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Higher-order field error sensitivity analysis and requirements

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Introduction

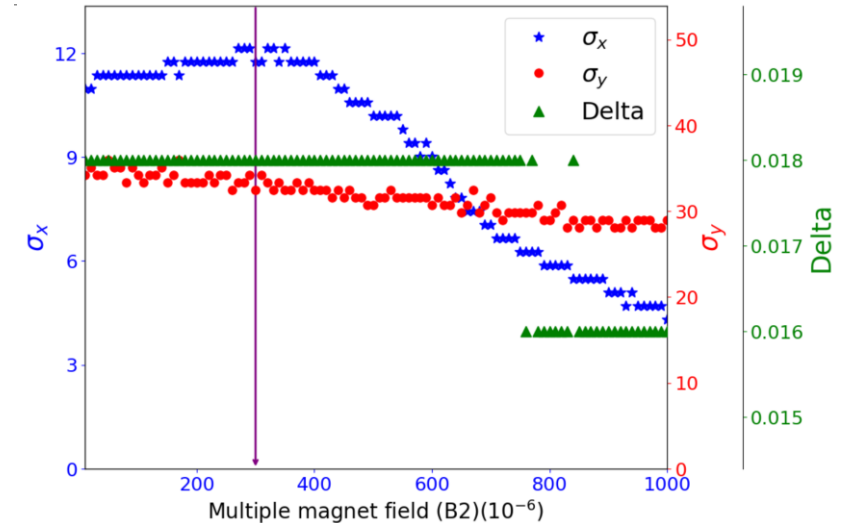
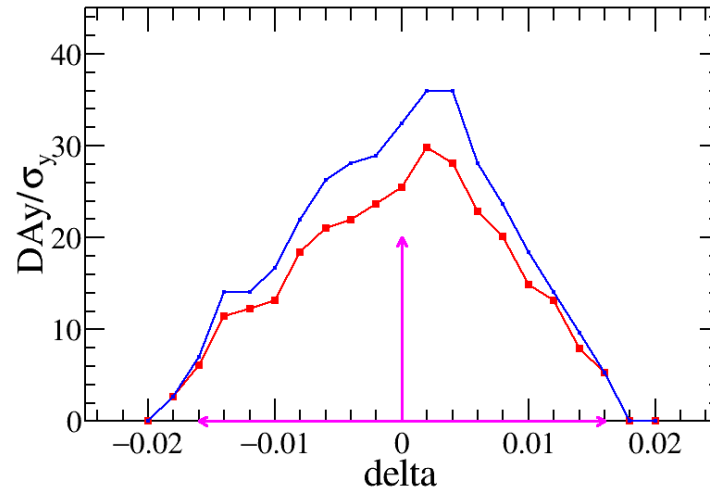
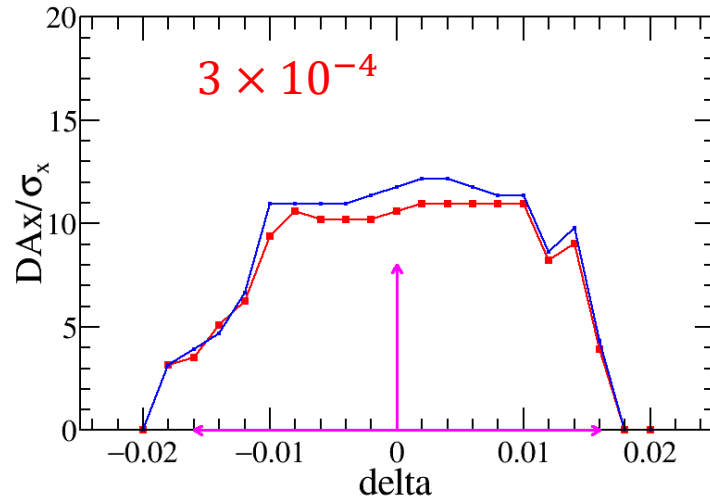
- ▶ $B_2 \sim B_{10}$ of the Quadrupole is considered.
- ▶ The Higgs Lattice with error correction is used.
- ▶ Multipole errors in the magnet are calculated on reference radius $R_{ref} = 12$ mm.
- ▶ Using 10^{-6} as the unit, we scan the multipole field errors from 10^{-5} to 10^{-3} .
- ▶ The higher field requirement is configured as the initial value when dynamic aperture reduction begins.

