

Beta-beating studies and thick model for the LHC

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Contributions acknowledged: R. Tomás, G. Vanbavinckhove
and M. Giovannozzi

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Beta-beat modeled - Thin model

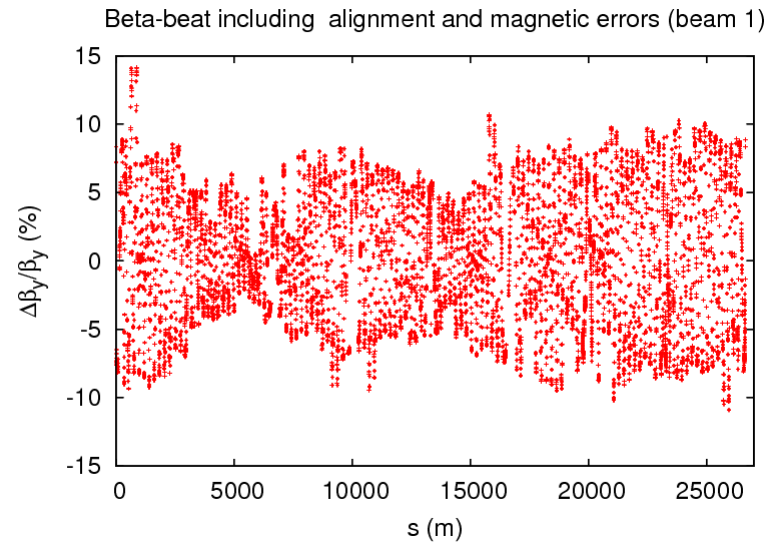
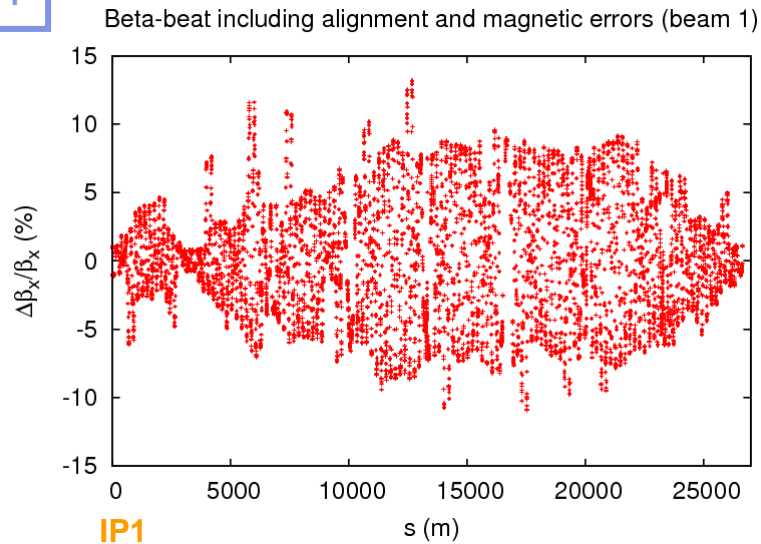
Beta-beat modeled* (using the thin model):

- including magnetic errors in the bending magnets
- including measured alignment errors
- matching the final orbit to the measured one

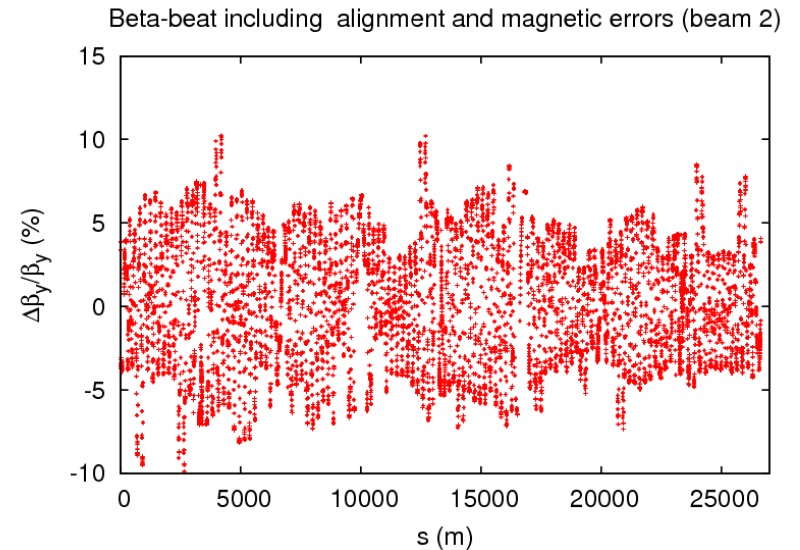
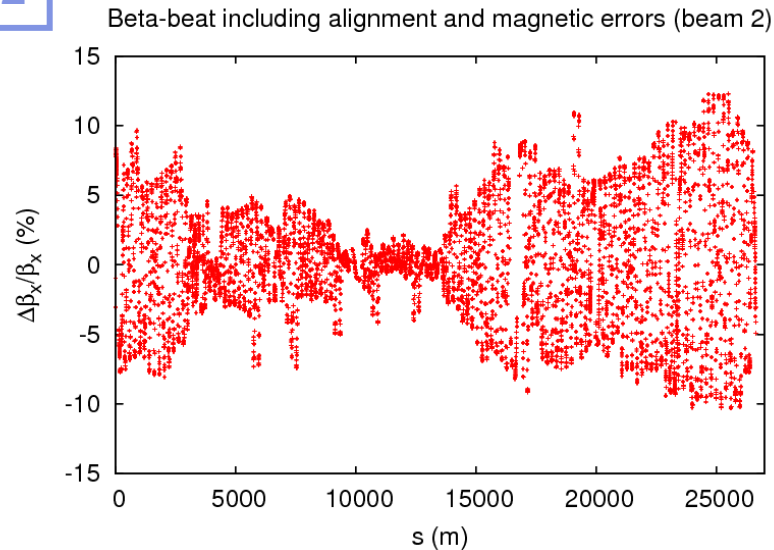
*All the studies are performed at injection

