HL-LHC optics MD results

Yannis Angelis
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All contributors to HL-LHC MDs:
Y. Angelis, R. Bruce, X. Buffat, F. Carlier, R. De Maria, J. Dilly, A. Donadon, L. Giacomel, P. Hermes, M. Hostettler, G. Iadarola, U. Kar, M. Le Garrec, V. Ferrentino, B. Lindström, E. Maclean, D. Mirarchi, M. Monikowska, N. Mounet, O. Naumenko, T. Pugnat, S. Redaelli, D. Rivorin, B. Salvant, M. Solfaroli, K. Skoufaris, R. Tomas, G. Trad, D. Veres, F. Wharton, J. Wenninger, P. Zisopoulos

Contents

- Arc45, Arc81 corrections for Beam1
- Arc45 correction for Beam2
- Deeper Investigation of phase error

Focus only at a single β*, to compare
before and after the applied corrections

Arc corrections for Beam1

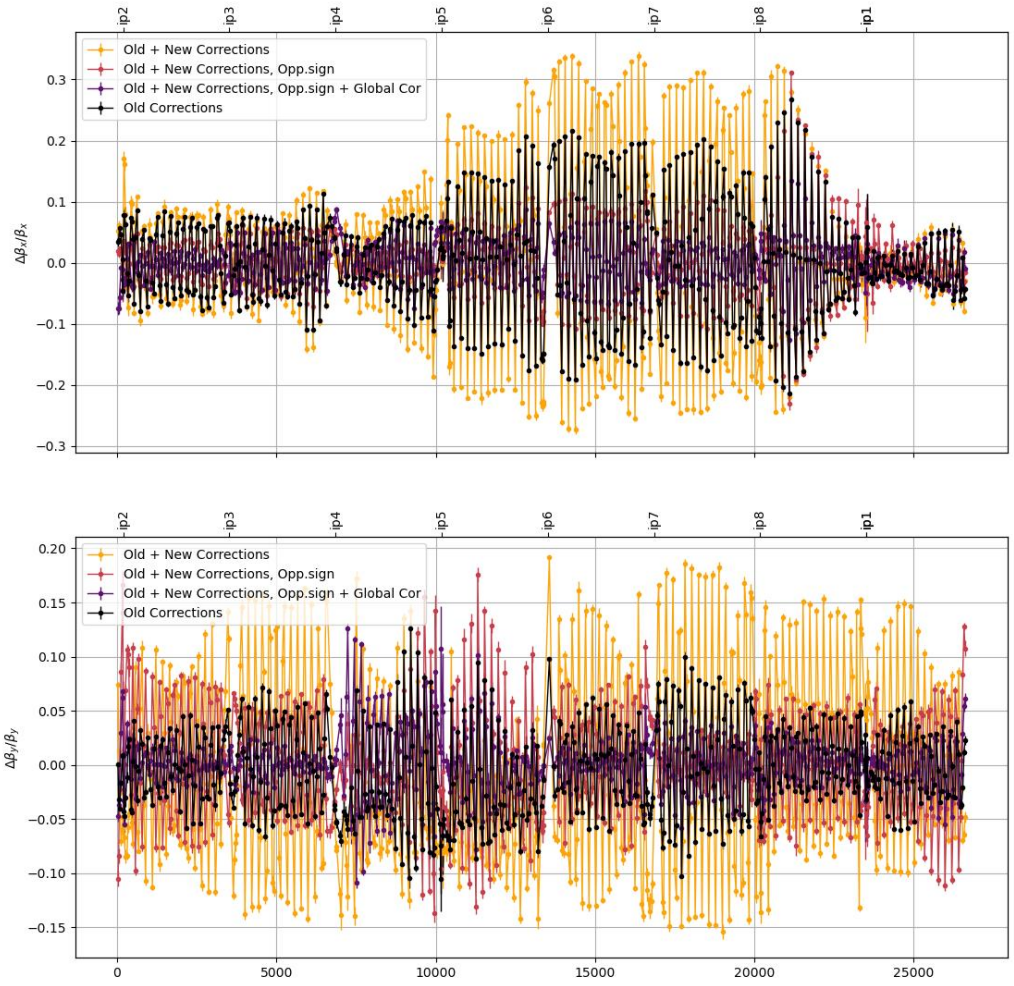
Analysis for the step: 165/84cm