The higher field errors in IR region and arc region are studied independently.

Dipole	Quadrupole	Sextupole
$B_2/B_0 \leq 4 \times 10^{-4}$	$B_2/B_1 \leq 4 \times 10^{-4}$	$B_3/B_2 \leq 20 \times 10^{-4}$
$B_3/B_0 \leq 0.8 \times 10^{-4}$	$B_3/B_1 \leq 4 \times 10^{-4}$	$B_4/B_2 \leq 3 \times 10^{-4}$
$B_4/B_0 \leq 0.2 \times 10^{-4}$	$B_4/B_1 \leq 2 \times 10^{-4}$	$B_5/B_2 \leq 20 \times 10^{-4}$
$B_n(n>4)/B_0 \leq 0.8 \times 10^{-4}$	$B_n(n>4)/B_1 \leq 1 \times 10^{-4}$	$B_n(n>5)/B_2 \leq 10 \times 10^{-4}$



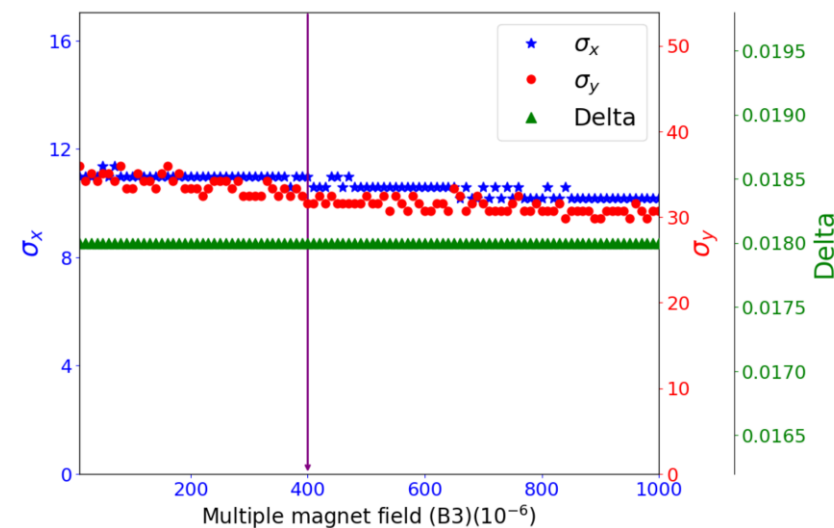
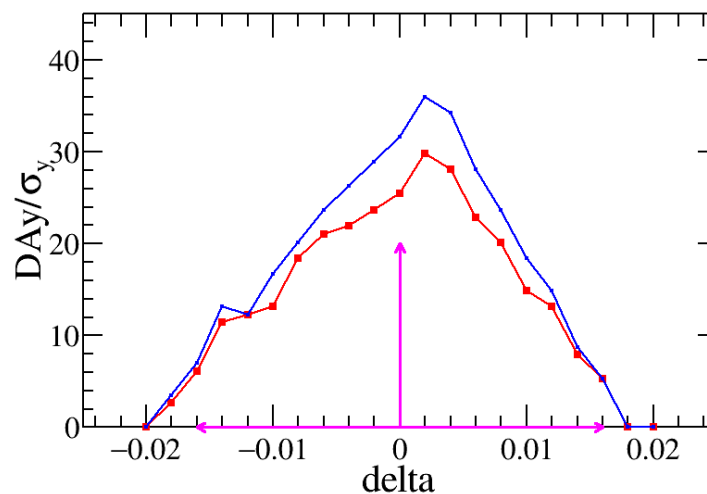
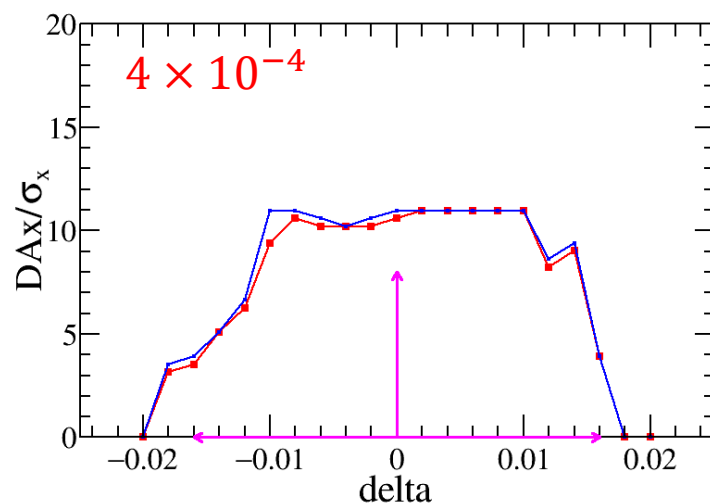
B2 in IR quadrupole