Beta-beat modeled - Thin model

Beam 1



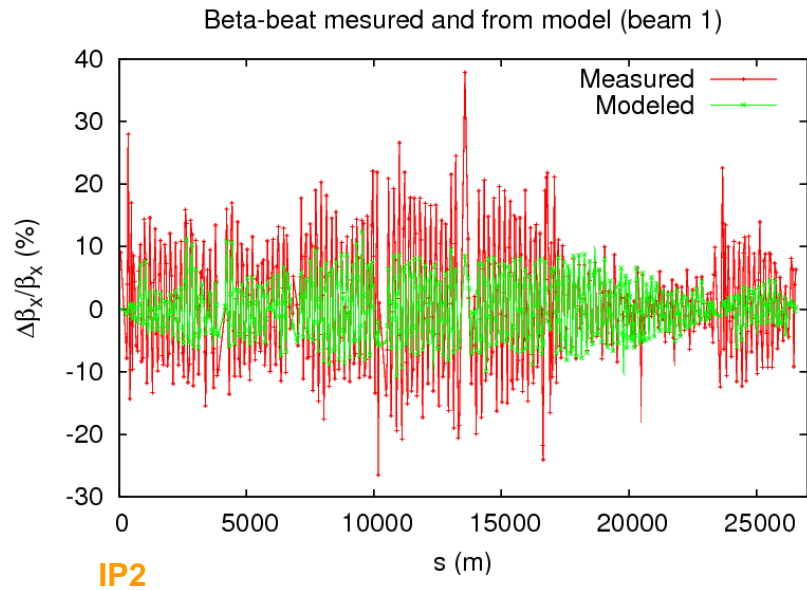
Beam 2



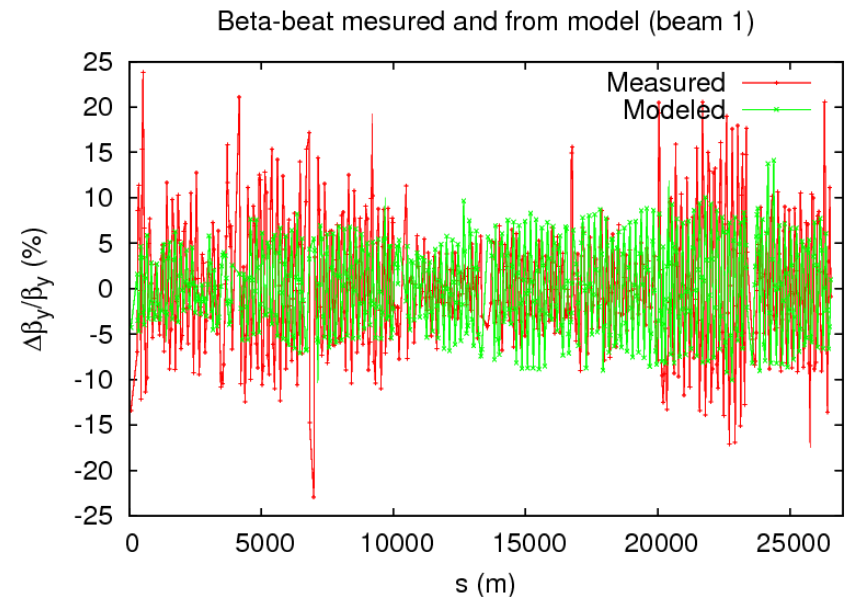
Main effect due to the B2 component in the MB's.

Beta-beat modeled vs measured*

Beam 1 - Horizontal



Beam 1 - Vertical



*Study performed in May 2010

- a fraction ($\sim 1/2$) of the measured beta-beat comes from the known errors
- in the H plane measurement and model seems to be in phase
- in the V plane errors would need to be corrected

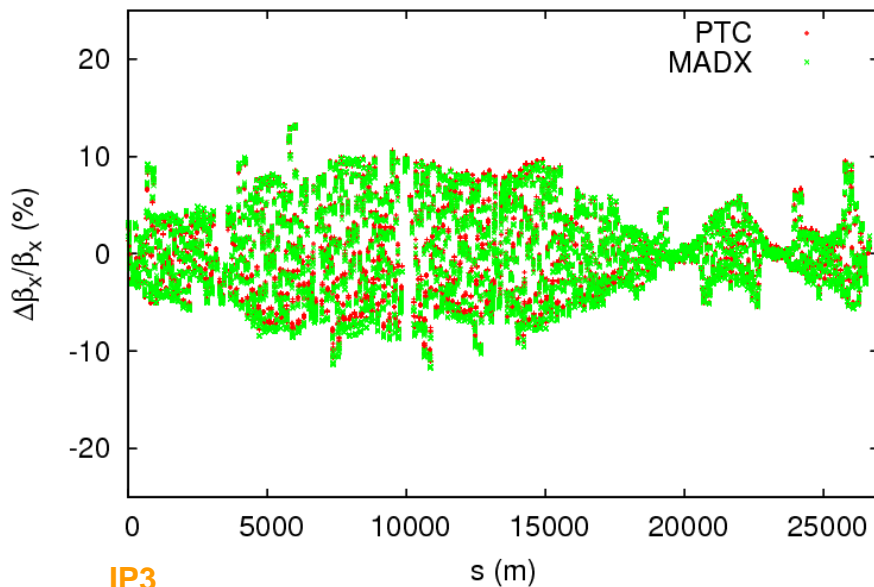
Beta-beat modeled - Thick model

Beta-beat modeled (using the thick model in MADX and PTC):

- including B2 errors in the MB's (seed 1 from WISE simulation)