Old corrections: Sextupole Bumps + Q10 + MQT, at Arc45, Arc81

New Corrections: Sextupole Bumps +MQT at Arc45, Arc81

‘Similarly’ for both arcs

Goal: Reduce β-beating by reducing the phase errors in the arcs



Arc corrections for Beam1

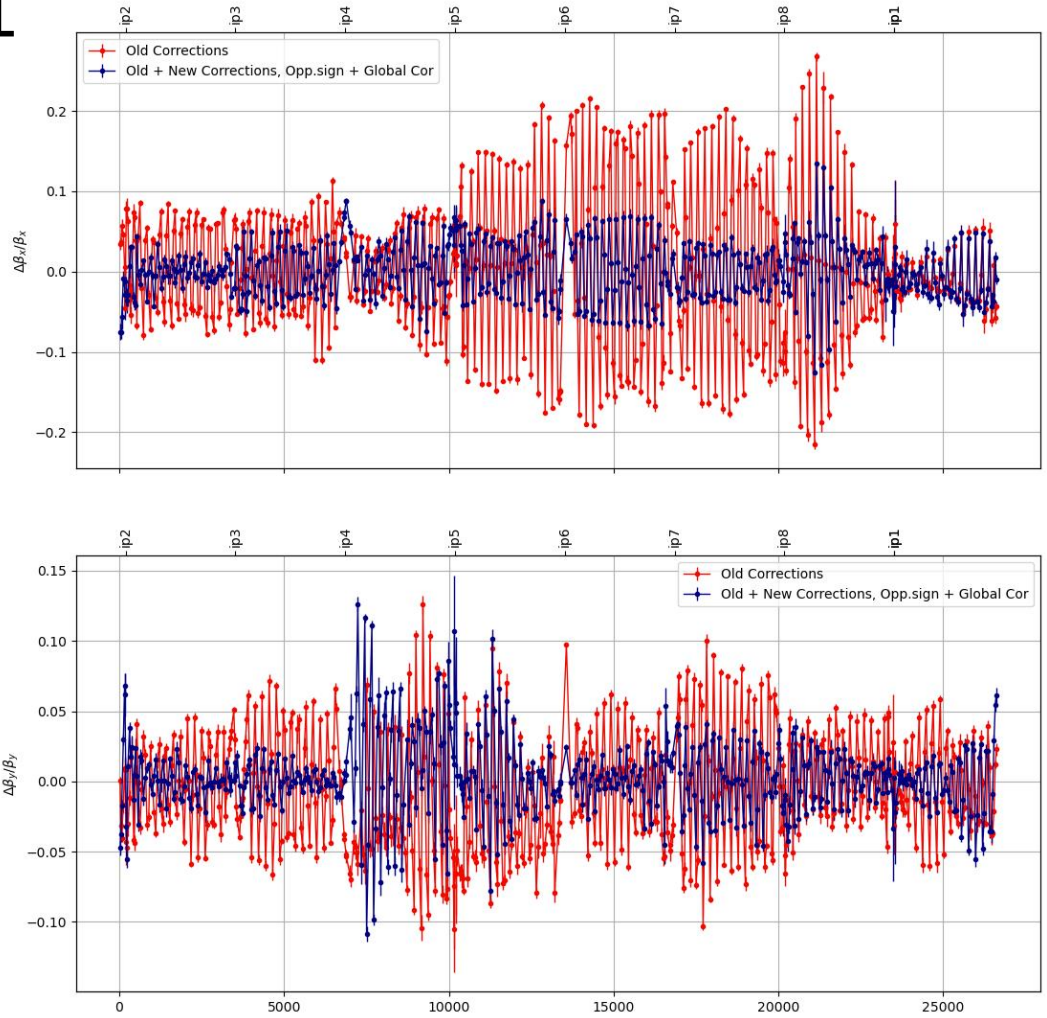
Analysis for the step: 165/84cm

Old corrections: Sextupole Bumps + Q10 + MQT, at Arc45, Arc81

New Corrections: Sextupole Bumps +MQT at Arc45, Arc81

Peak β-beat ~12% both planes

Goal: Reduce β-beating by reducing the phase errors in the arcs

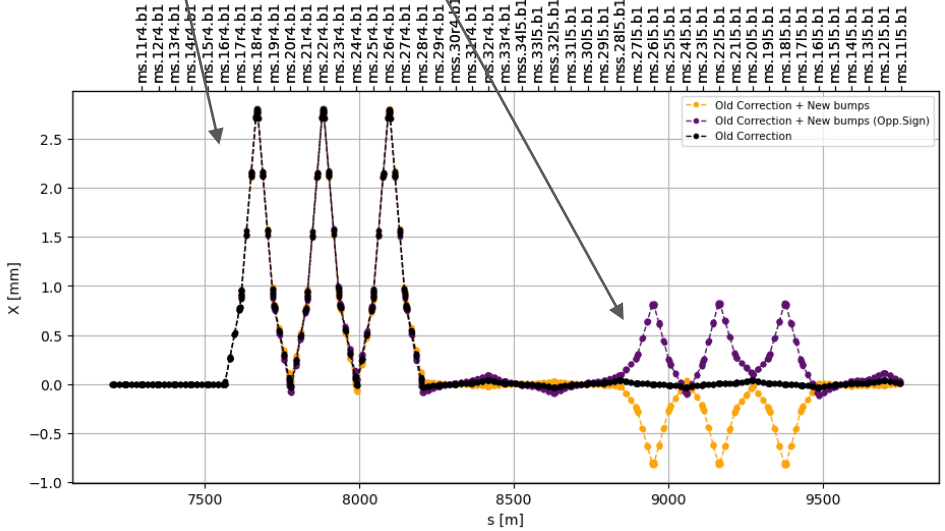


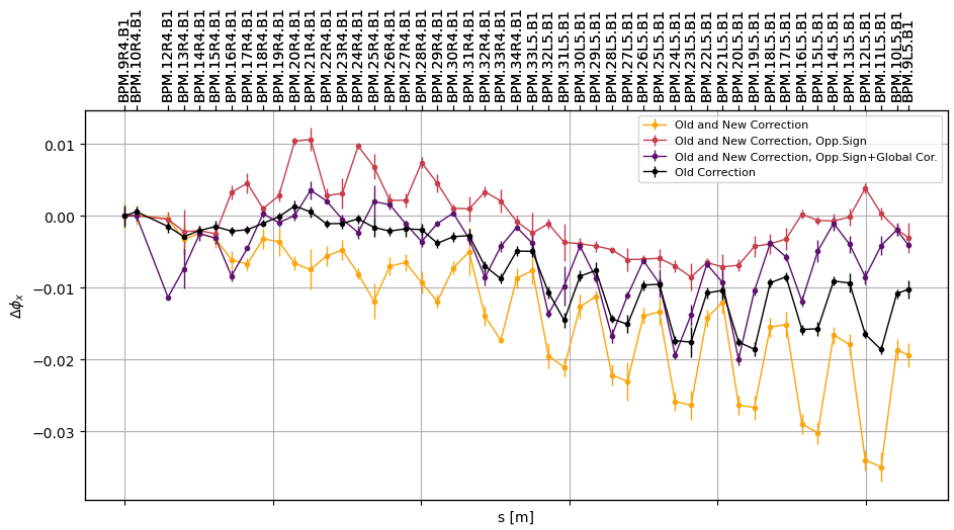
Arc45 corrections for Beam1

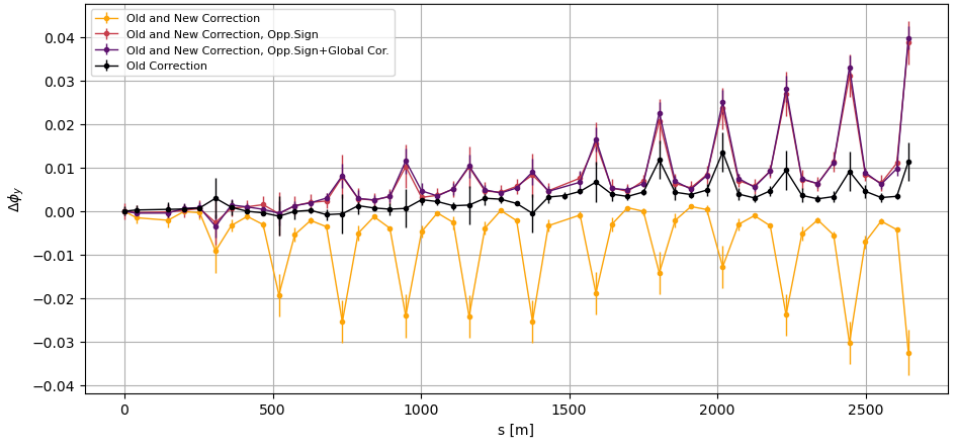
Sextupole bumps**:**

Old corrections: Left side of the arc

New Corrections: Right side of the arc



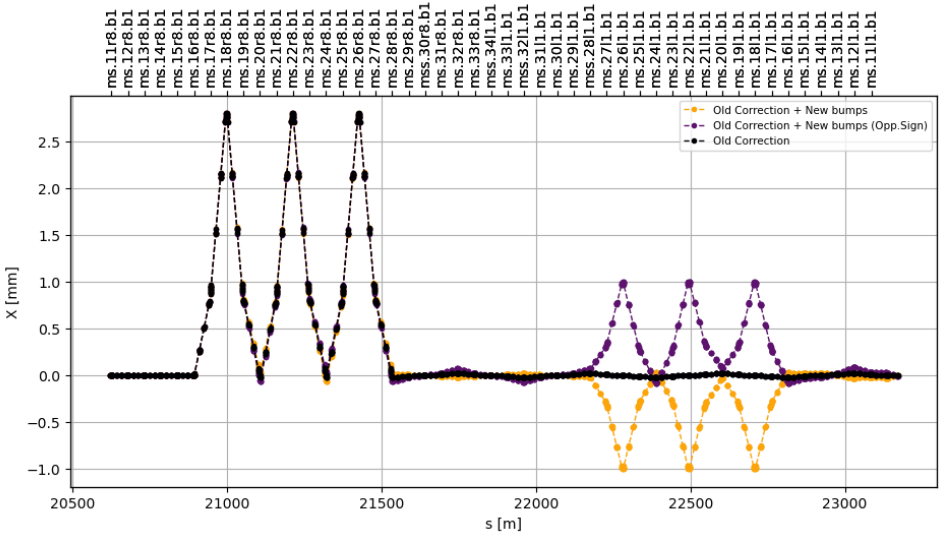


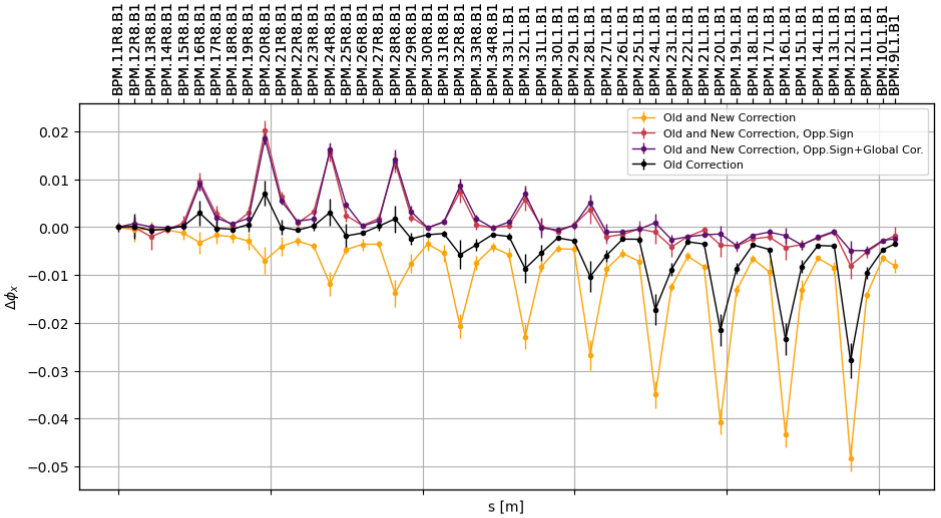