- For the left and middle plots, **the red** and **blue** curves show the DAs **without** and **with** higher-order field error, the pink arrows show the DA requirement.
- 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.



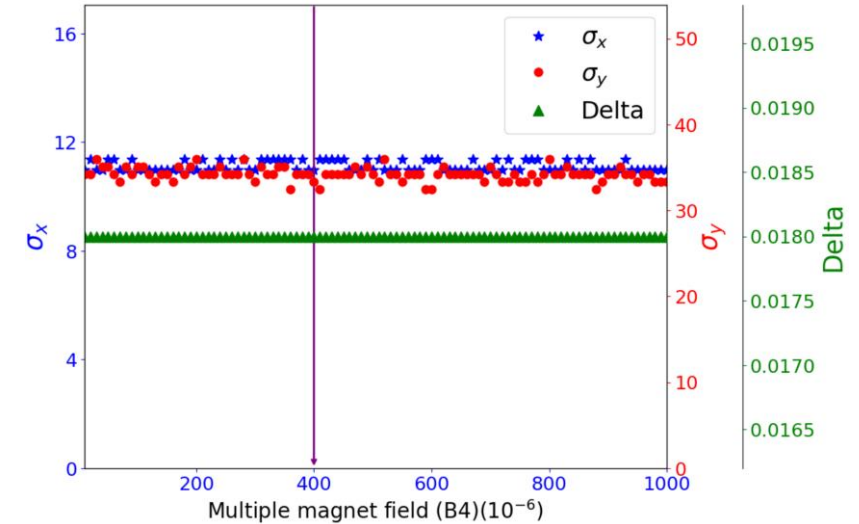
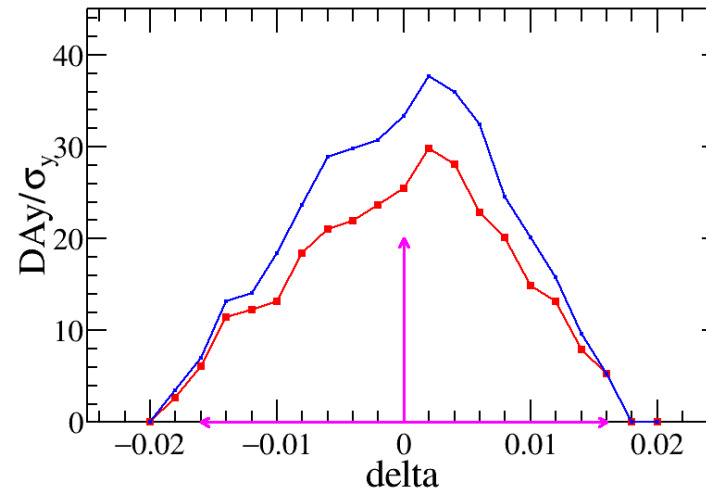
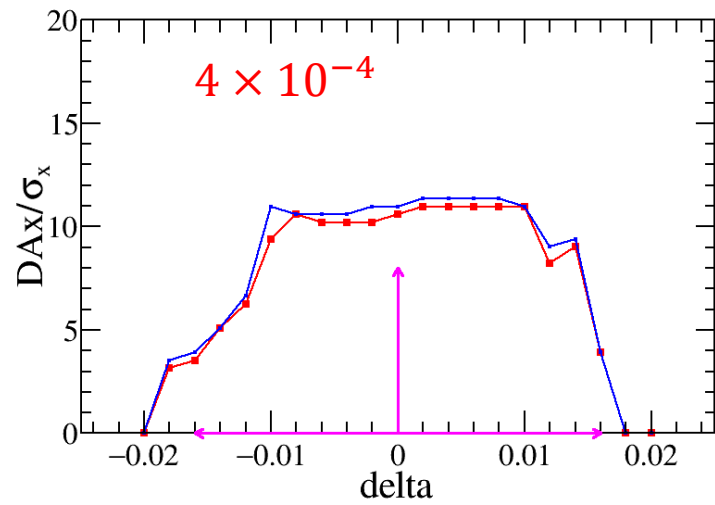
B3 in IR quadrupole