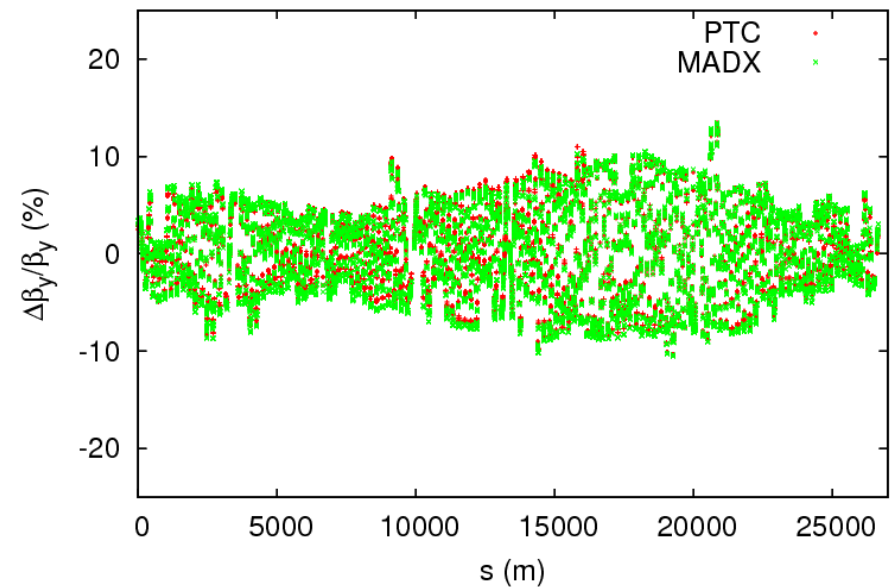
Beam 1 - Horizontal

Beta-beat (beam 1): b2 errors in MBs



Beam 1 - Vertical

Beta-beat (beam 1): b2 errors in MBs



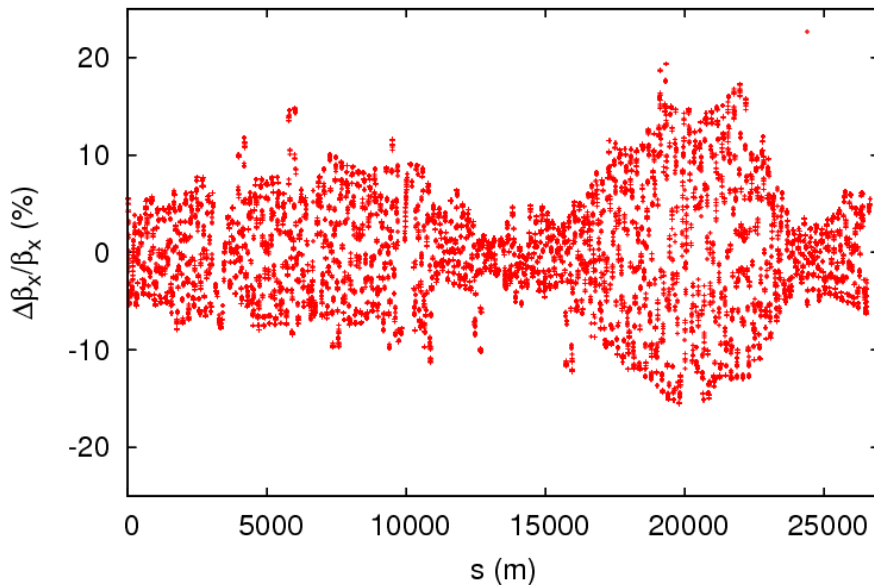
Beta-beat modeled - Thick model

Beta-beat modeled (using the thick model in PTC):

