Booster ORM status

by Meghan, Alexey and Eliana

Status overview

- A MADX file for describing the optics has been created by Meghan and Tan. This is a translation of Kiyomi MAD8 2011 file. It still contains a too weak dogleg setting and some imperfections. It contains numerical values for the magnet strength.
- Data have been acquired by Meghan. The procedure worked w/o problems. It uses B40 for setting the orbit acquisition parameters and B116 for starting the procedure which runs ACL scripts. Those scripts reads the parameters for the dipole settings from ORMConfig.txt and DISPConfig.txt under

  /usr/local/cbs_files/cns_write/booster/LOCO/
- A set of measurements taken March 28, after chromaticity was corrected for the first 18 ms, was used for measuring the coupling. Corrections were set April 3.
- Meghan used her script for recording the minimum tune split along the ramp after correction. Coupling looked much smaller when observing the effect of the pinger on the orthogonal plane.
- The fitting procedure is still done by using Elegant LOCO implementation from Alexey.

- Meghan and Alexey (remotely) were extremely supportive. Meghan is doing some clean up remotely.
  The all procedure (data acquisition+data processing+fitting+installing corrections) involves scripts and Mathematica notebooks spreaded between clx, heimdall and own PC (for Mathematica) and relative files transfers.
- The procedure is cumbersome [a] and a documentation is absolutely necessary.
- I wrote a fortran program for the evaluation of the ORM and dispersion data for avoiding Mathematica (at the moment still needed for creating the current files with the corrections), both for speeding up the calculation and reducing the number of machines involved.
- But execution time on heimdall turned out to be rather long. C-Y. Tan managed to get it working on a MAC: fitting the whole ramp takes 75 minutes, while on April 9 the fit of the first 15 ms took 210 minutes on heimdall, after that the whole ramp fit which was running over night had to be stopped... It depends on the machine usage (and management?)

[a] it is not a criticism, just a fact

Modeling and Correcting

The source of errors are represented in the model by 48+48 fictitious thin lenses. The skew thin lenses are at the same location as the actual skew quadrupoles. LOCO model consists of the ideal model completed by the actual machine settings which are collected by a Meghan script.

LOCO attempts to find values for the fictitious thin lenses which inserted in the model reproduce the measured response to corrector and RF scans.

Coupling correction

$$\boldsymbol{K}^{(0)}_{meas} = \boldsymbol{K}_{err} + \boldsymbol{K}^{(0)}_{model} = \boldsymbol{K}^{(0)}_{fit} + \boldsymbol{K}^{(0)}_{model}$$

With

$$\boldsymbol{\Delta K}^{(0)}_{model} = -(\boldsymbol{K}^{(0)}_{fit} + \boldsymbol{K}^{(0)}_{model}) \quad \rightarrow \quad \boldsymbol{K}^{(1)}_{model} = -\boldsymbol{K}^{(0)}_{fit}$$

it is

$$\boldsymbol{K}^{(1)}_{meas} = \boldsymbol{K}_{err} + \boldsymbol{K}^{(1)}_{model} = \boldsymbol{K}_{err} + \boldsymbol{K}^{(0)}_{model} + \boldsymbol{\Delta K}^{(0)}_{model} =$$

$$\boldsymbol{K}_{err} + \boldsymbol{K}^{(0)}_{model} - (\boldsymbol{K}^{(0)}_{fit} + \boldsymbol{K}^{(0)}_{model}) = \boldsymbol{0}$$

if the fit is well representing the unknown errors.

Examples.

1) Coupling perfeclty compensated:

$$\boldsymbol{K}^{(0)}_{meas} = 0 = \boldsymbol{K}_{err} + \boldsymbol{K}^{(0)}_{model}$$

ie

$$\boldsymbol{\Delta K}^{(0)}_{model} = -(\boldsymbol{K}^{(0)}_{fit} + \boldsymbol{K}^{(0)}_{model}) = 0$$

2) $\boldsymbol{K}_{err}$=0 but $\boldsymbol{K}^{(0)}_{model} \neq 0$ by mistake:

$$\boldsymbol{K}^{(0)}_{meas} = \boldsymbol{K}_{err} + \boldsymbol{K}^{(0)}_{model}$$

$$\boldsymbol{\Delta K}^{(0)}_{model} = -(\boldsymbol{K}^{(0)}_{fit} + \boldsymbol{K}^{(0)}_{model}) = -\boldsymbol{K}^{(0)}_{model}$$

Between the correcting normal quadrupoles (qQSnn and qQLnn) and the error thin lenses there is a 0.024 m long BPM; the beta-beating correction should be as straightforward as the coupling correction.