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



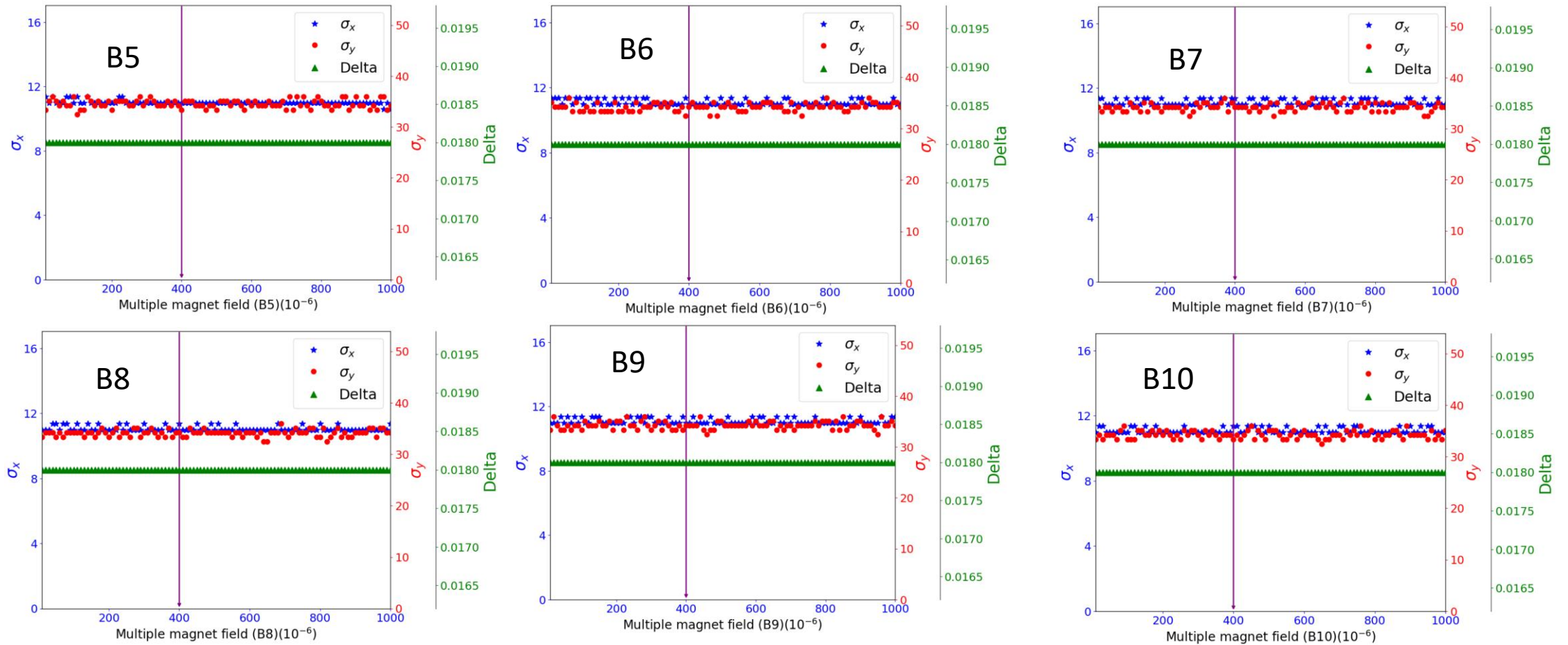
B4 in IR quadrupole



- 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