- including all magnetic errors in bending and quadrupole magnets

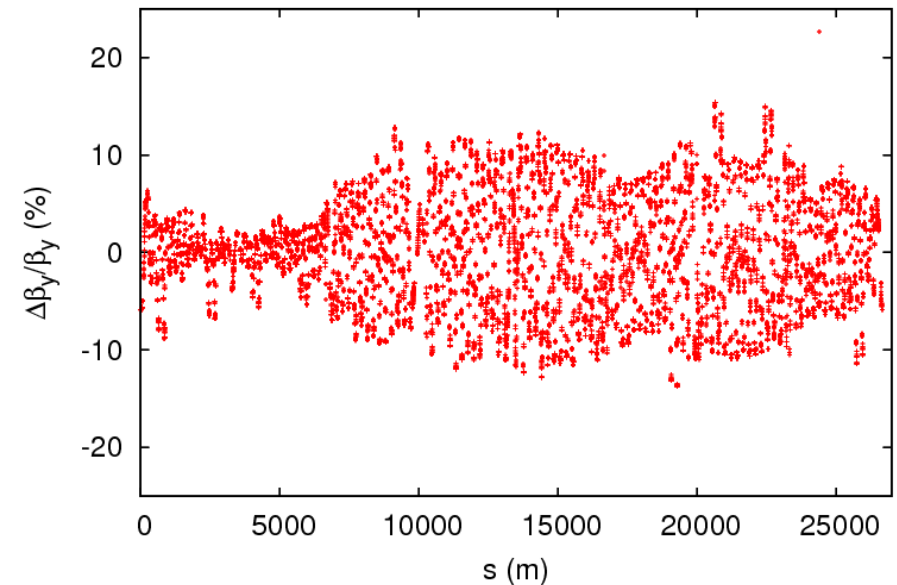
Beam 1 - Horizontal

Beta-beat (beam 1): all harmonics



Beam 1 - Vertical

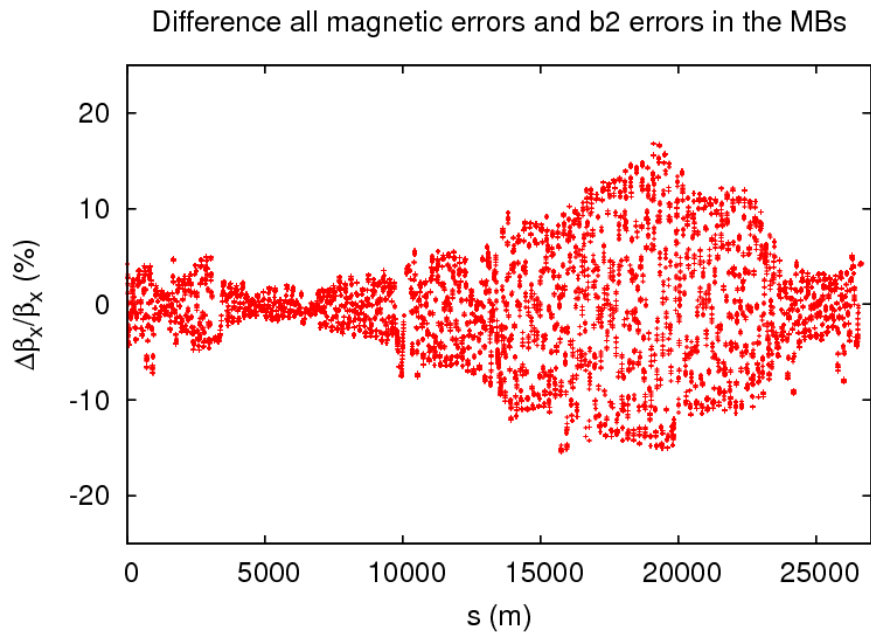
Beta-beat (beam 1): all harmonics



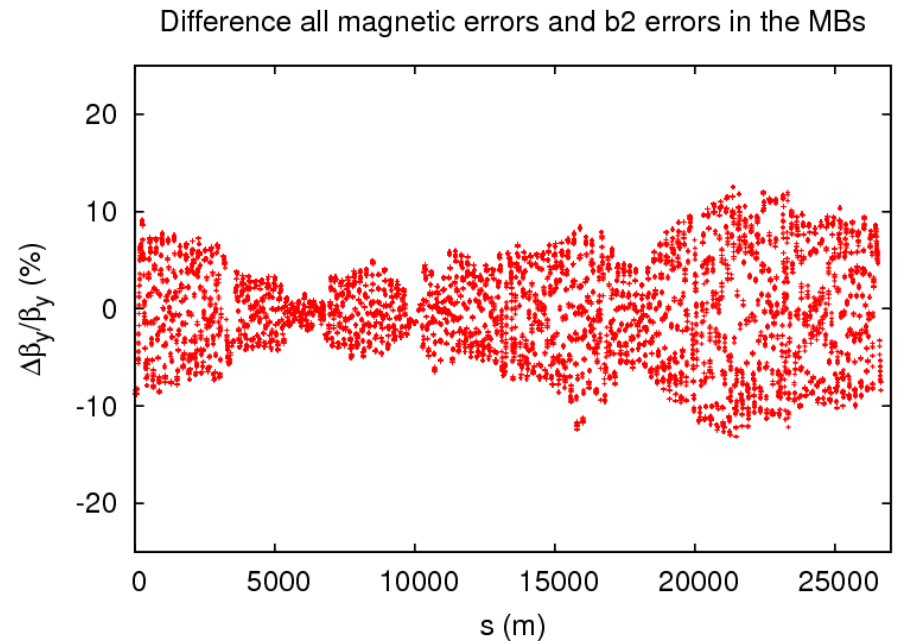
Beta-beat modeled - Thick model

Difference including all magnetic errors and including only b2 errors in the MB's

Beam 1 - Horizontal



Beam 1 - Vertical



Beta-beat modeled - Thick model

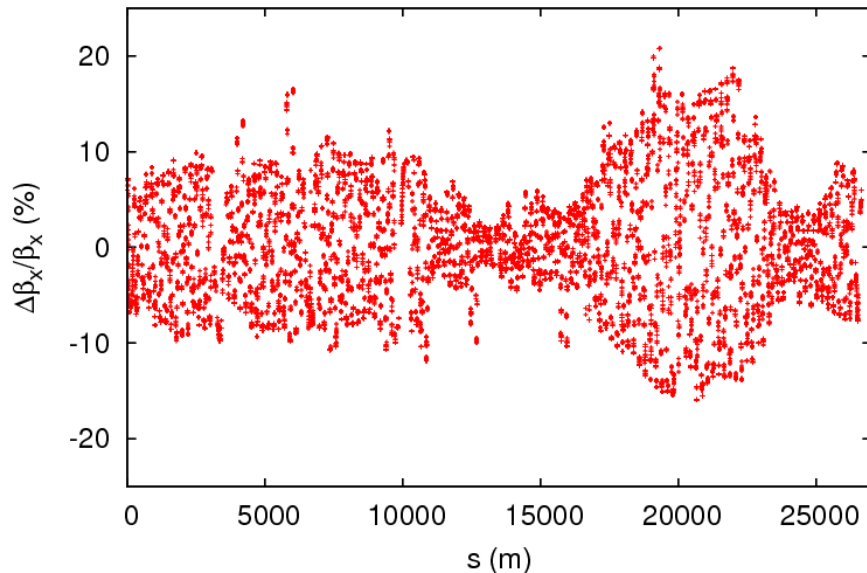
Beta-beat modeled (using the thick model in PTC):

- including all magnetic errors in bending and quadrupole magnets
- including measured alignment errors
- matching the final orbit to zero

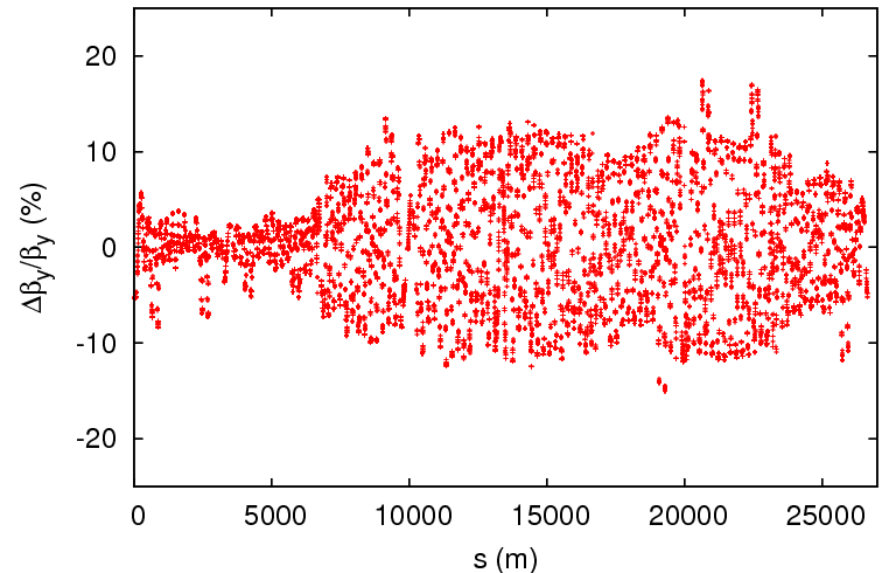
Beam 1 - Horizontal

Beam 1 - Vertical

Beta-beat (beam 1): all harmonics + alignment errors(orbit zero)



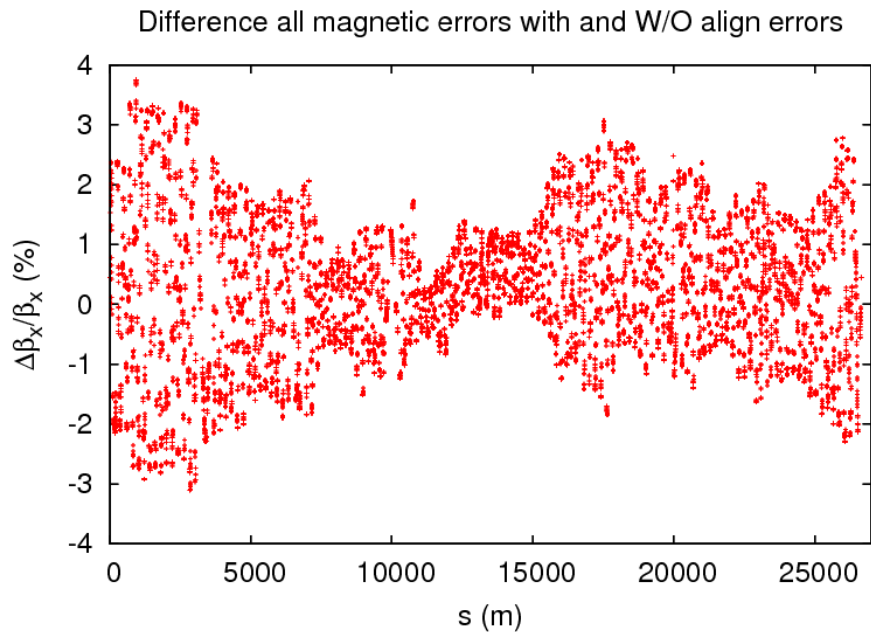
Beta-beat (beam 1): all harmonics + alignment errors(orbit zero)