β-beating correction

$$K^{(0)}_{meas} = K_{err} + K^{(0)}_{model} = K^{(0)}_{fit} + K^{(0)}_{model}$$

With

$$\Delta K^{(0)}_{model} = K_{design} - (K^{(0)}_{fit} + K^{(0)}_{model})$$

$$K^{(1)}_{model} = K^{(0)}_{model} + K_{design} - (K^{(0)}_{fit} + K^{(0)}_{model}) = K_{design} - K^{(0)}_{fit}$$

it is

$$K^{(1)}_{meas} = K_{err} + K^{(1)}_{model} = K_{err} + K_{design} - K^{(0)}_{fit} = K_{design}$$

if the fit is well representing the unknown errors.

Examples.

1) β-beating perfeclty compensated:

$$\boldsymbol{K}^{(0)}_{meas} = \boldsymbol{K}_{design} = \boldsymbol{K}_{err} + \boldsymbol{K}^{(0)}_{model}$$

ie

$$\boldsymbol{\Delta K}^{(0)}_{model} = \boldsymbol{K}_{design} - (\boldsymbol{K}^{(0)}_{fit} + \boldsymbol{K}^{(0)}_{model}) = \boldsymbol{0}$$

2) $\boldsymbol{K}_{err}$=0 but $\boldsymbol{K}^{(0)}_{model} \neq \boldsymbol{K}_{design}$ by mistake:

$$\boldsymbol{K}^{(0)}_{meas} = \boldsymbol{K}_{err} + \boldsymbol{K}^{(0)}_{model}$$

$$\boldsymbol{\Delta K}^{(0)}_{model} = \boldsymbol{K}_{design} - (\boldsymbol{K}^{(0)}_{fit} + \boldsymbol{K}^{(0)}_{model}) = \boldsymbol{K}_{design} - \boldsymbol{K}^{(0)}_{model}$$

$$\boldsymbol{K}^{(1)}_{model} = \boldsymbol{K}^{(0)}_{model} + \boldsymbol{K}^{design} - \boldsymbol{K}^{(0)}_{model} = \boldsymbol{K}^{design}$$

Data

28 March files:

/usr/local/cbs_files/cns_write/booster/booster/beta_studies/28MARCH_ORM_H_6.txt

/usr/local/cbs_files/cns_write/booster/booster/beta_studies/28MARCH_ORM_V_1.txt

/usr/local/cbs_files/cns_write/booster/booster/beta_studies/28MARCH_DISP_1.txt

/usr/local/cbs_files/cns_write/booster/booster/beta_studies/28Mar_MagnetSettings.txt