.

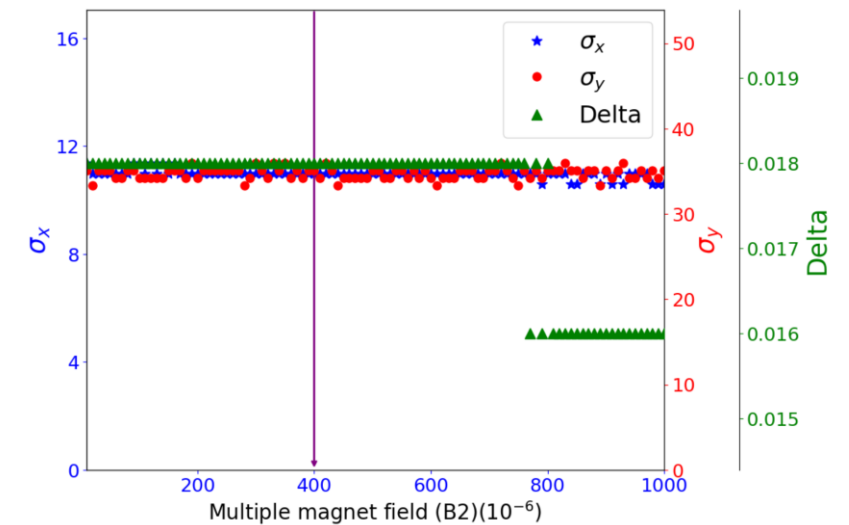
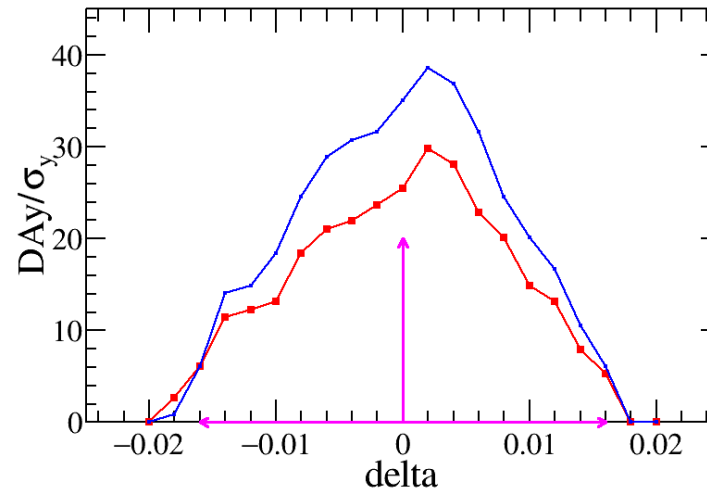
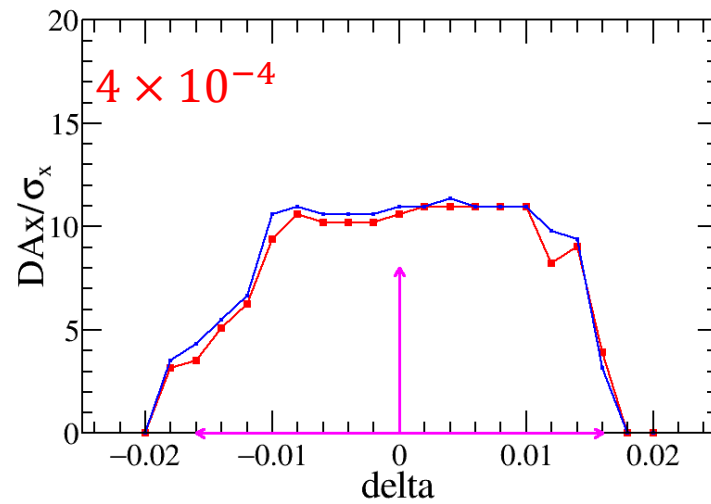