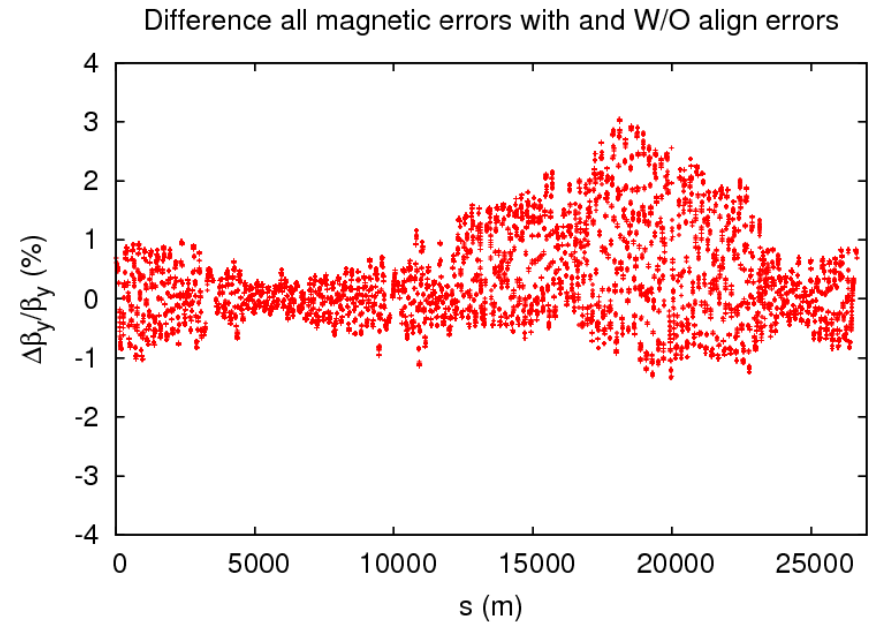
Beta-beat modeled - Thick model

Difference with and without including alignment errors (orbit zero)

Beam 1 - Horizontal



Beam 1 - Vertical



Beta-beat modeled - Thick model

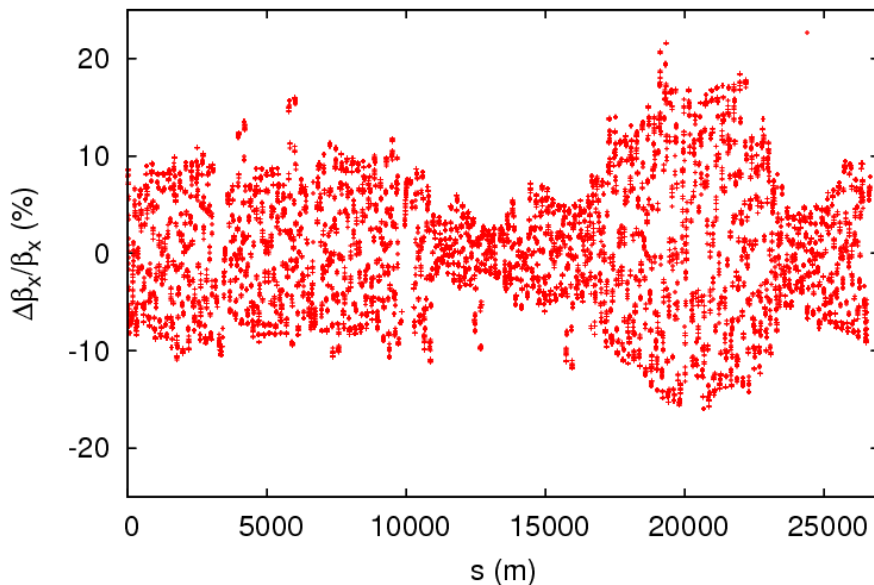
Beta-beat modeled (using the thick model in PTC):

- including all magnetic errors in bending and quadrupole magnets
- including measured alignment errors
- matching the final orbit to the measured one

