News on the LHC online model and data analysis

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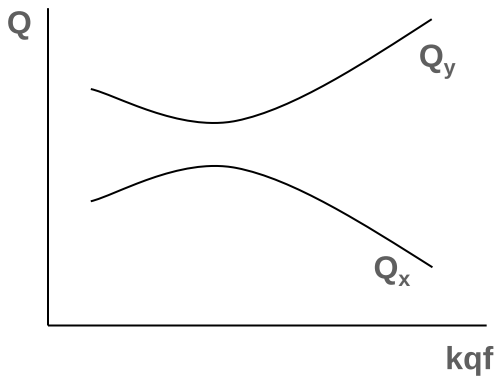
Online model aplications: coupling knobs

Creation of coupling correction knobs for the LHC:

The aim is to reduce the module of the C^- coupling vector, which can be measured:



Skew quadrupole families available:

Beam 1:
- kqs.r7b1
- kqs.r5b1
- kqs.r3b1
- kqs.r1b1
- kqs.l8b1
- kqs.l6b1
- kqs.l4b1
- kqs.l2b1
- kqs.a81b1
- kqs.a67b1
- kqs.a45b1
- kqs.a23b1

Beam 2:
- kqs.r2b2
- kqs.r4b2
- kqs.r6b2
- kqs.r8b2
- kqs.l1b2
- kqs.l3b2
- kqs.l5b2
- kqs.l7b2
- kqs.a12b2
- kqs.a78b2
- kqs.a56b2
- kqs.a34b2

Online model aplications: coupling knobs

- Coupling knobs redone for both beams from IP1 (as demanded by the operators)

Skew quadrupoles varied to get certain coupling coefficients, knobs normalized to the minimum tune difference

BEAM 1

For C^{-}_{real} :

kqs.r7b1 = 0.002918050948
kqs.r5b1 = -0.003890653974
kqs.r1b1 = -0.001607496029
kqs.l8b1 = 0.002918050948
kqs.l6b1 = -0.003890653974
kqs.l2b1 = -0.001607496029
kqs.a81b1 = -0.0429437779
kqs.a67b1 = 0.002257439027
kqs.a45b1 = 0.0528938668
kqs.a23b1 = 0.01336480383

For C^{-}_{imag} :

kqs.r7b1 = -0.007636090556
kqs.r5b1 = 0.03791092411
kqs.r1b1 = 0.009180748553
kqs.l8b1 = -0.007636090556
kqs.l6b1 = 0.03791092411
kqs.l2b1 = 0.009180748553
kqs.a81b1 = -0.02920127391
kqs.a67b1 = -0.0008972271658
kqs.a45b1 = -0.01492350985
kqs.a23b1 = -0.03321119582

Online model aplications: coupling knobs

- Coupling knobs redone for both beams from IP1 (as demanded by the operators)

Skew quadrupoles varied to get certain coupling coefficients, knobs normalized to the minimum tune difference

BEAM 2

For C^-_{real} :

kqs.r2b2 = -0.07861208699
kqs.r4b2 = -0.006467324901
kqs.r6b2 = -0.03300626877
kqs.r8b2 = -0.02694461894
kqs.l1b2 = -0.02694461894
kqs.l3b2 = -0.07861208699
kqs.l5b2 = -0.006467324901
kqs.l7b2 = -0.03300626877
kqs.a12b2 = -0.06005456312
kqs.a78b2 = 0.10107831
kqs.a56b2 = 0.0668479318

For C^-_{imag} :

kqs.r2b2 = 0.04975907469
kqs.r4b2 = -0.04731414785
kqs.r6b2 = 0.01944707069
kqs.r8b2 = -0.02165357863
kqs.l1b2 = -0.02165357863
kqs.l3b2 = 0.04975907469
kqs.l5b2 = -0.04731414785
kqs.l7b2 = 0.01944707069
kqs.a12b2 = 0.07478613211
kqs.a78b2 = -0.1718734802
kqs.a56b2 = -0.09219969124

Online model aplications: coupling knobs

- Coupling knobs created to compensate the ATLAS, ALICE and CMS solenoids at injection (give similar results to the ones given by T.Risselada).