B5-B10 in IR quadrupole





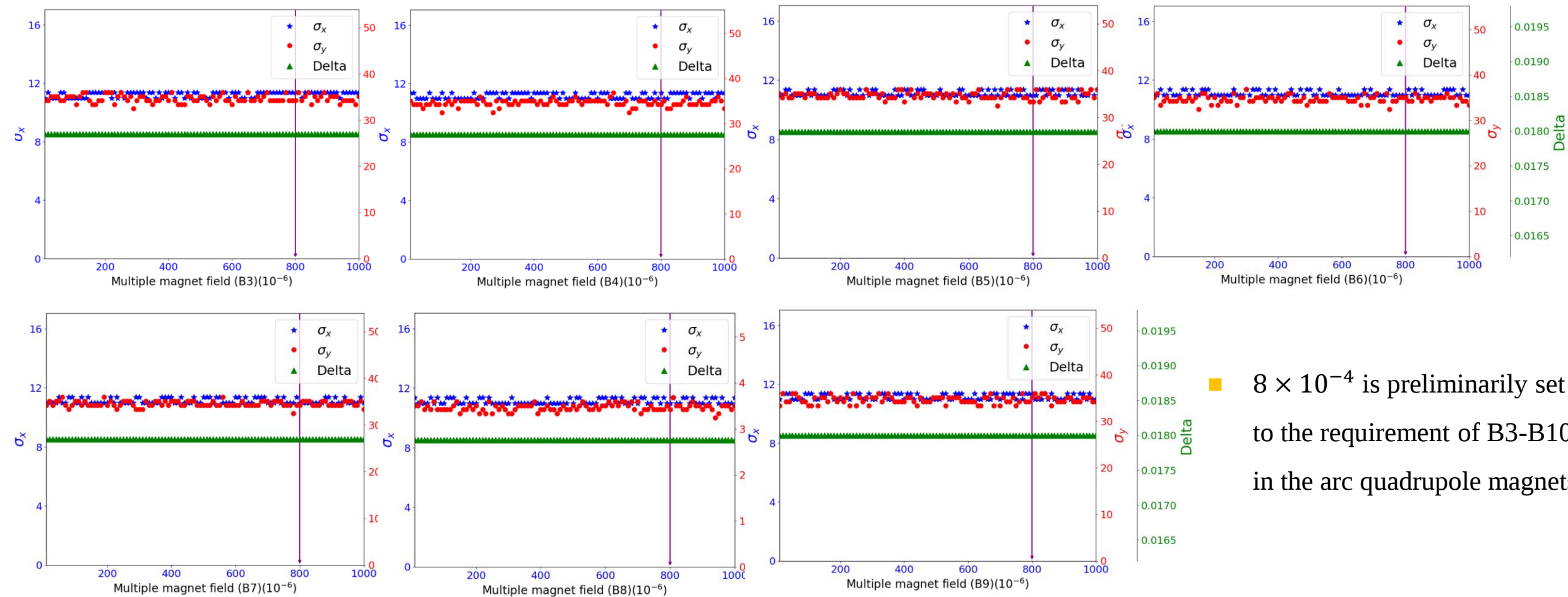
B2 in ARC quadrupole



- 4×10^{-4} is preliminarily set to the requirement of B2 in the arc quadrupole magnets.