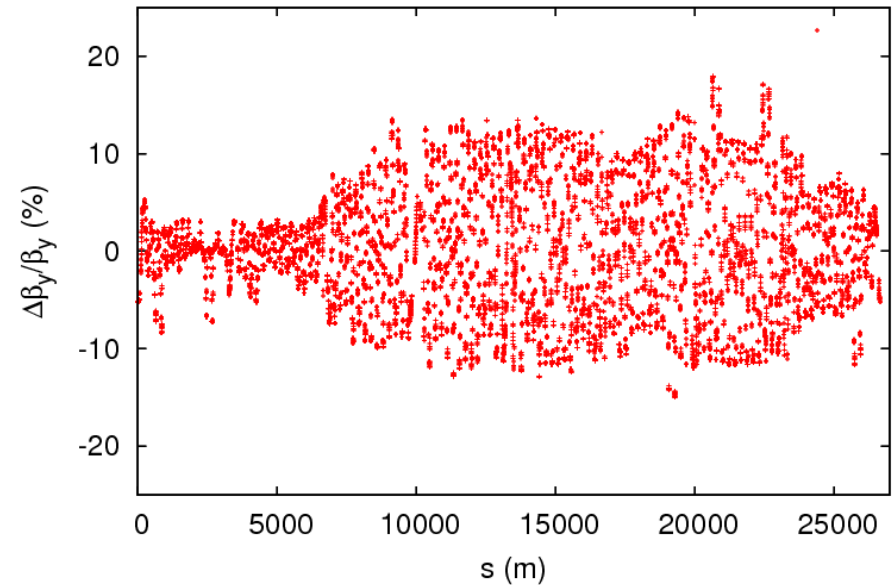
Beam 1 - Horizontal

Beam 1 - Vertical

Beta-beat (beam 1): all harmonics + alignment errors



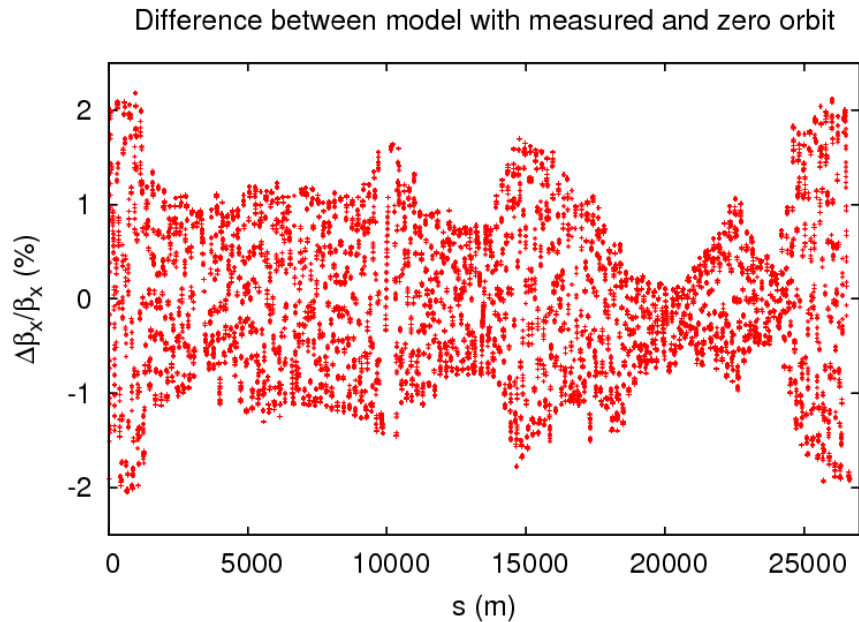
Beta-beat (beam 1): all harmonics + alignment errors



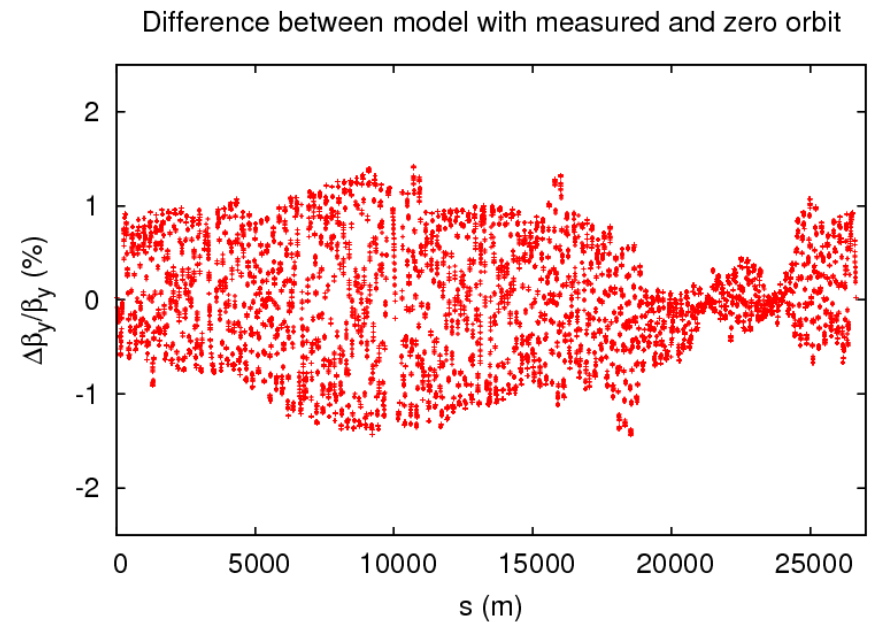
Beta-beat modeled - Thick model

Difference between the model with alignment errors fitting the orbit to the measured one and matching the final orbit to zero:

Beam 1 - Horizontal



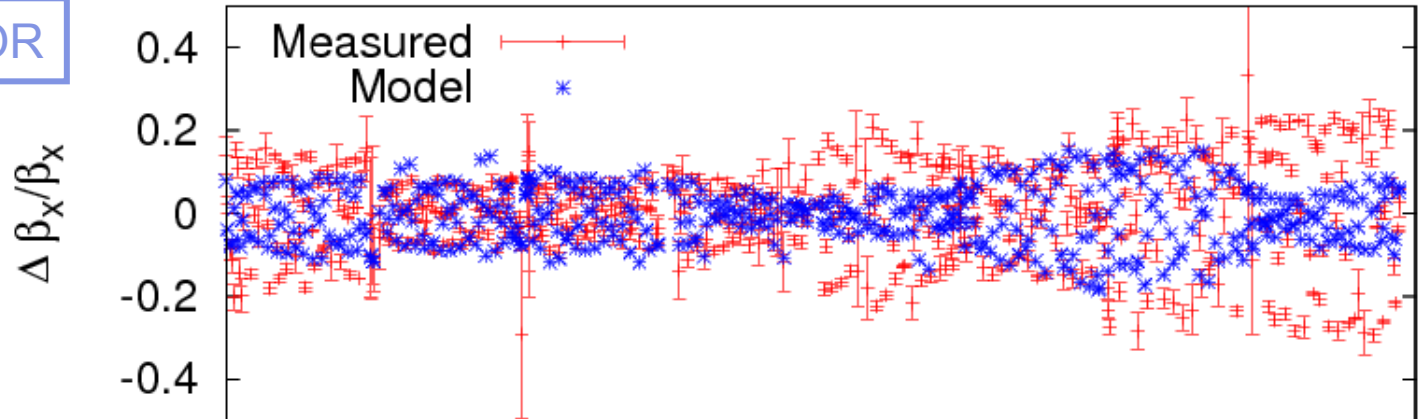
Beam 1 - Vertical



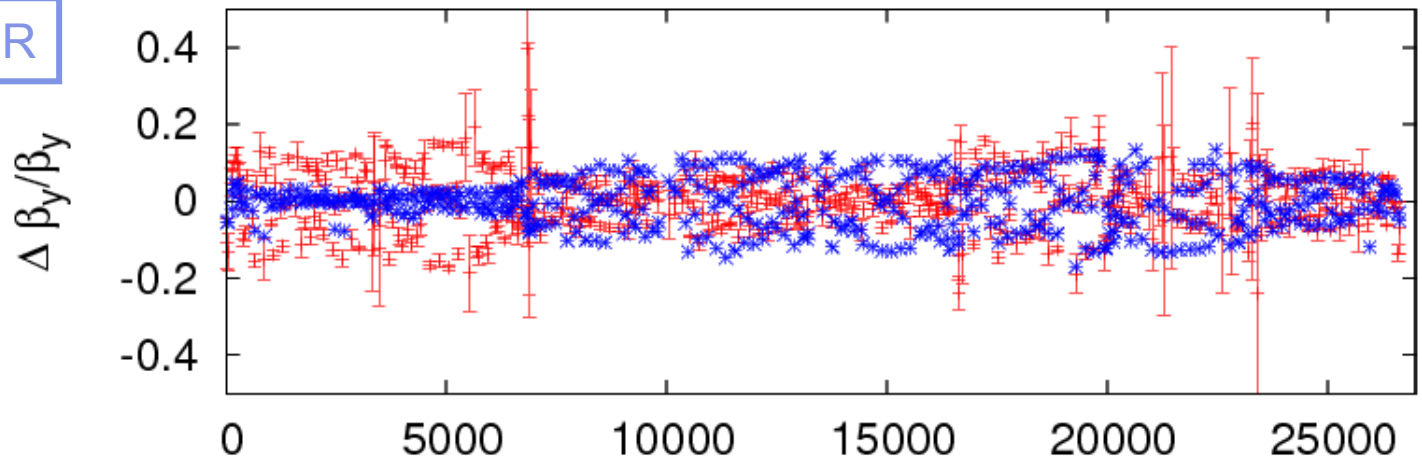
Beta-beat modeled vs measured

Beta-beat modeled (including magnetic and alignment errors and orbit fitted to the measured one) compared to the measurements:

Beam 1 - HOR



Beam 1 - VER



Longitudinal position [m]

G. Vanbavinckhove

Beta-beat modeled - Thick model

Beta-beat modeled (using the thick model in PTC):

- including all magnetic errors in bending and quadrupole magnets
- including measured alignment errors
- matching the final orbit to zero

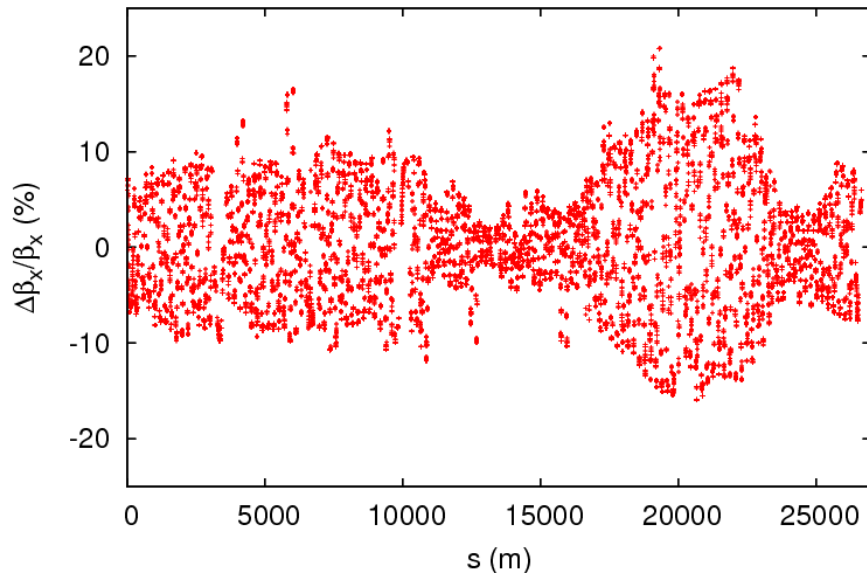
Beam 1 - Horizontal

Seed 1

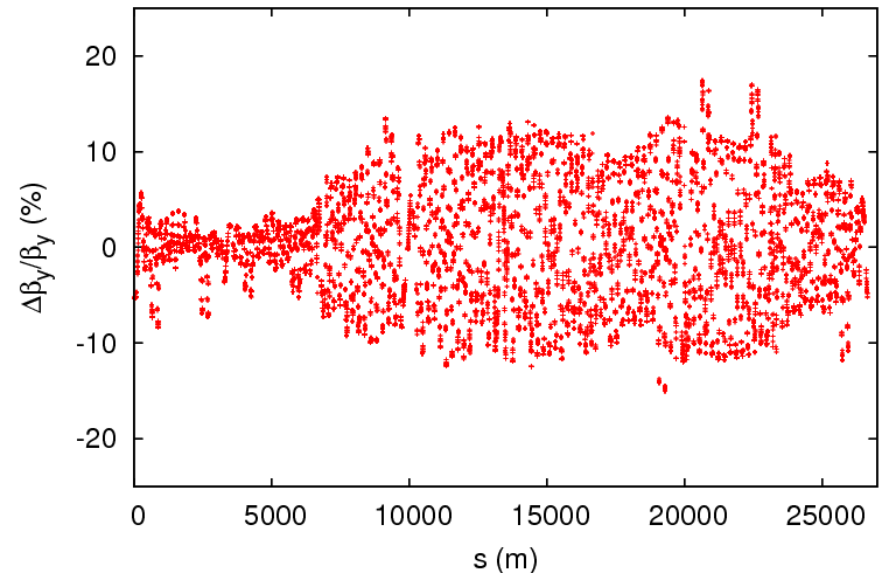
Beam 1 - Vertical

Seed 1

Beta-beat (beam 1): all harmonics + alignment errors(orbit zero)



Beta-beat (beam 1): all harmonics + alignment errors(orbit zero)



Beta-beat modeled - Thick model

Beta-beat modeled (using the thick model in PTC):

- including all magnetic errors in bending and quadrupole magnets
- including measured alignment errors
- matching the final orbit to zero

