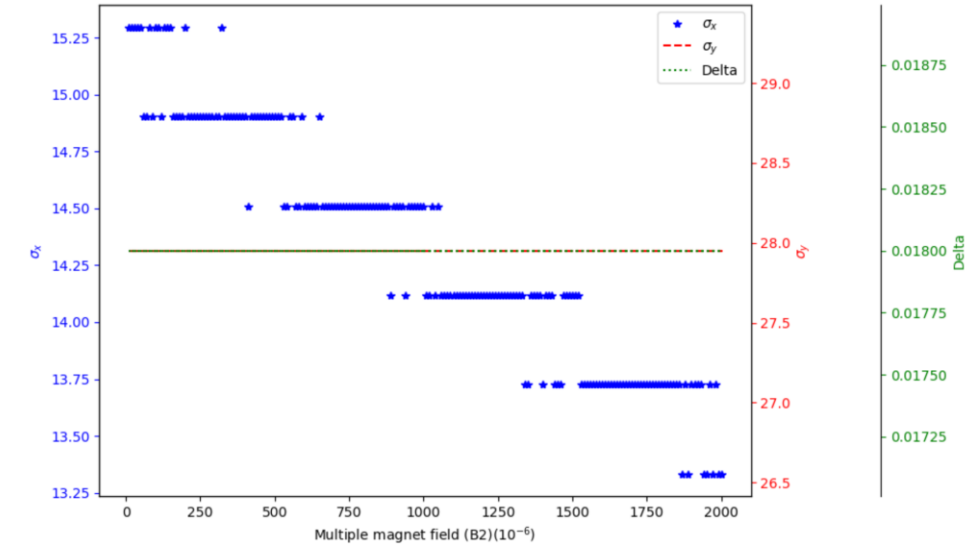
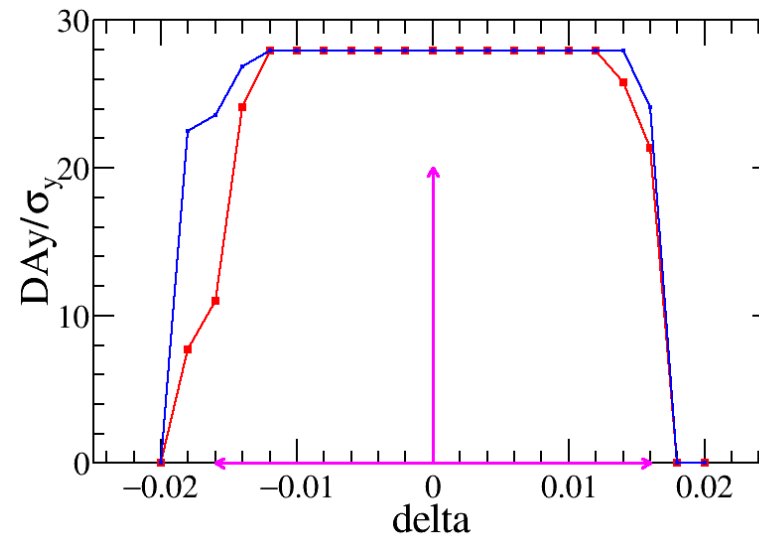
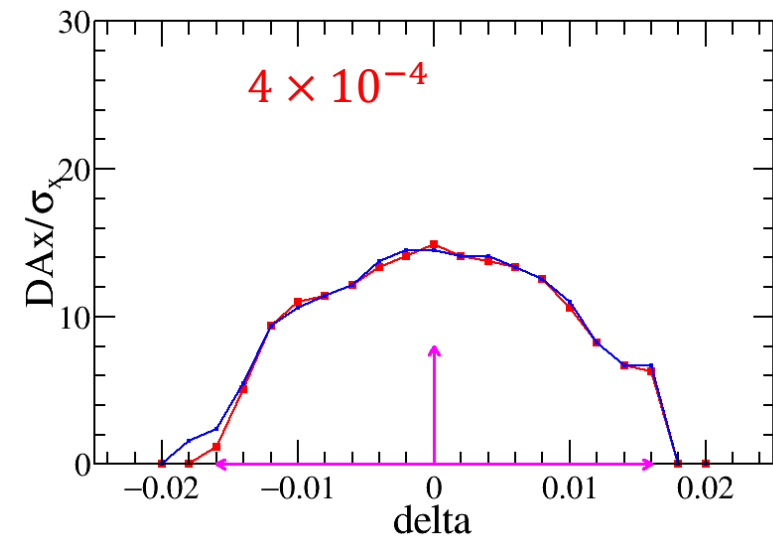