ATLAS

BEAM 1

kqs.r7b1	6.989447984e-06
kqs.r5b1	-3.478188872e-05
kqs.r1b1	4.326773078e-05
kqs.l8b1	6.989447984e-06
kqs.l6b1	-3.478188872e-05
kqs.l2b1	4.326773078e-05
kqs.a81b1	-1.613935965e-05
kqs.a67b1	-5.691612883e-07
kqs.a45b1	1.195221579e-05
kqs.a23b1	-1.242429505e-06

BEAM 2

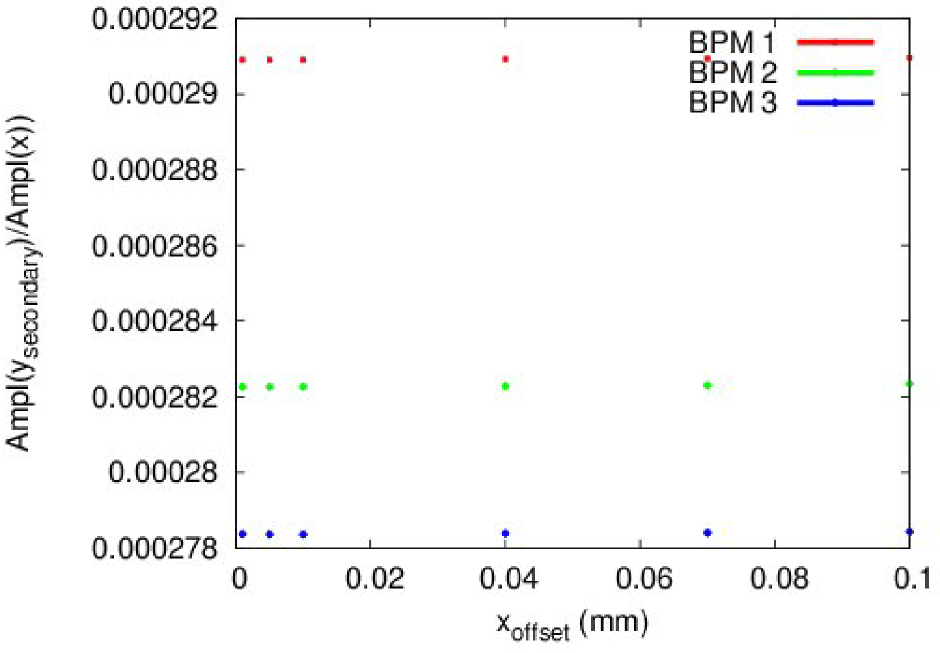
kqs.r2b2	2.269909172e-05
kqs.r4b2	4.717120537e-05
kqs.r6b2	-5.314021553e-05
kqs.r8b2	2.631383375e-05
kqs.l1b2	2.631383375e-05
kqs.l3b2	2.269909172e-05
kqs.l5b2	4.717120537e-05
kqs.l7b2	-5.314021553e-05
kqs.a12b2	-1.131136769e-05
kqs.a78b2	3.151494529e-06
kqs.a56b2	-3.821752443e-05

Coupling knobs from secondary lines

Ongoing work: coupling knobs computed from the secondary lines of the tunes

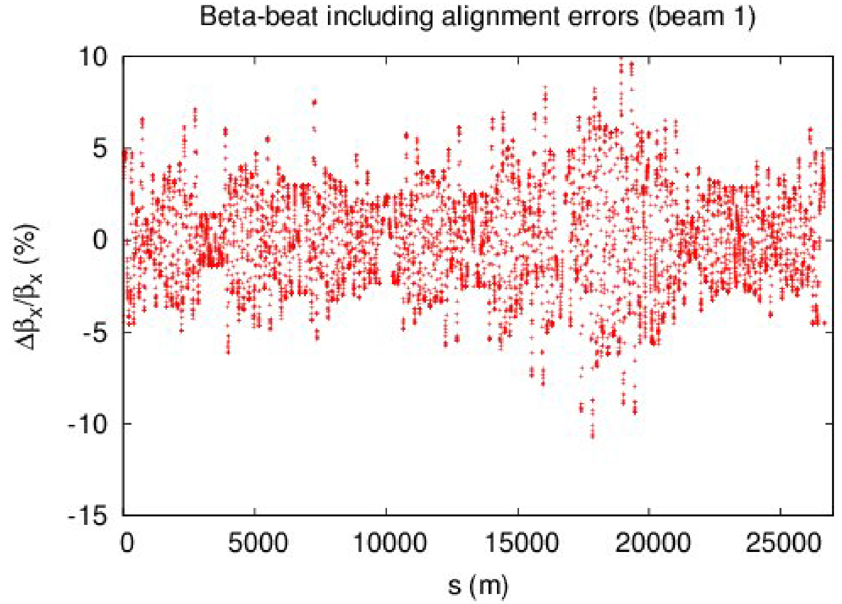
- Introduce coupling corresponding to certain $C^-(Re)/C^-(Im)$ coefficients
- Particles kicked in the horizontal plane at certain BPM location
- Tracking performed with MADX
- Data analysed with SUSSIX