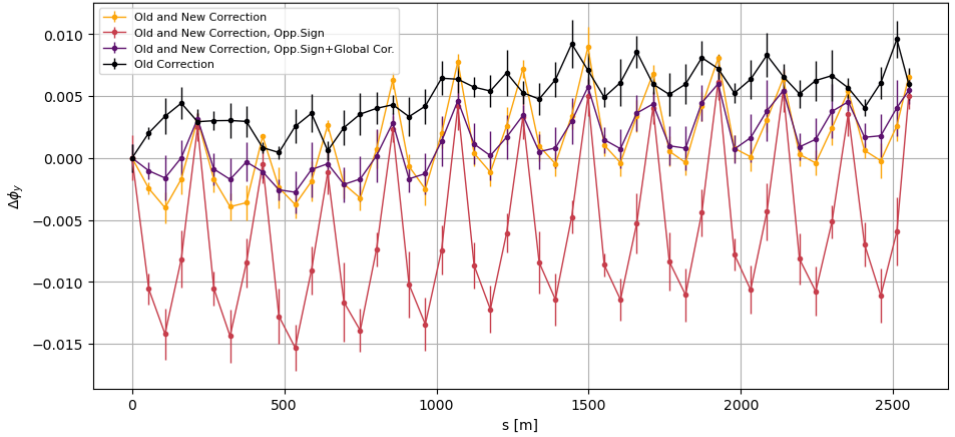
Arc81 corrections for Beam1

Sextupole bumps**:**
Old corrections: Left side of the arc

New Corrections: Right side of the arc







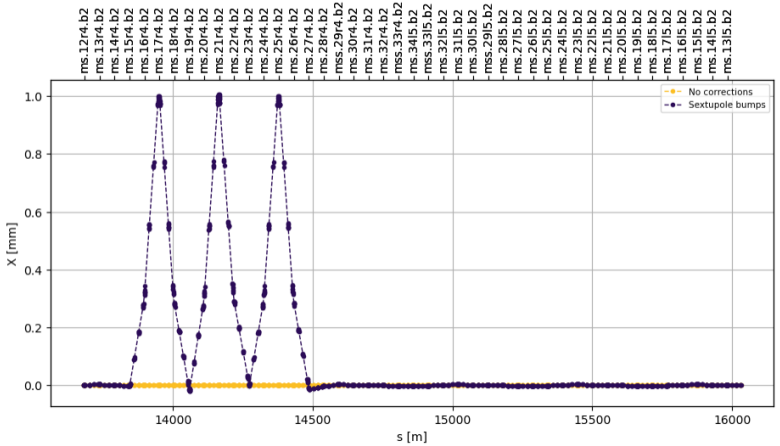
Arc45 corrections for Beam2

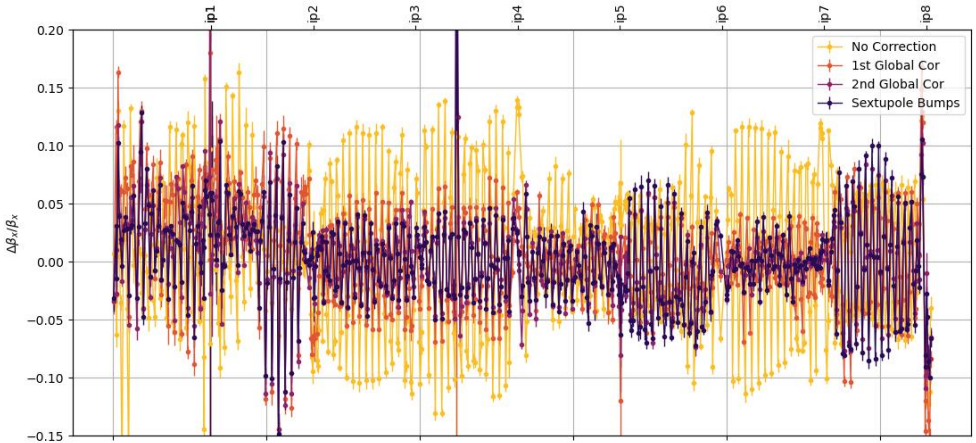
110/43cm

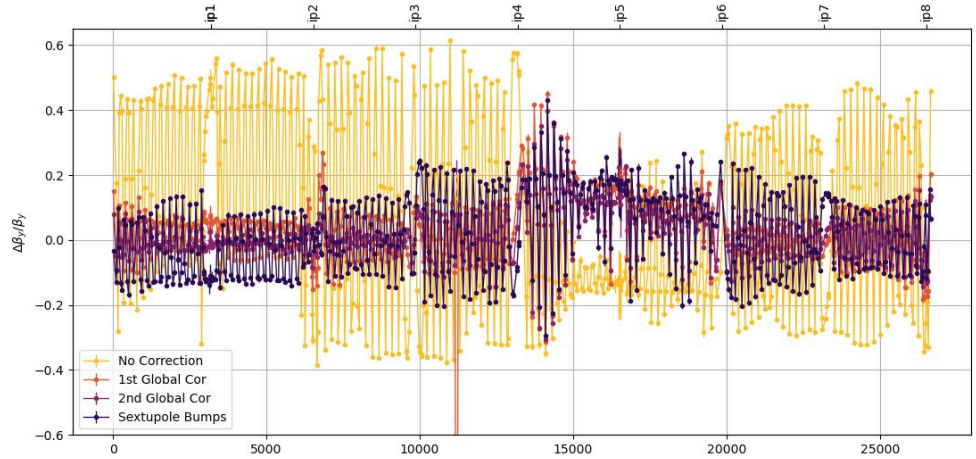
Sextupole bumps: Applied with the 1st iteration of Global corrections

2nd iteration did not improve arc45 beating

Correction: Sextupole bumps on the left side of the arc + KQTD.A45B2







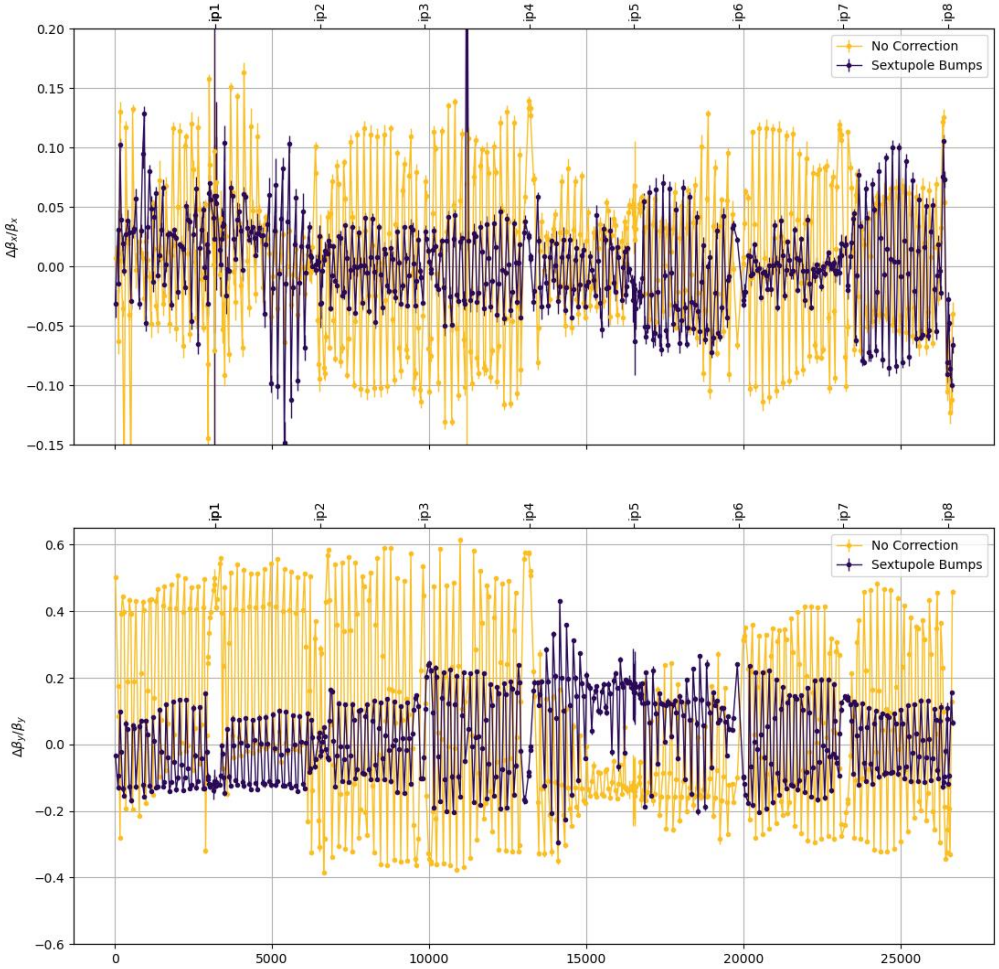
Arc45 corrections for Beam2

110/43cm

Very good control of the β-beat apart from Arc45 vertical

Reached the end of the MD before another iteration of corrections

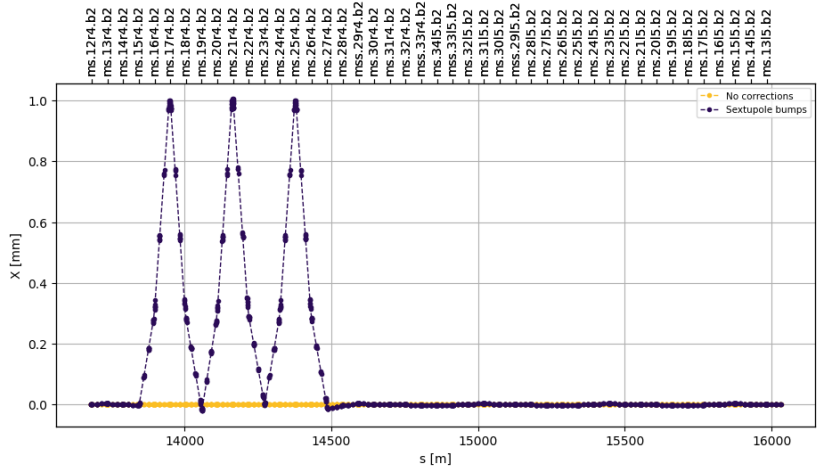
New corrections and improvements could not be tested during MD5