B5-B10 in IR quadrupole





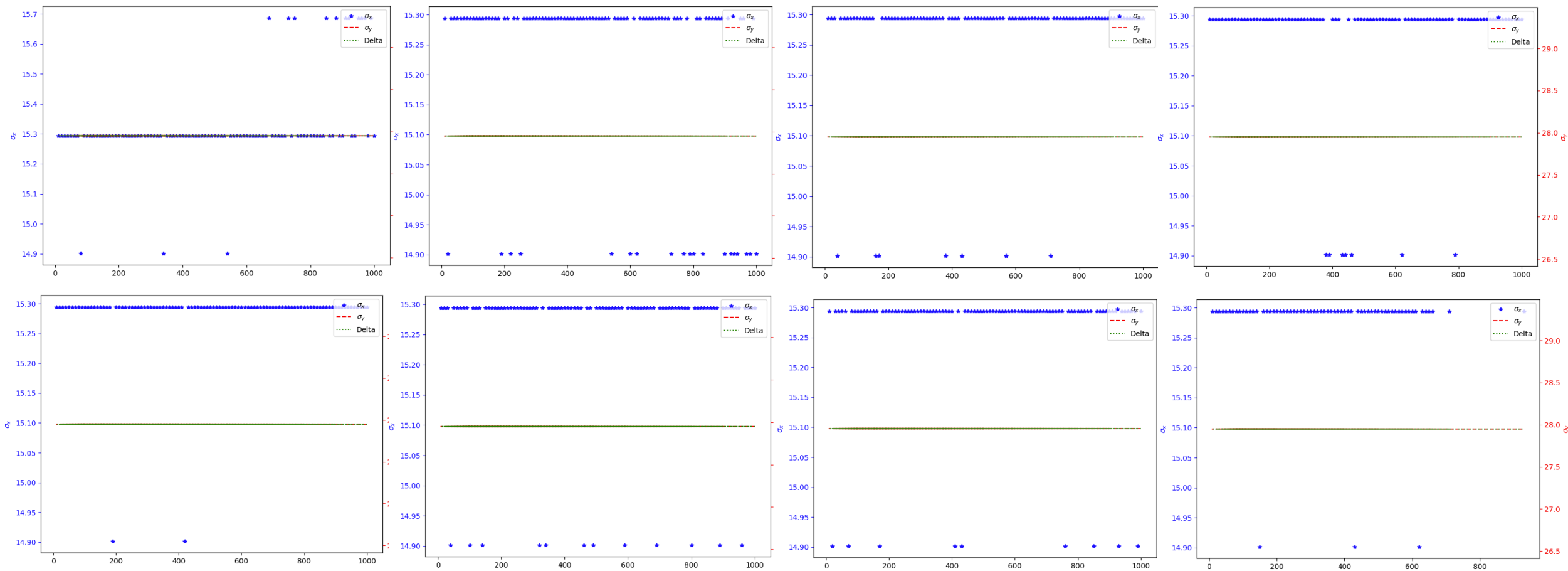
B2 in ARC quadrupole



- 4×10^{-4} is preliminarily set to the requirement of B3 in the arc quadrupole magnets.

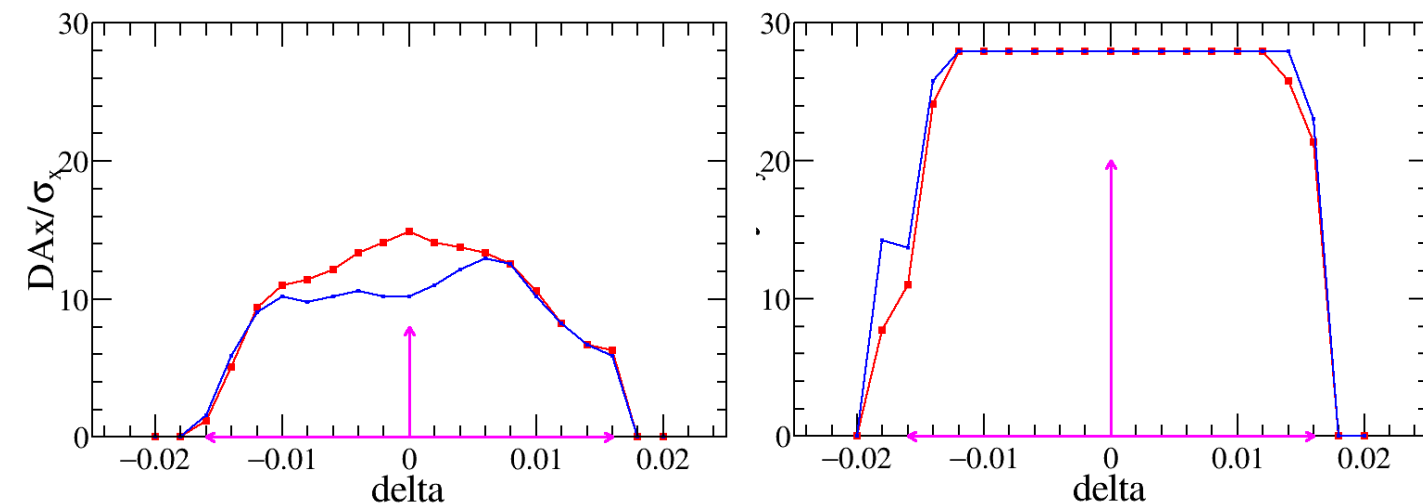


B3-B10 in ARC quadrupole





DA result with all higher-order field errors in quadrupole magnets



Quadrupole field errors	IR (10^{-4})	ARC (10^{-4})
B2	≤ 3	≤ 3
B3	≤ 2	≤ 2
B4	≤ 1	≤ 1
B5	≤ 1	≤ 1
B6	≤ 0.5	≤ 0.5
B7	≤ 0.5	≤ 0.5
B8	≤ 0.5	≤ 0.5
B9	≤ 0.5	≤ 0.5
B10	≤ 0.5	≤ 0.5

- Clear horizontal DA reduction with higher-order field errors in quadrupole magnets.

Summary and To-do list

- The higher-order magnet fields in the quadrupole magnets are detailed analyzed.
- The horizontal DA clearly decrease with increasing higher-order field errors, while the vertical DA and momentum acceptance are stable, further check is necessary.
- The results show that the B2 and B3 of quadrupole exhibit higher sensitivity to dynamic aperture.
- An preliminary requirement of higher-order fields is released, the DA with this requirement shows
- More detail analyze as well as for dipole and sextupole higher-order fields are ongoing, the corresponding tec. Note is under preparation.



Thank you for your attention

E-mail:
wangbin@ihep.ac.cn