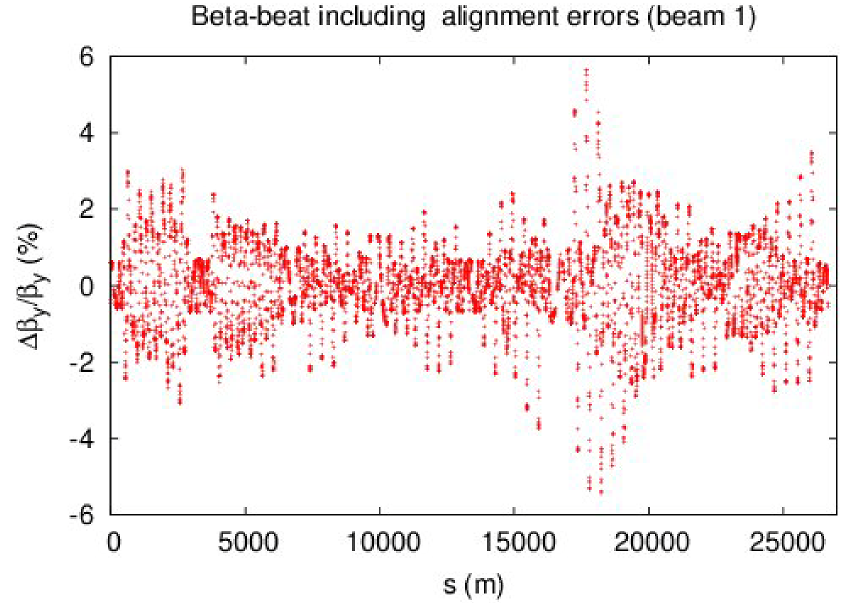
Amplitude of the secondary y line with respect to the x tune amplitude versus x offset

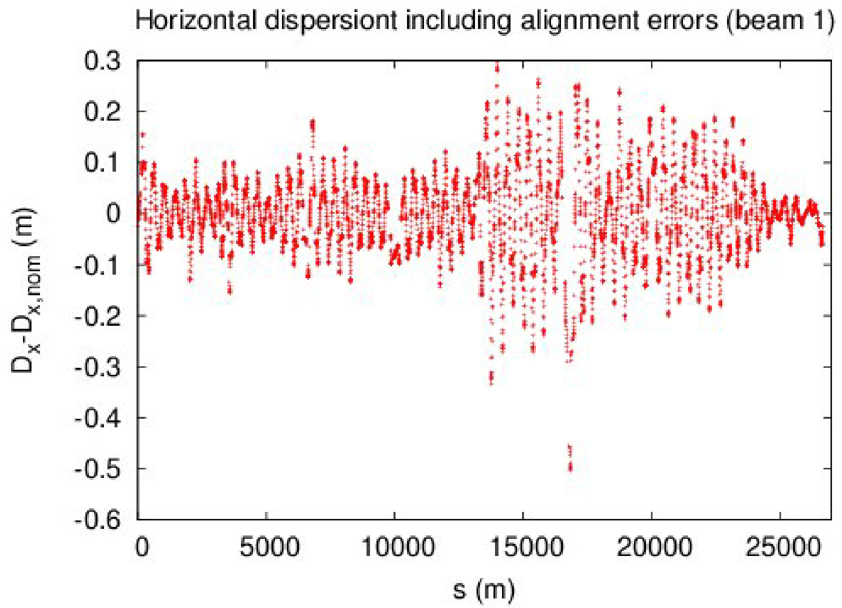


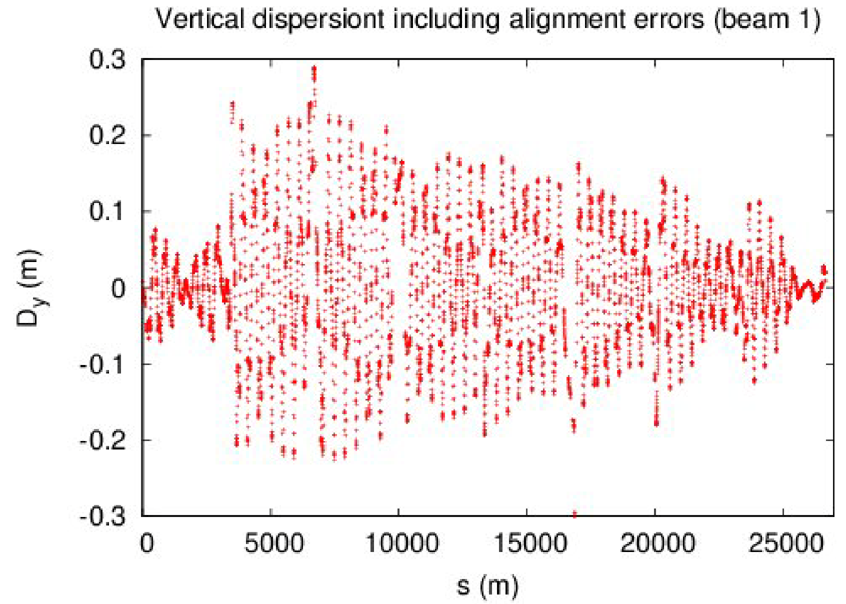
Effect of the alignment errors on the beta-beat