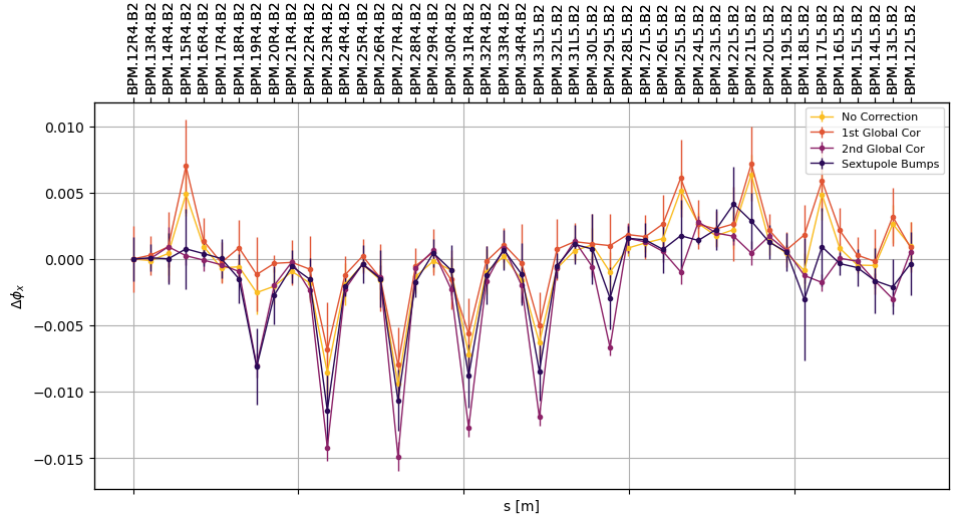


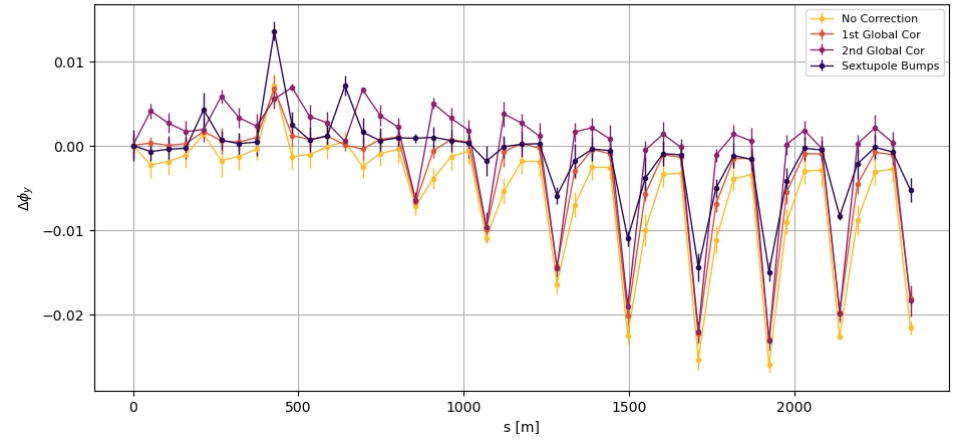
Arc45 corrections for Beam2

Correction: Sextupole bumps on the left side of the arc + KQTD.A45B2

Vertical Δφ reduction
BUT β-beat increased globally

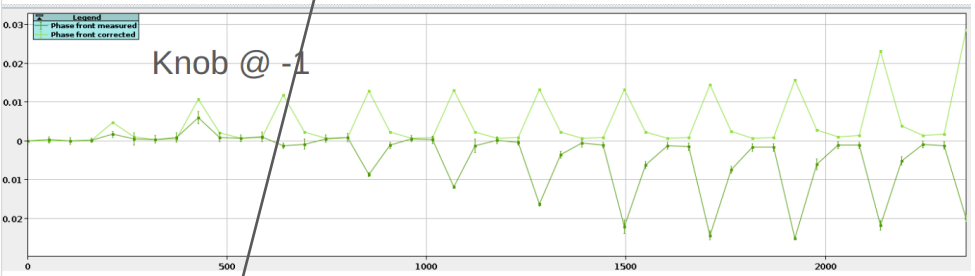


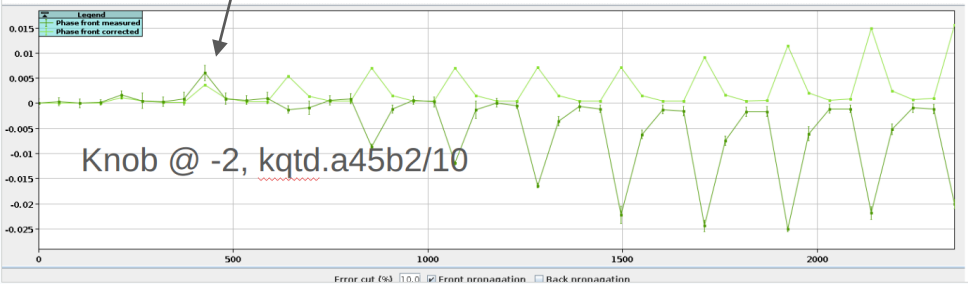


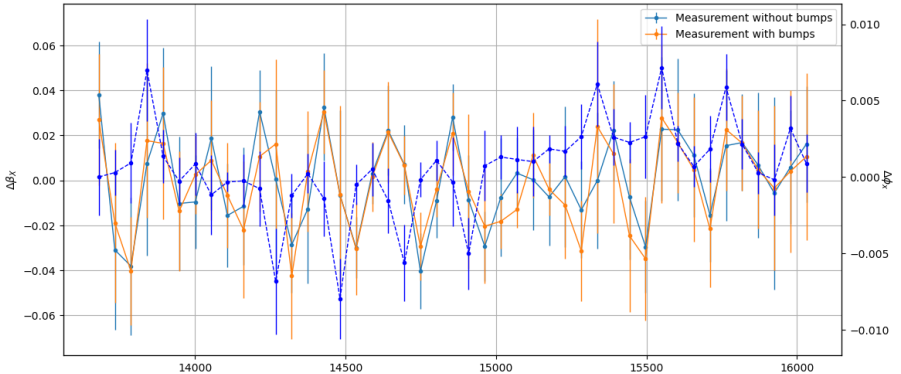


Arc45 corrections for Beam2

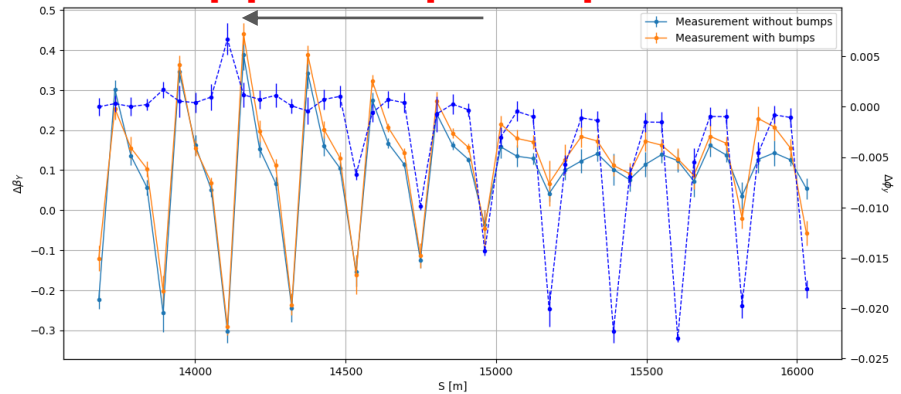
Simulation studies: Modification of the used knob to reduce the left peak