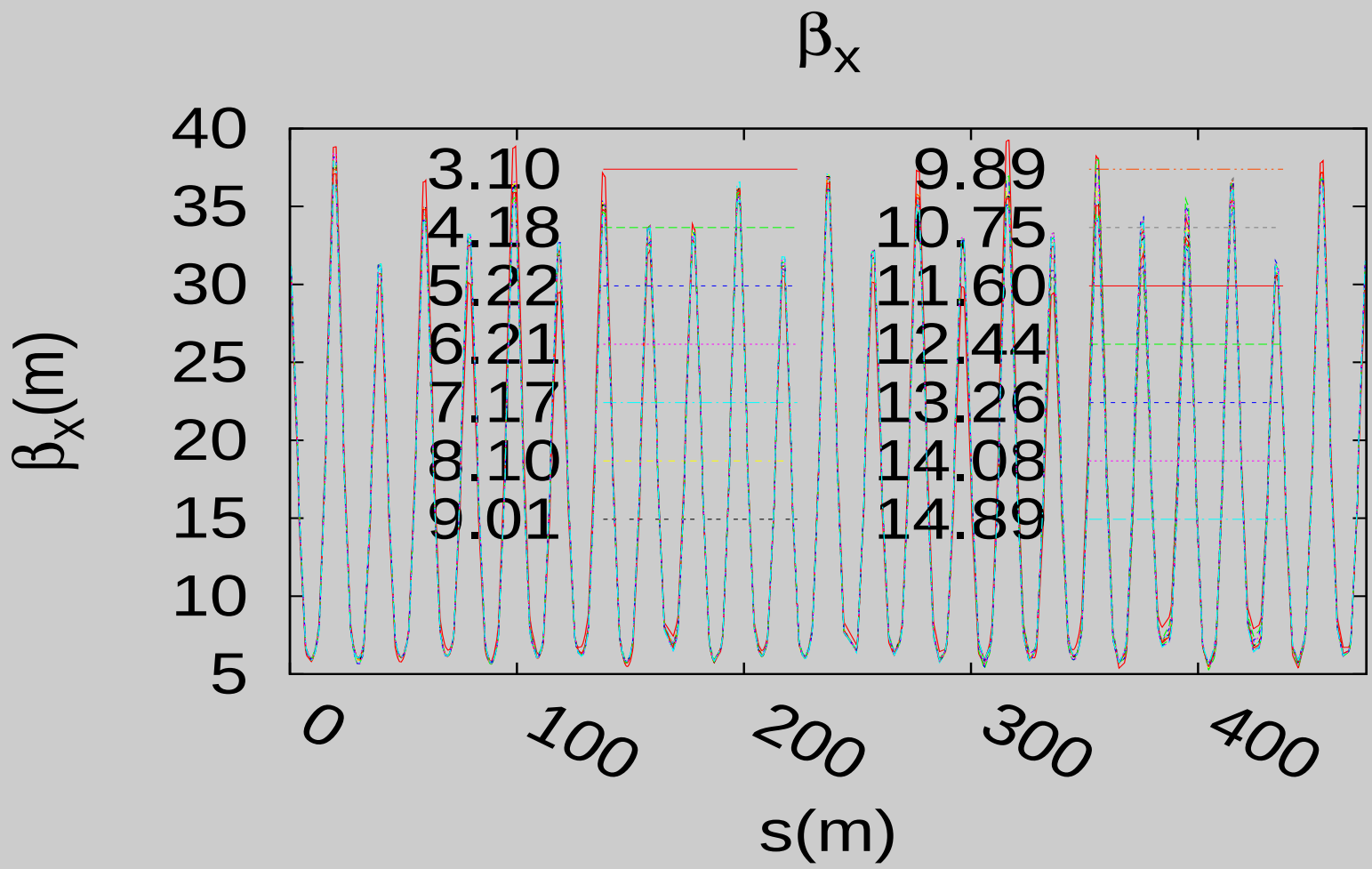
Corrections applied and new data taken April 3:

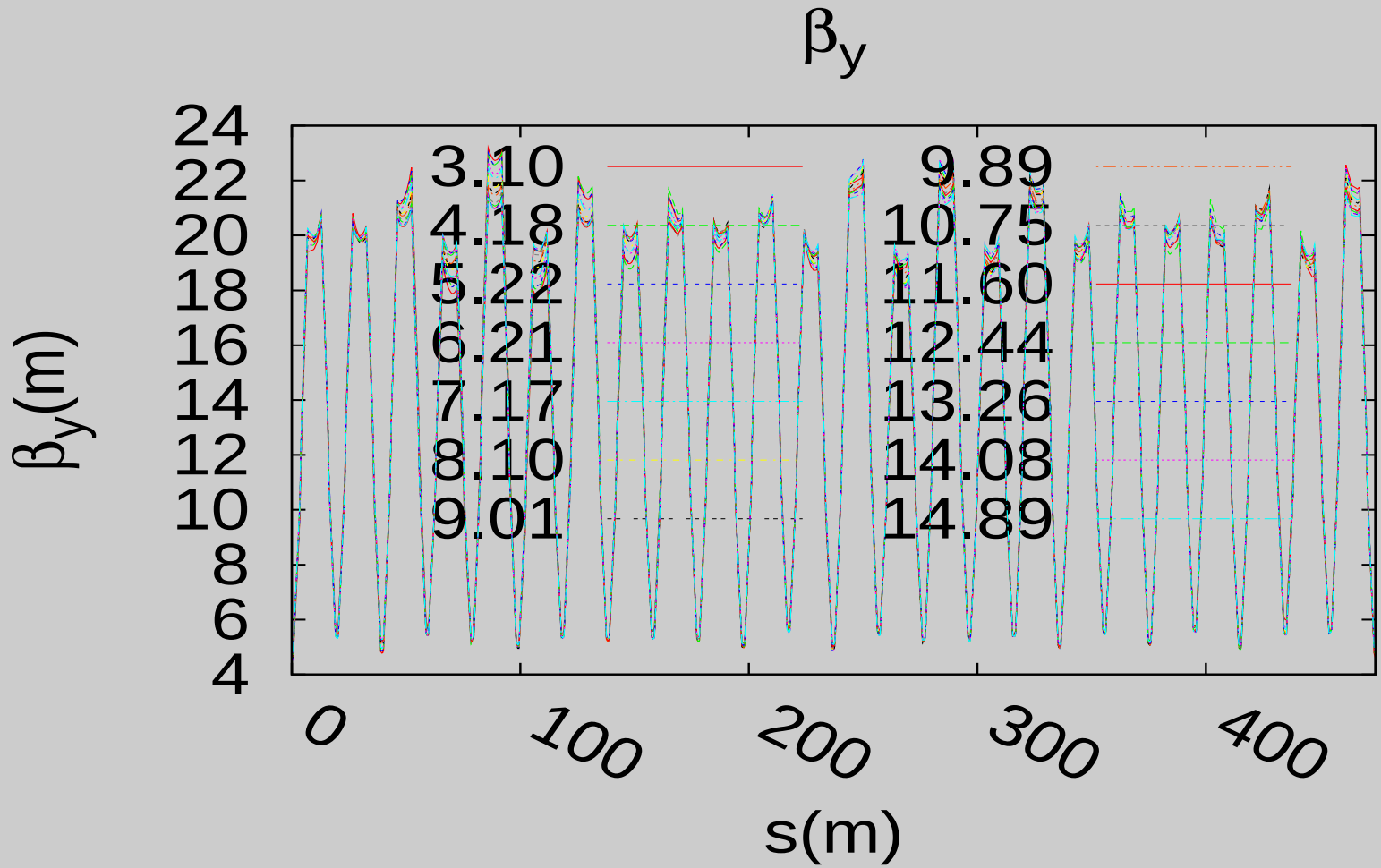
/usr/local/cbs_files/cns_write/booster/booster/LOCO/data/3APR_ORM_H.TXT

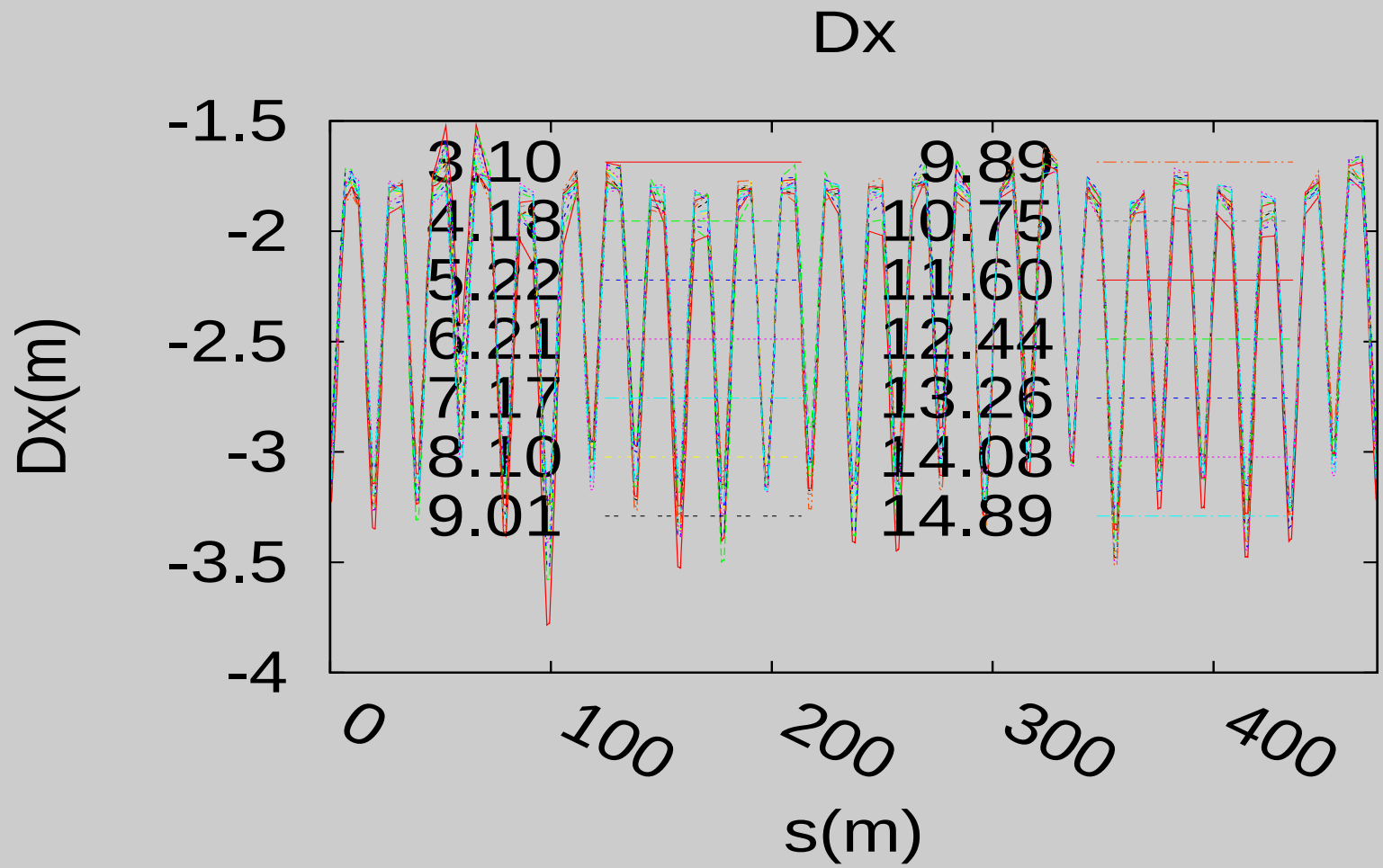
/usr/local/cbs_files/cns_write/booster/booster/LOCO/data/3APR_ORM_V.TXT