BEAM 1 (simulation with nominal optics)



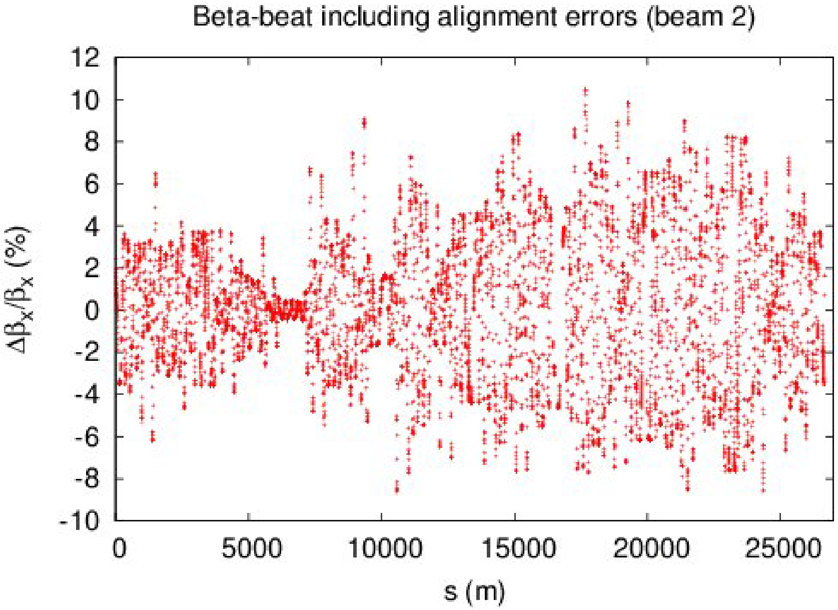


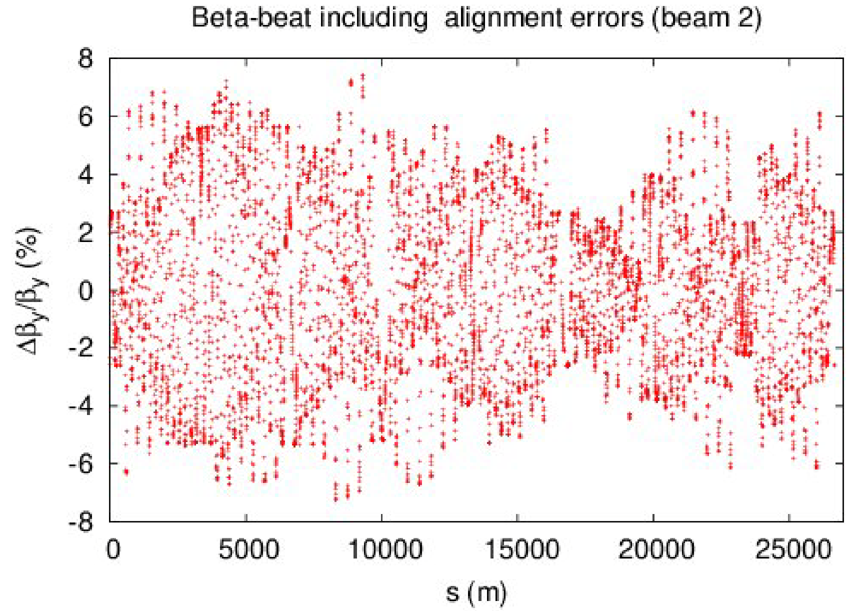


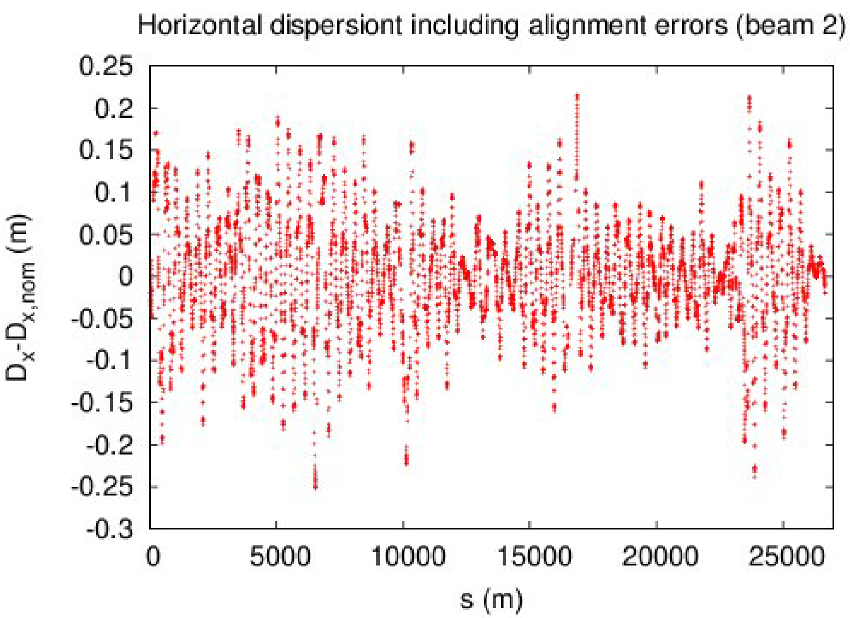


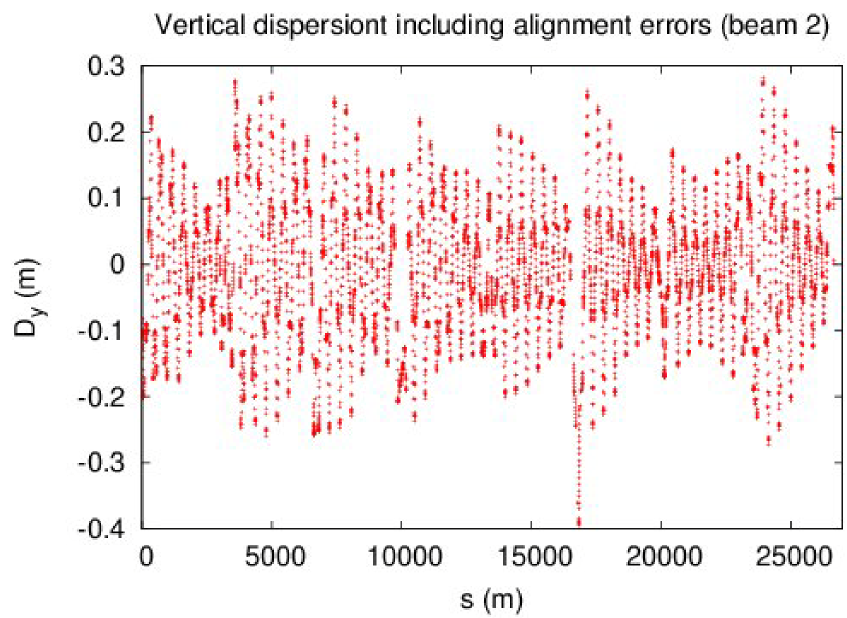
Effect of the alignment errors on the beta-beat

BEAM 2 (simulation with nominal optics)