Δφ peak at β-beat peak

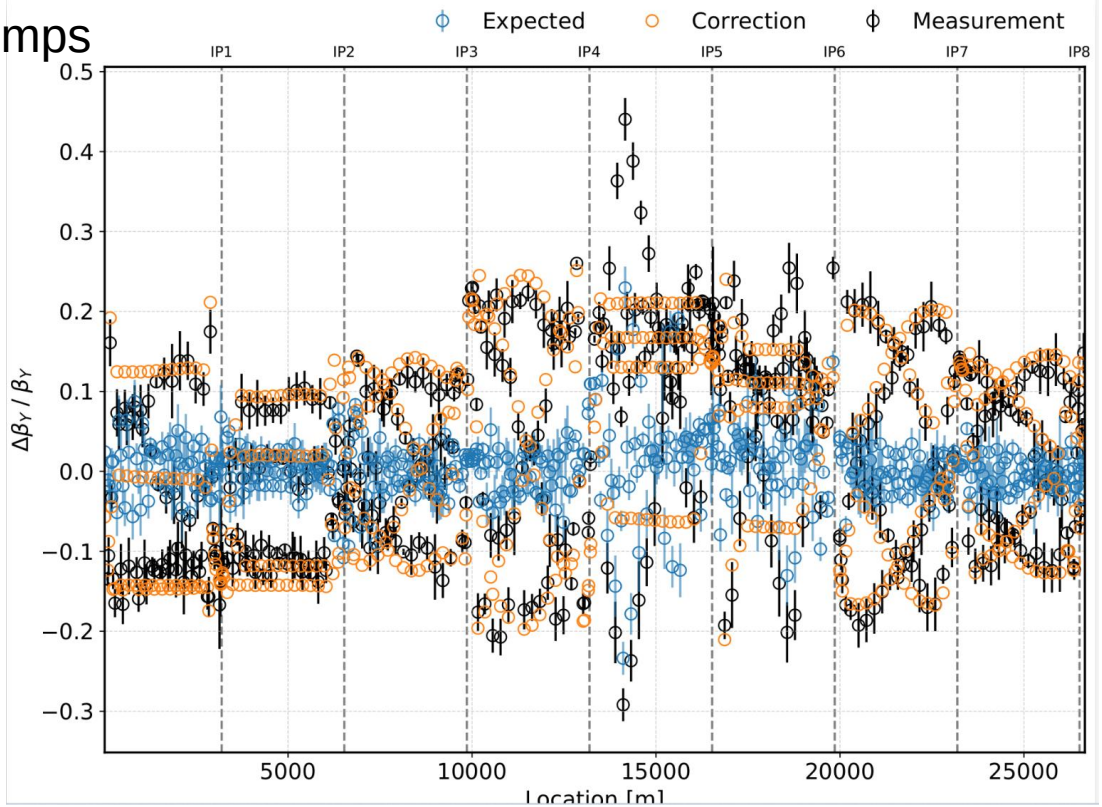


Arc45 corrections for Beam2

Simulation studies: New global corrections on top of the sextupole bumps

Peak vertical β-beat ~20% expected

NOTE: Due to limited time no global corrections were applied for Beam2 after the arc corrections



Courtesy of Joschua W. Dilly

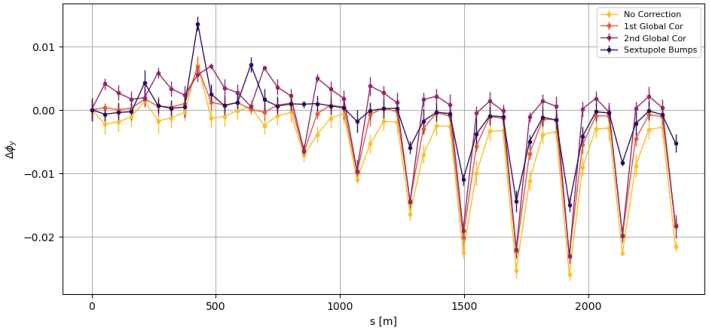
Arc45 Beam2

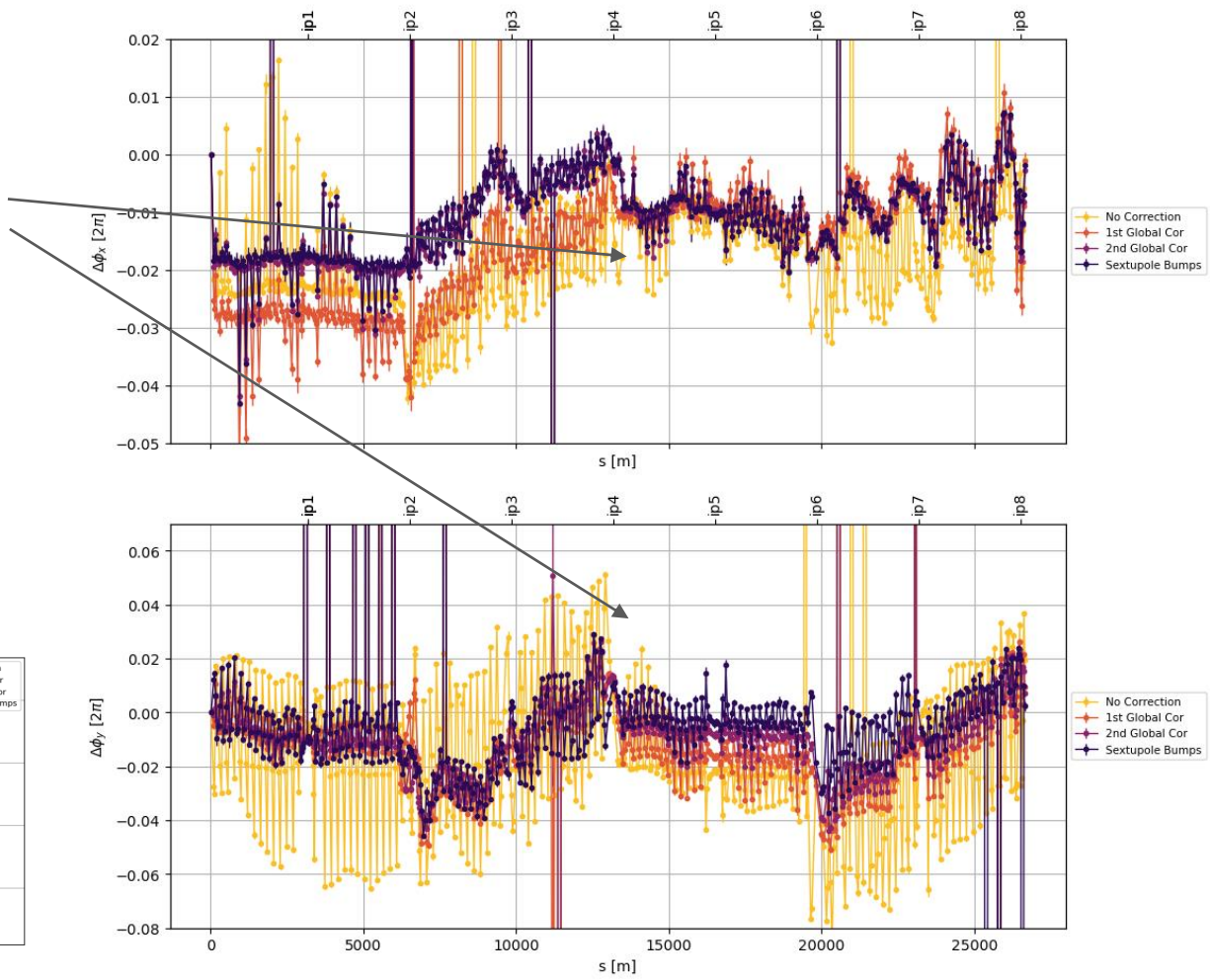
Investigating the phase error:

Focusing around IP4

Vertical Δφ reduction

BUT β-beat increased globally

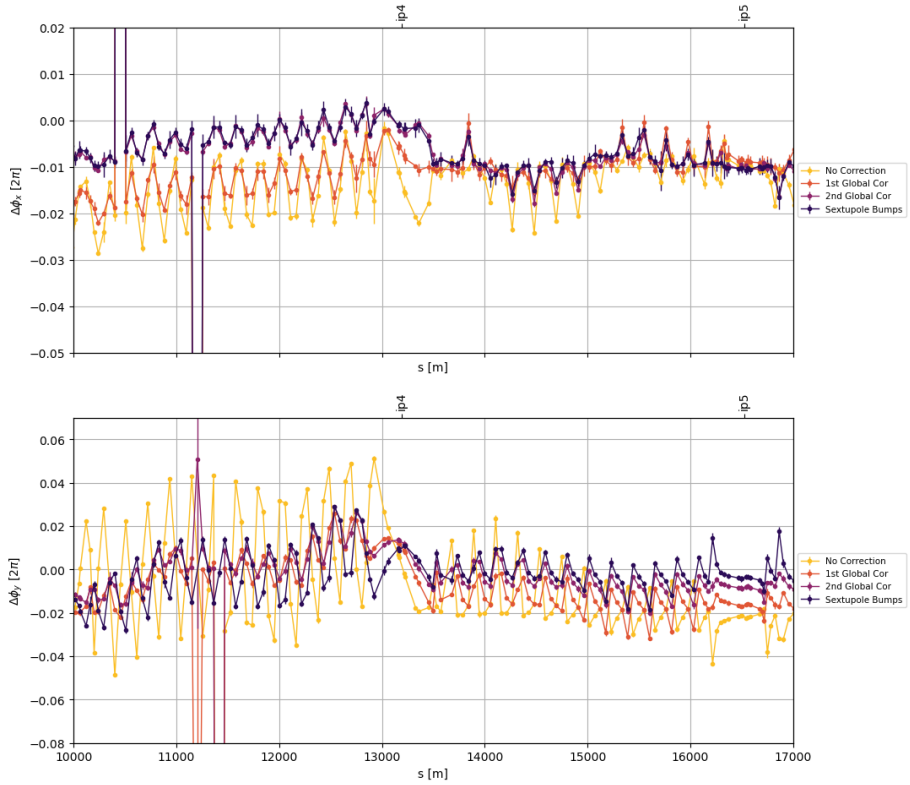


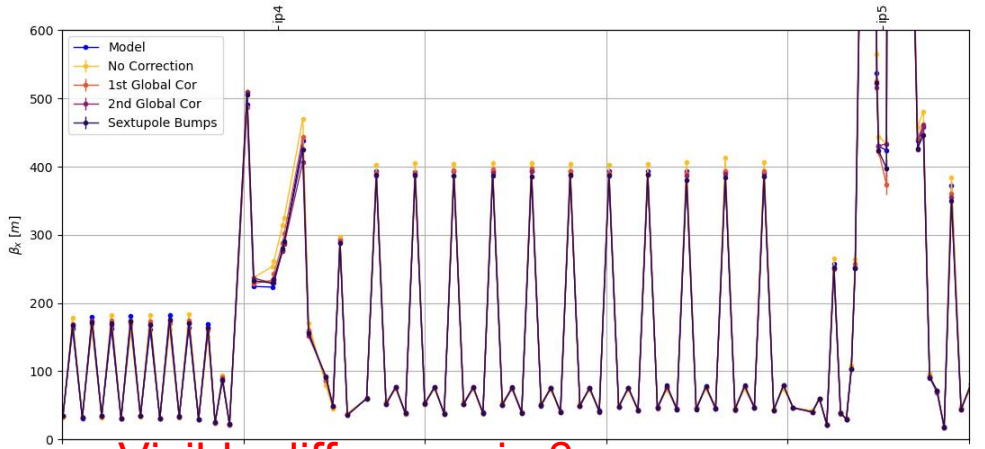


Arc45 Beam2

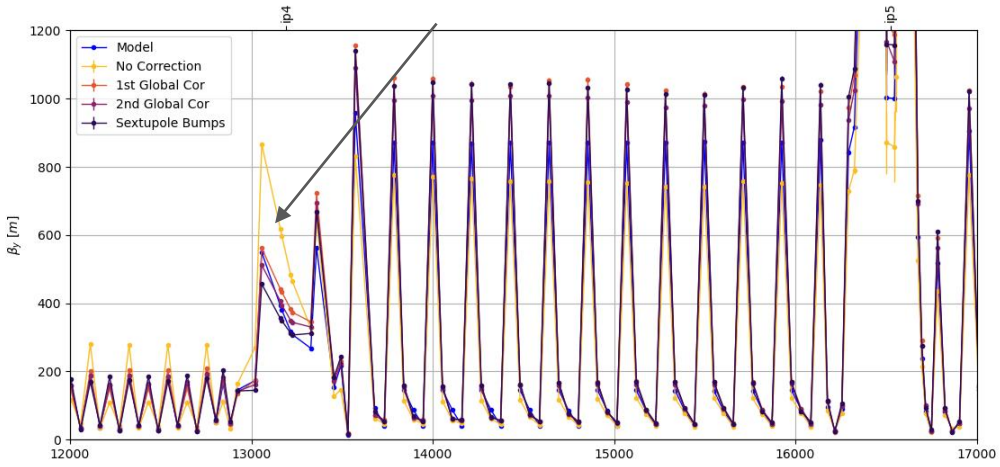
Investigating the phase error:

Focusing around IP4





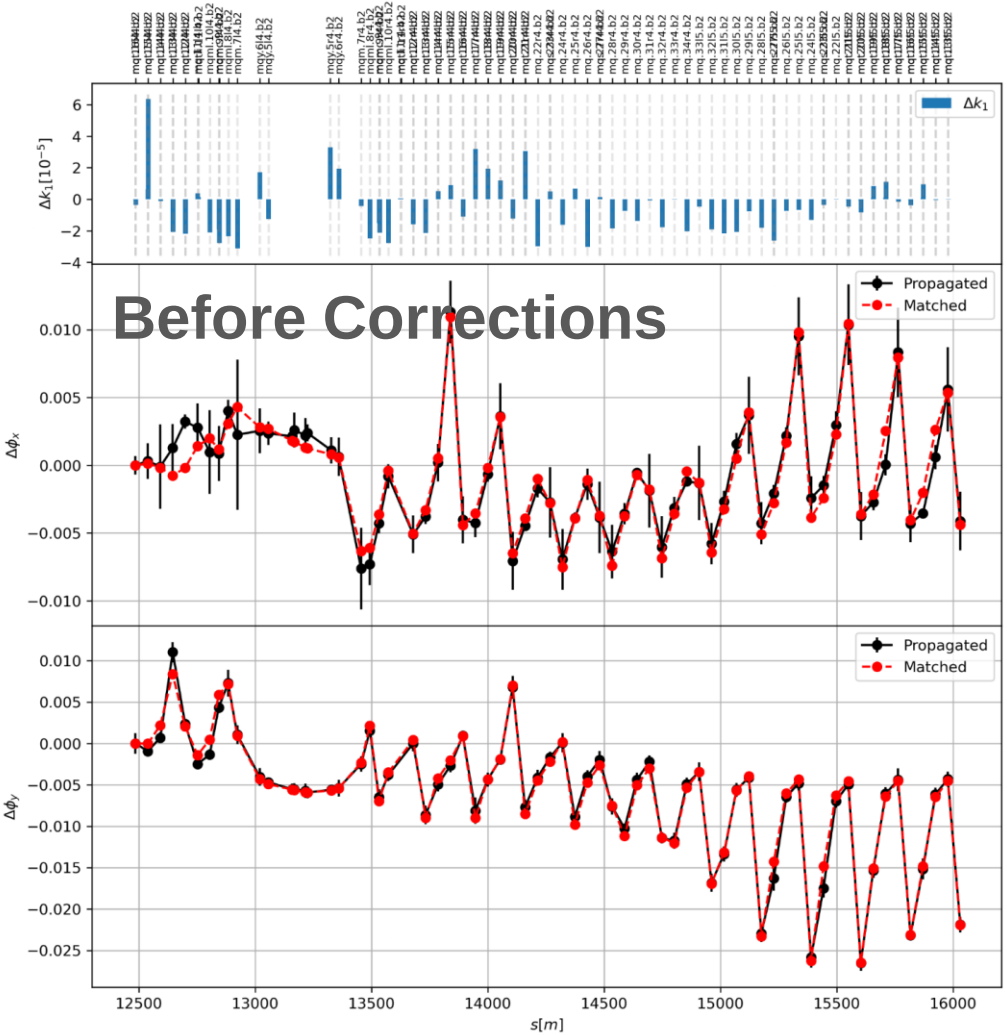
Visible difference in β



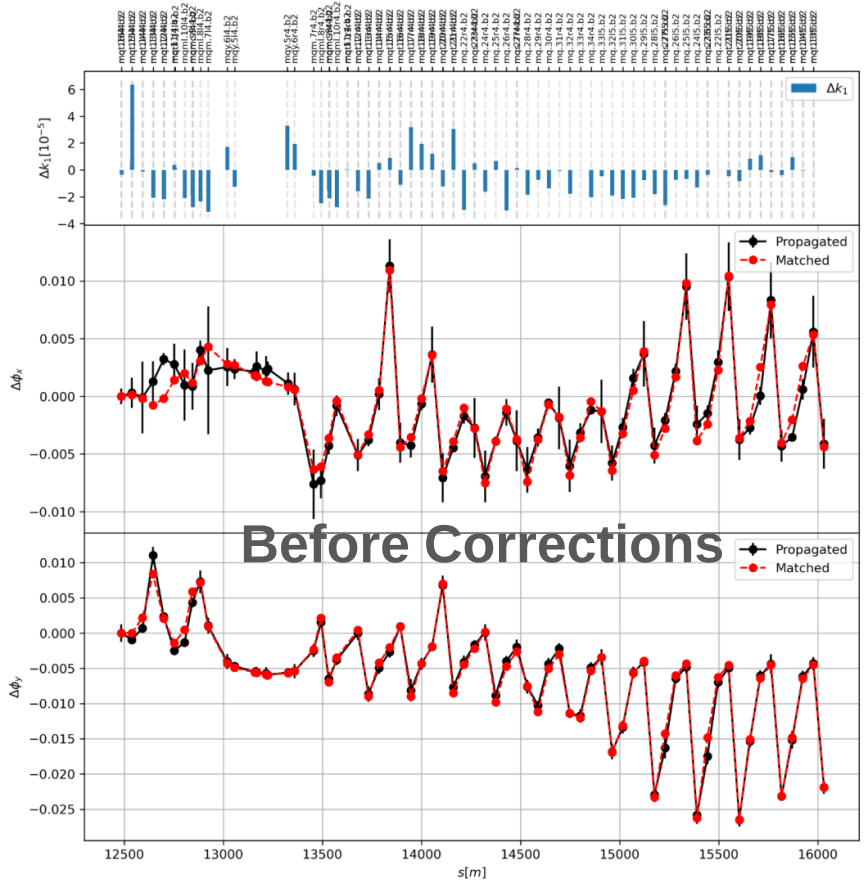
Arc45 Beam2

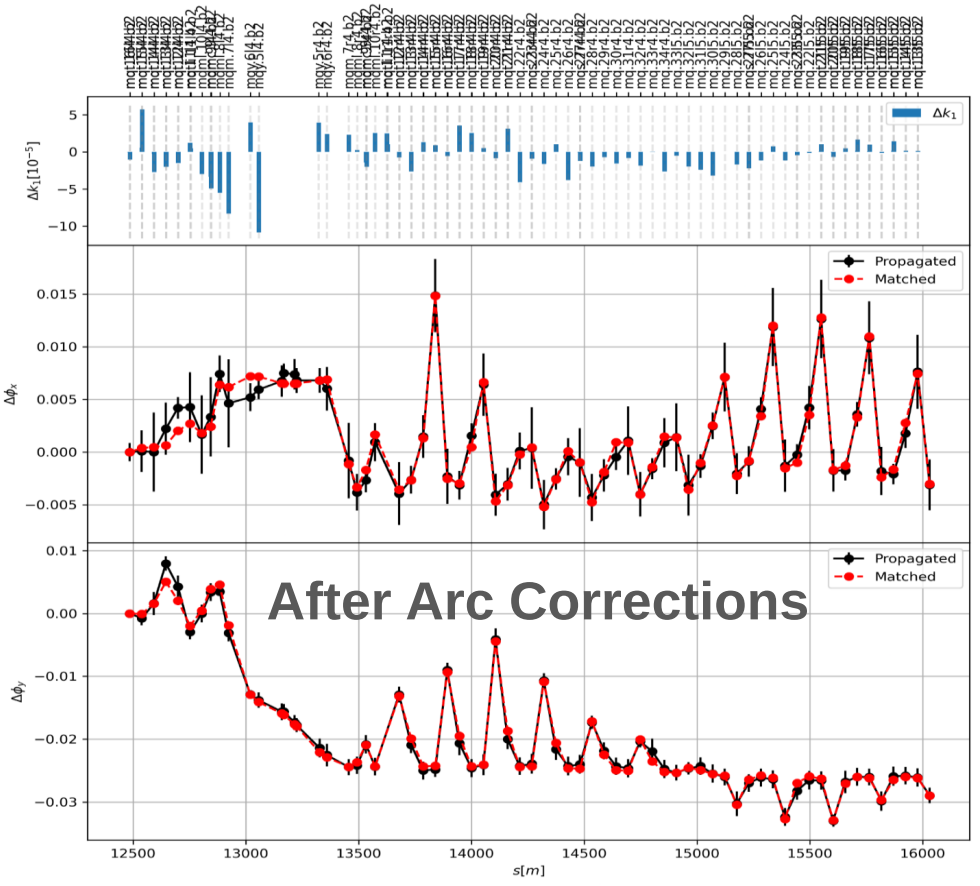
Investigating the phase error

- Selection of quadrupoles in the segment
- Each quadrupoles as individual powered
- Response matrix for the phase error
- Invert the system to extract quad strengths



Arc45 Beam2 Comparing before and after





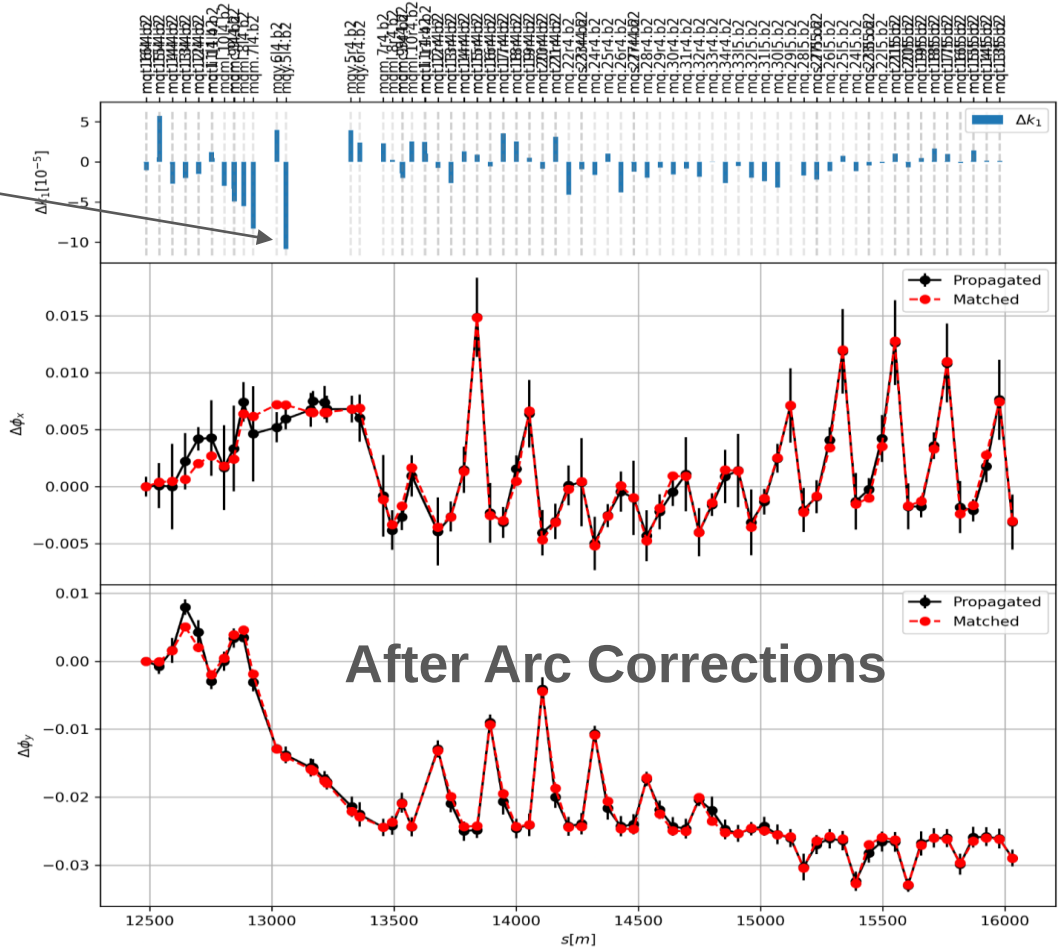
Arc45 Beam2

Investigating the phase error

Global corrections include kq5.l4b2 with strength ~ 8.6e-5

From the segment response, kq5 seems to generate a significant part of the phase error

Possibility for a local correction for IP4 and/or removing kq5.l4b2 from the global corrections?



Conclusions

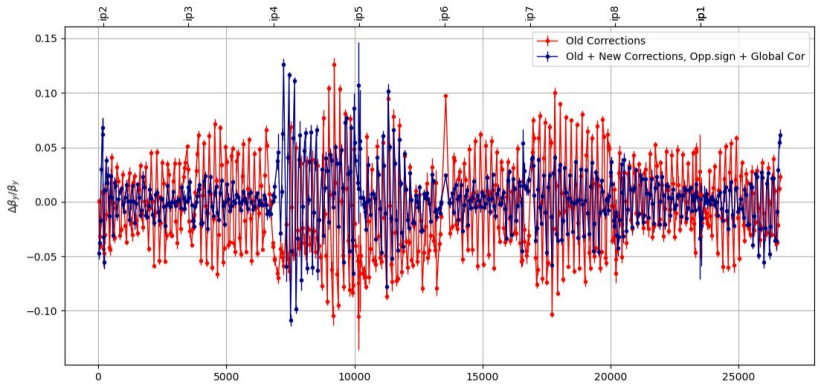
- Successful optics corrections with local arc corrections for HL optics with high ATS factors
- Beam1 corrections improve optics control with ~12% peak β-beat
- Beam2 under control, apart from Arc45
- MD5 part canceled, so no more studies could be performed
- Simulated corrections for Beam2 show improvement