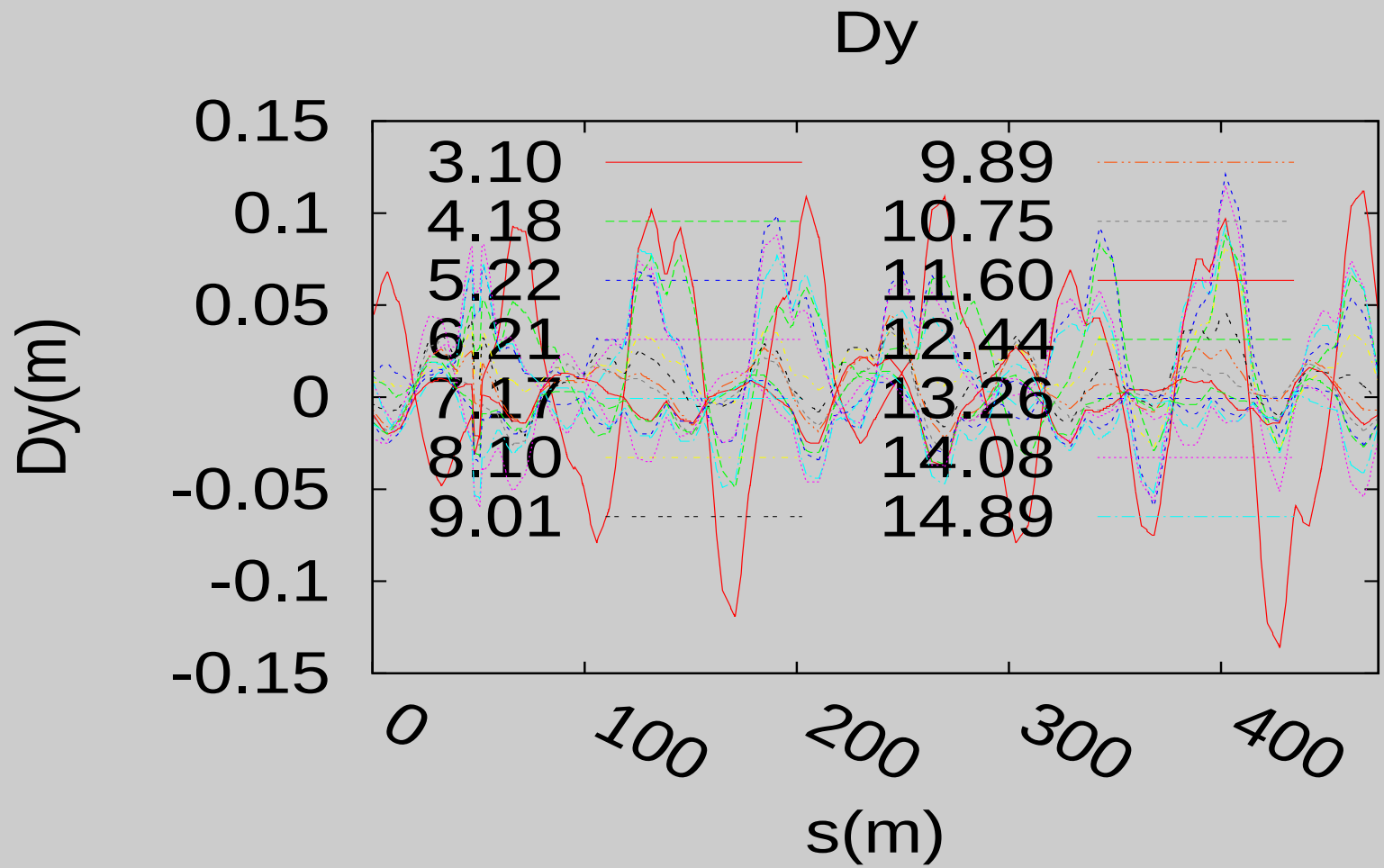
/usr/local/cbs_files/cns_write/booster/booster/LOCO/data/3APR_DISP.TXT