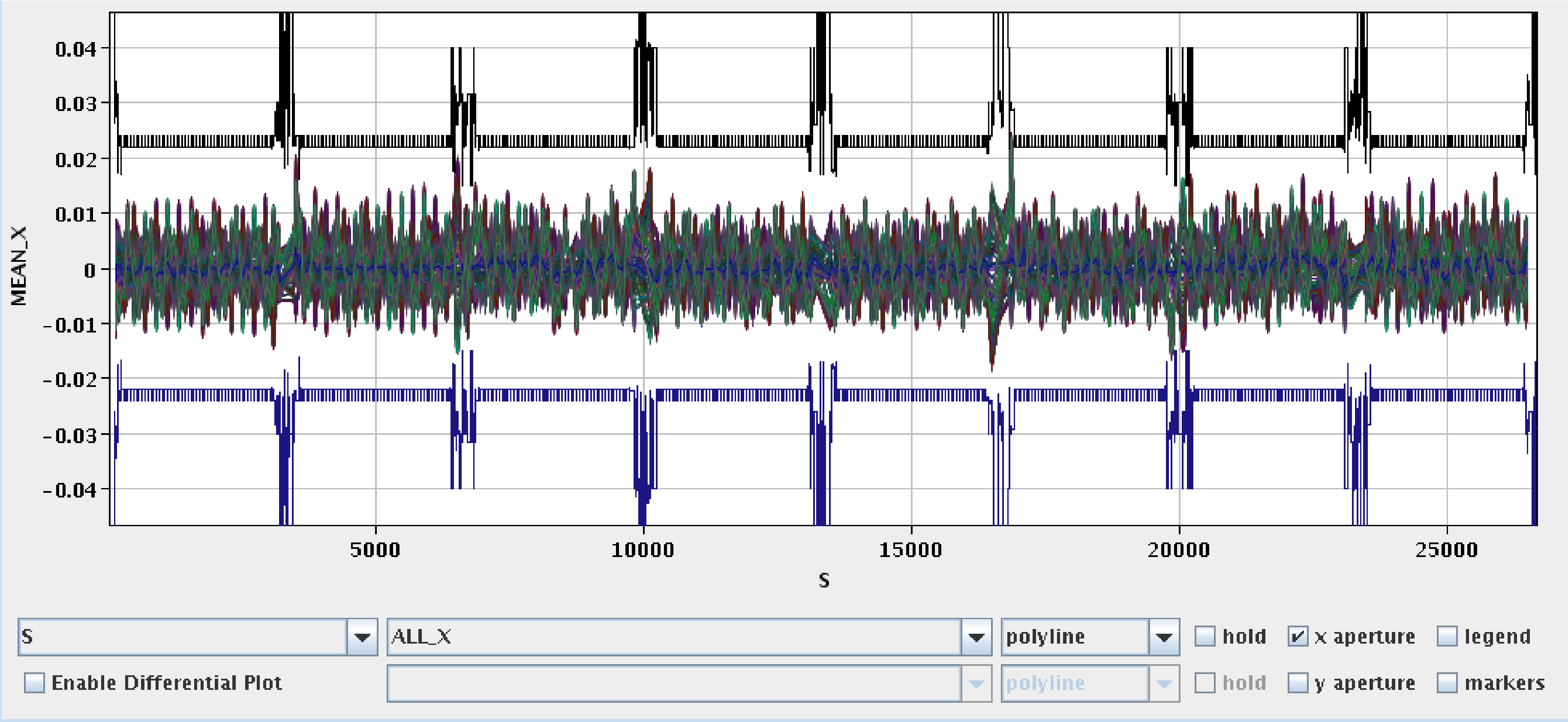




LHC aperture measurements

Beam 2 – Horizontal aperture scan

- The bump amplitude was limited to 7 or 8 σ.



LHC aperture measurements

Bump amplitude limited to:

Main losses at:

	Horizontal	**Vertical**
Beam 1	+7 / -7 sigma MQM.6R2 smaller peak: MQM.6R8 / MQY.4R6 MQY.5R6	+8 / -9 sigma MQY.4L6 MQ.31L1 smaller peak: MQ.13L5 / MQY.4L6
Beam 2	+8 / -7 sigma MQY.5R6 MQ.11R6 / MQY.4L6 MQY.5R6 MQM.6L8	+7 / -7.5 sigma MQ.12R8 MQ.29L2 / MQ.20L3 MQ.16R8 smaller peak: MQY.5L6

LHC aperture measurements

	Horizontal
Beam 2	+8 / -7 sigma MQY.5R6 MQ.11R6 / MQY.4L6 MQY.5R6 MQM.6L8

Beam envelope added (3 σ) computed with the measured optics and

$\varepsilon_{x,n}$= 12.7 umrad

n1 computed with:
- **measured aperture**
- **measured optics**
- **mech. tolerances set to zero**
- **closed orbit set to zero**

n1 computed with:
- **nominal aperture, tolerances**
- **meas optics and 3.5 mm closed orbit**

	Meas apert. (m)	n1 meas - n1 nom - n1 meas opt		Meas apert. (m)	n1 meas - n1 nom - n1 meas opt
			MQY.4L6	**0.027**	**9.8 - 9.4 - 8.5**
MQY.5R6	**0.021**	**6.39 - 9.3 - 7.1**	**MQY.5R6**	**-**	**-**
MQ.11R6	**0.020**	**10.1 - 10.9 - 7.9**	**MQM.6L8**	**0.020**	**9.9 -10.2 - 8.3**