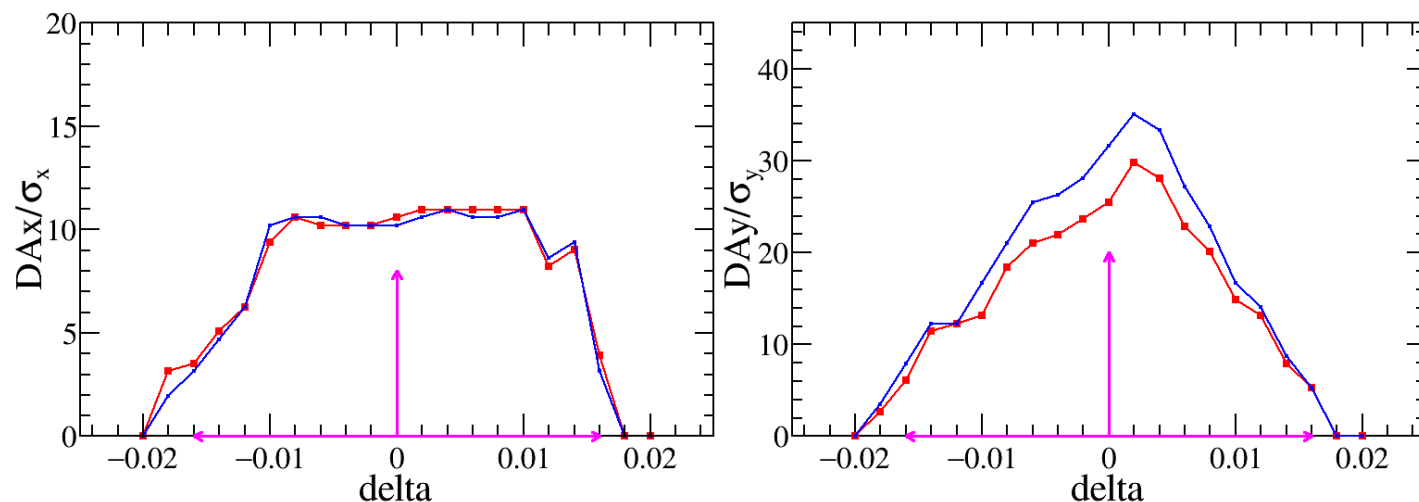
B3-B10 in ARC quadrupole



■ 8×10^{-4} is preliminarily set to the requirement of B3-B10 in the arc quadrupole magnets.



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



Quadrupole field errors	IR (10^{-4})	ARC (10^{-4})
B2	≤ 3	≤ 4
B3	≤ 4	≤ 8
B4	≤ 4	≤ 8
B5	≤ 4	≤ 8
B6	≤ 4	≤ 8
B7	≤ 4	≤ 8
B8	≤ 4	≤ 8
B9	≤ 4	≤ 8
B10	≤ 4	≤ 8

- Based on the setting values of higher-order field errors in the table, **no significant reduction in aperture is observed.**

Summary and To-do list

- The higher-order magnet fields in the quadrupole magnets are detailed analyzed.
- The results show that quadrupole fields B2 and B3 significantly impact dynamic aperture sensitivity, whereas higher-order field errors (B4-B10) show negligible influence. **Further investigation is required to verify the underlying mechanisms.**
- An preliminary requirement of higher-order fields is released, the DA with this requirement shows no obvious reduction.
- 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

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