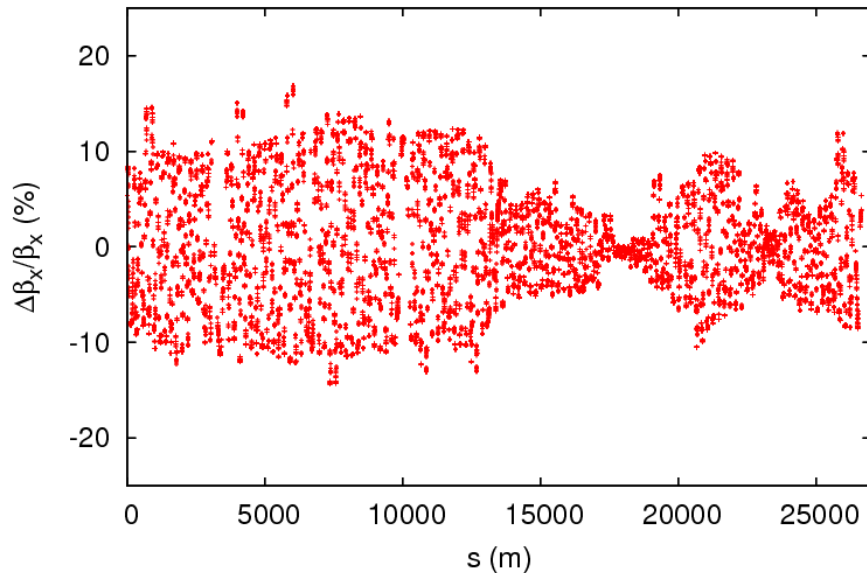
Beam 1 - Horizontal

Seed 2

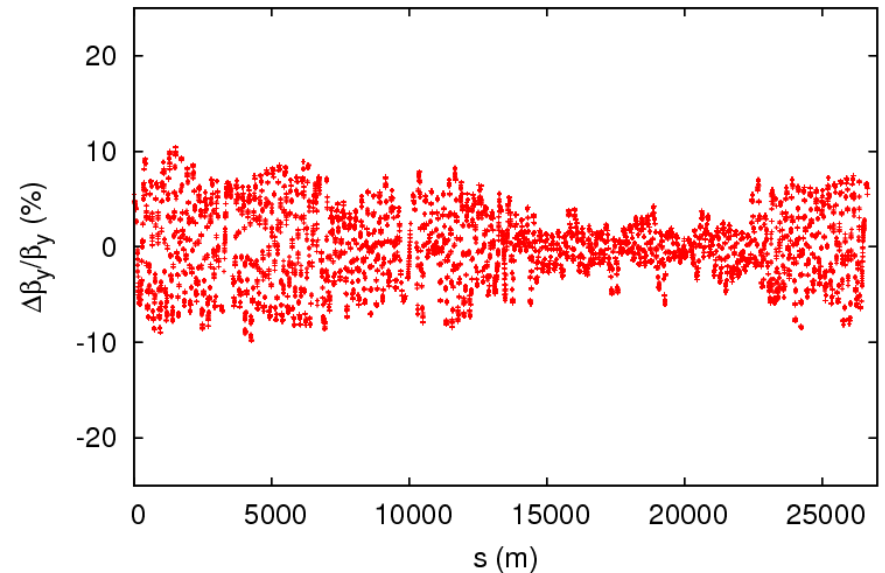
Beam 1 - Vertical

Seed 2

All harmonics (seed 2) + alignment errors (orbit zero) (Beam 1)



All harmonics (seed 2) + alignment errors (orbit zero) (Beam 1)



Beta-beat modeled - Thick model

Beta-beat modeled (using the thick model in PTC):

- including all magnetic errors in bending and quadrupole magnets
- including measured alignment errors
- matching the final orbit to zero

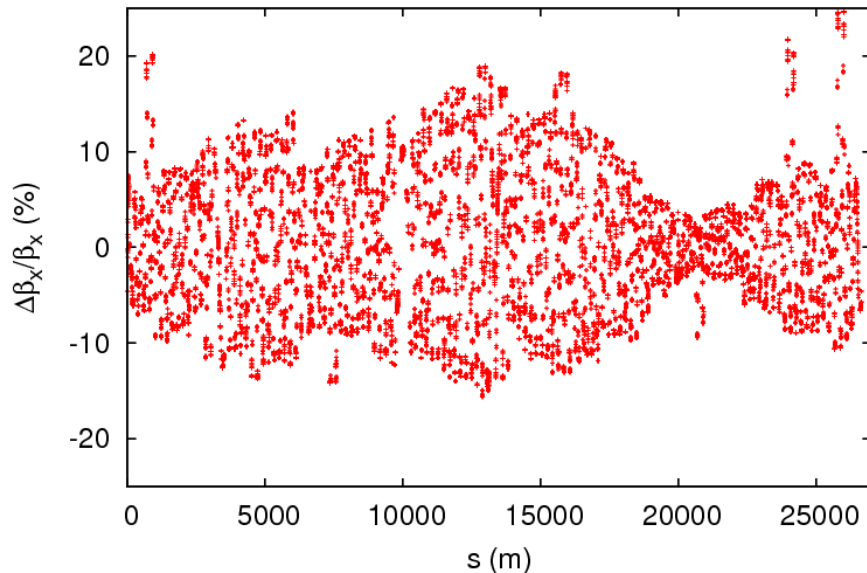
Beam 1 - Horizontal

Seed 3

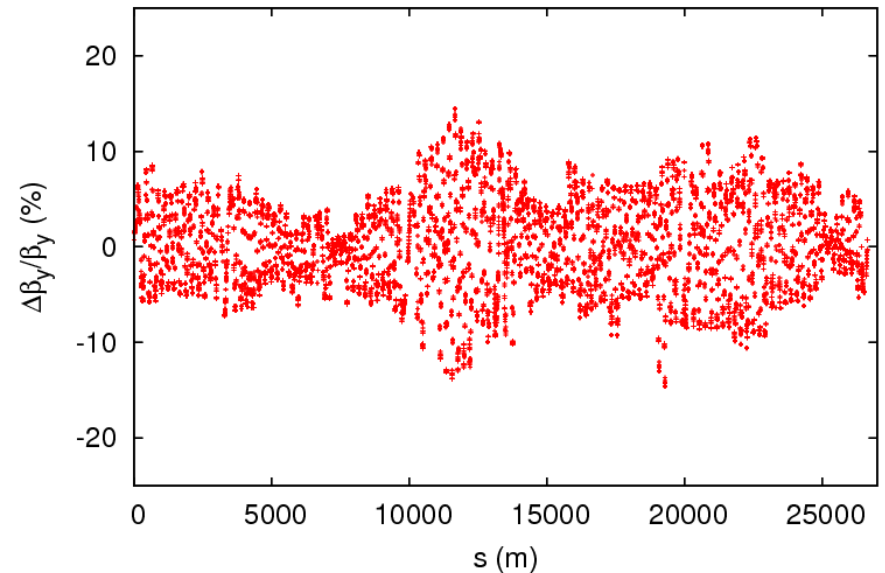
Beam 1 - Vertical

Seed 3

All harmonics (seed 3) + alignment errors (orbit zero) (Beam 1)



All harmonics (seed 3) + alignment errors (orbit zero) (Beam 1)



Conclusions

- Beta-beating has been modeled including measured alignment errors and magnetic errors (beam 2 and collision is on-going).
- For this study, a complete model has been developed using PTC in order to include magnetic errors up to high orders in the thick elements.
- A big effect arises from the B2 component in the MB's.
- A smaller effect arises when including measured alignment errors. The effect of the closed orbit is almost negligible, about 1% (max ~2%).
- A complete analysis is on-going to determine which model would represent enough well the machine status, including study of different seeds and study of solely systematic errors.