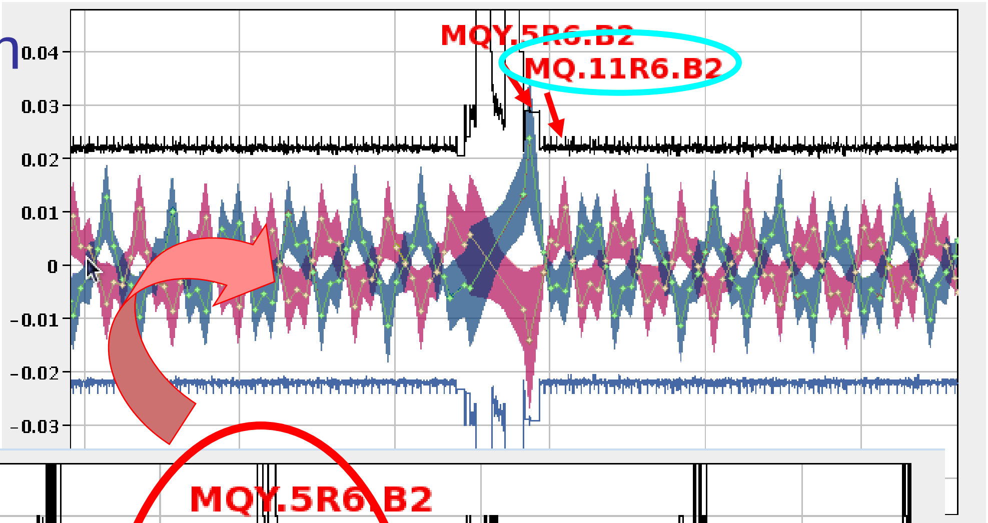
$\beta_{x,meas}$=719 m
$\beta_{x,nom}$=587 m