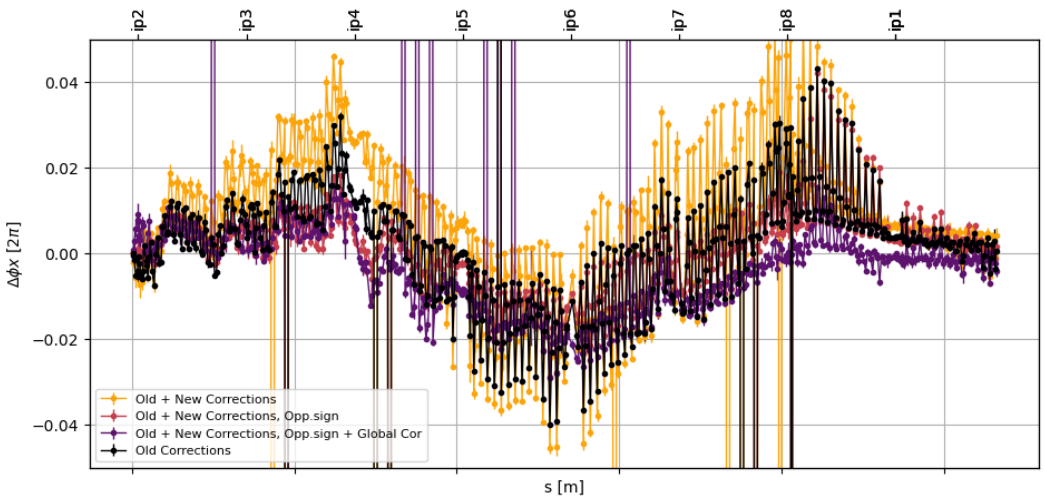
Spare slides

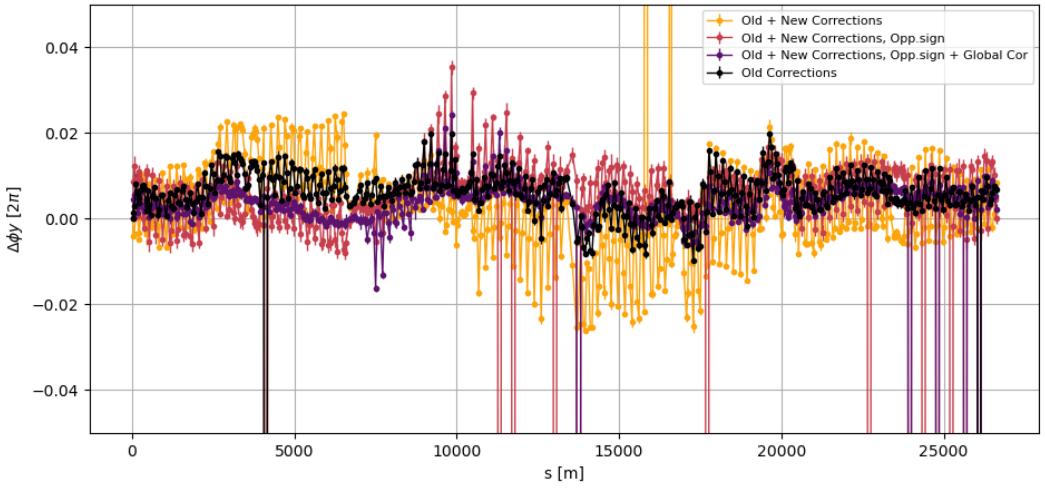
Arc45 Beam1

Arc 45 also has the peak β-beat for Beam1

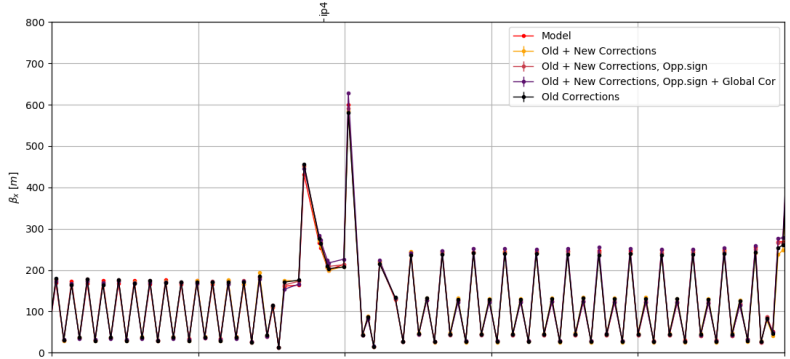
Same issue with global corrections and kq5.l4?

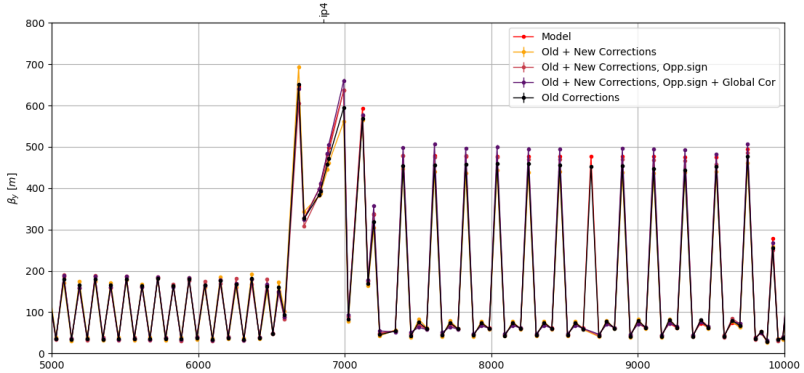


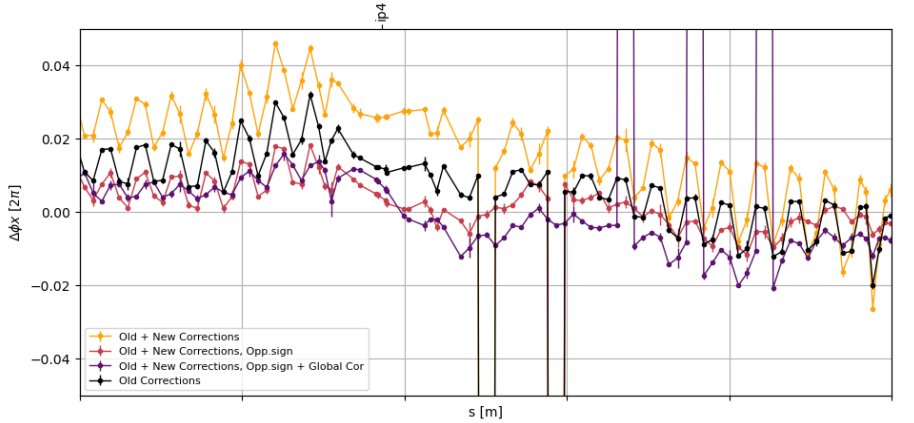


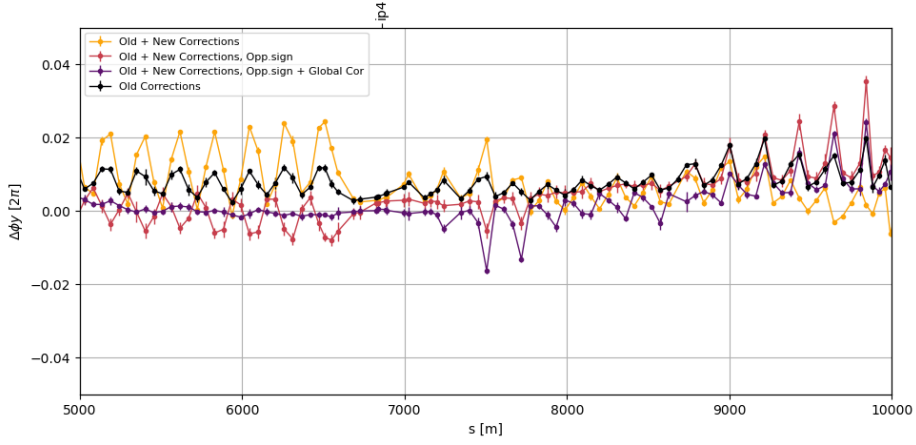


Arc45 Beam1


ip4
Model
Old + New Corrections
Old + New Corrections, Opp.sign
Old + New Corrections, Opp.sign + Global Cor
Old Corrections
β_x [m]


ip4
Model
Old + New Corrections
Old + New Corrections, Opp.sign
Old + New Corrections, Opp.sign + Global Cor
Old Corrections
β_y [m]
5000
6000
7000
8000
9000
10000


ip4
Old + New Corrections
Old + New Corrections, Opp.sign
Old + New Corrections, Opp.sign + Global Cor
Old Corrections
$\Delta\phi x$ [2π]
s [m]


ip4
Old + New Corrections
Old + New Corrections, Opp.sign
Old + New Corrections, Opp.sign + Global Cor
Old Corrections
$\Delta\phi y$ [2π]
s [m]
5000
6000
7000
8000
9000
10000

Arc45 Beam1

Investigating the phase error

KQ5.l4b1 included in the global corrections (~-3.4e-5)

After arc correction and global corrections