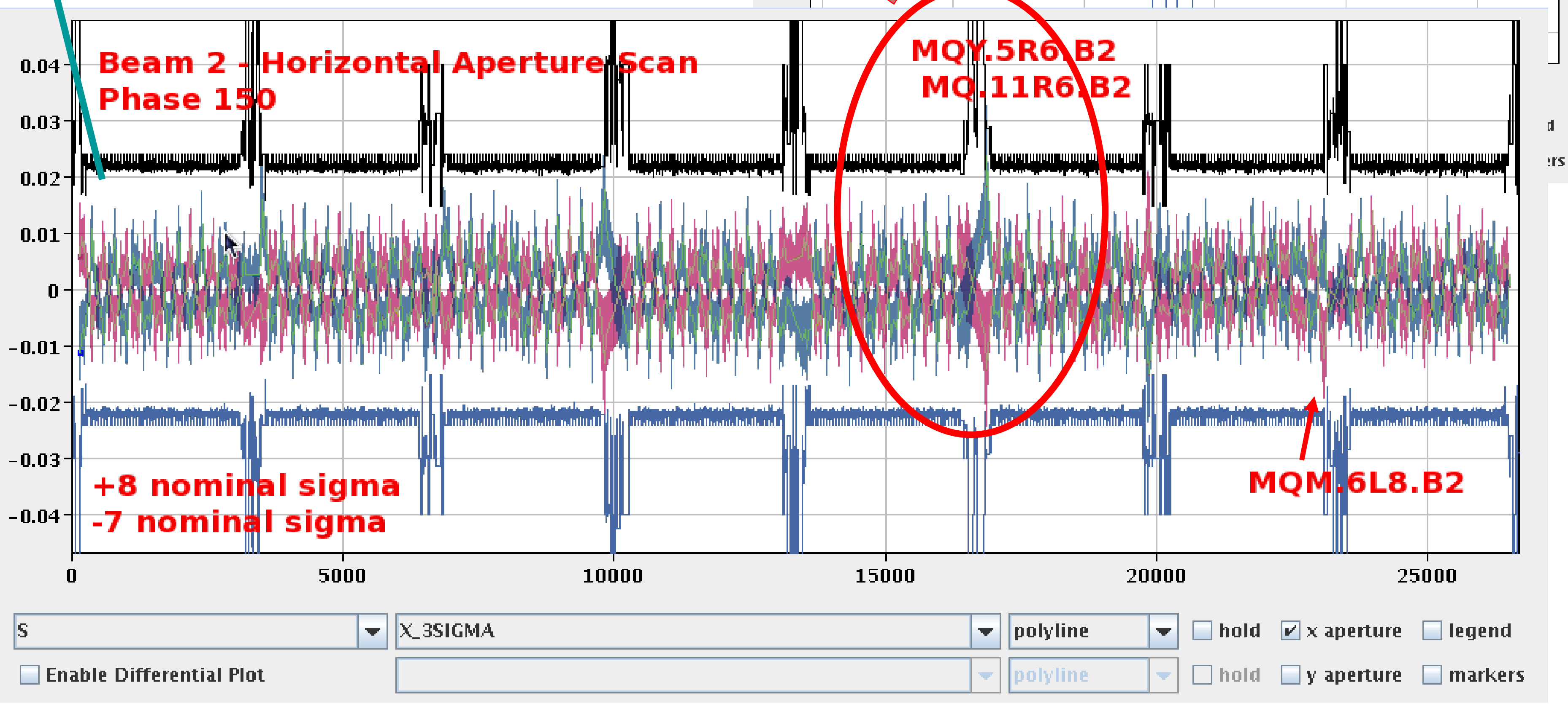
LHC aperture measurements

Beam 2 – Horizontal aperture scan

Beam envelope added (3 σ) computed with the measured optics and

$\varepsilon_{x,n}$= 12.7 umrad



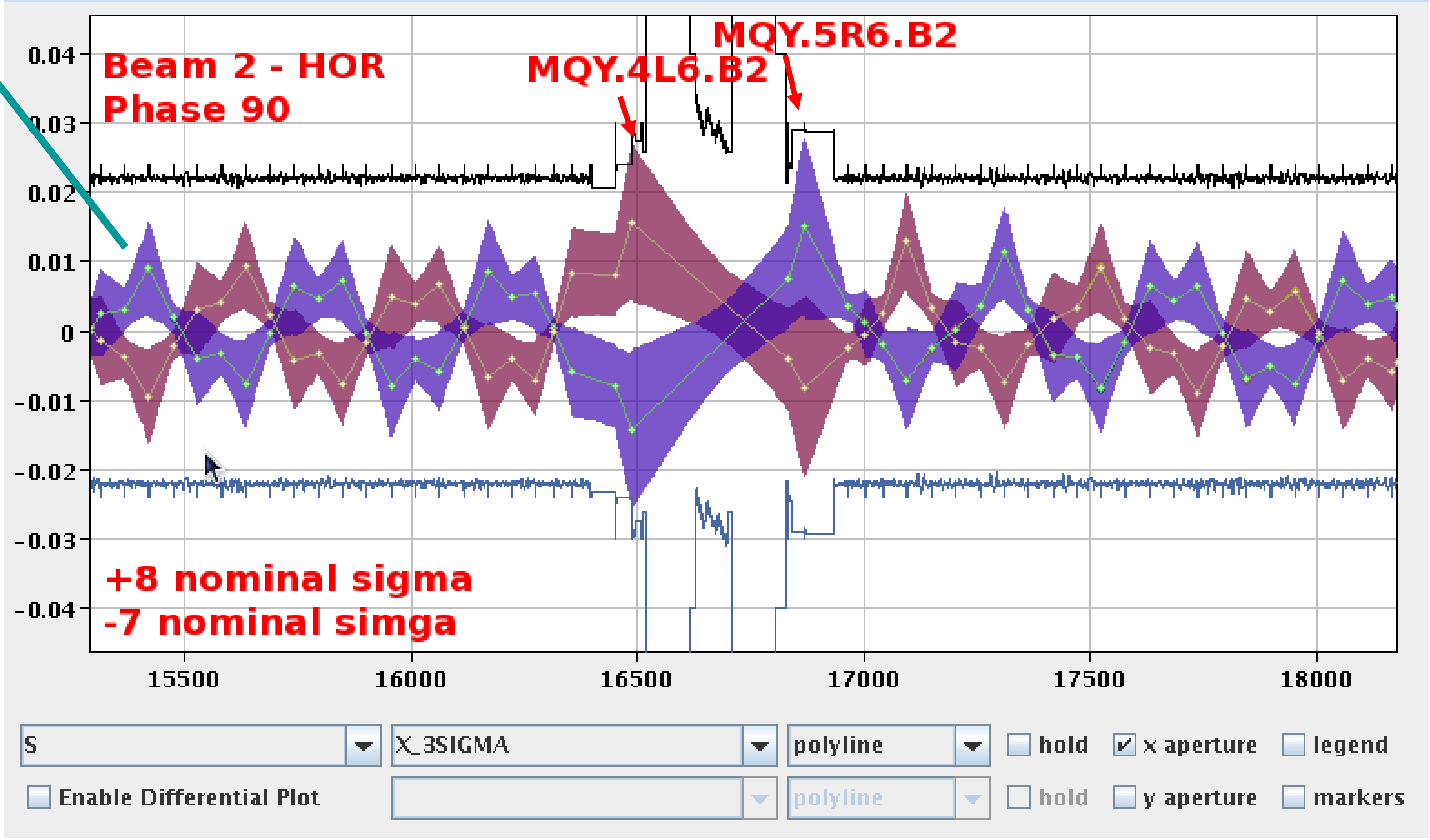


LHC aperture measurements

Beam 2 – Horizontal aperture scan

Beam envelope added (3 σ) computed with the measured optics and

$\varepsilon_{x,n}$= 12.7 umrad



Next steps

- LHC aperture measurements
    - complete analysis, more automatic
    - off-momentum measurements

- Thick model: introduce multipole field errors from magnet measurements in the thick lattice