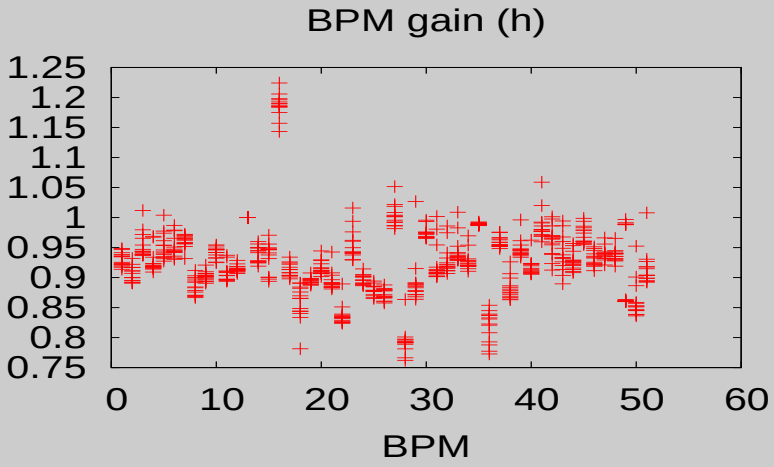
/usr/...../LOCO/data/3APR_newSkew_Settings.txt

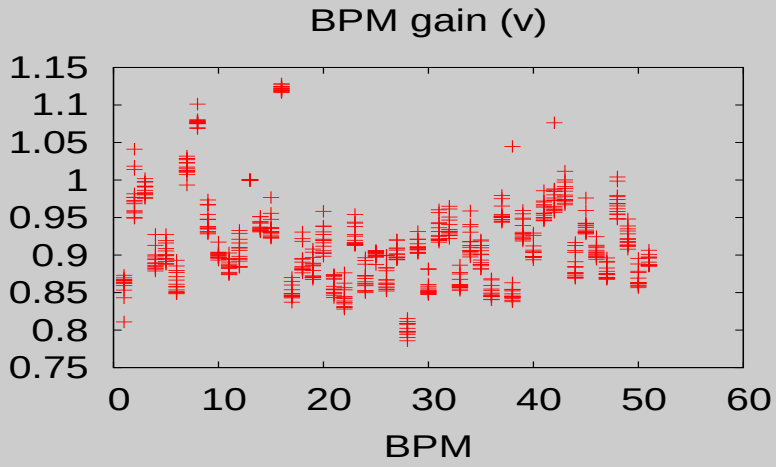

β_x
β_x(m)
40
35
30
25
20
15
10
5
0
100
200
300
400
s(m)
3.10
4.18
5.22
6.21
7.17
8.10
9.01
9.89
10.75
11.60
12.44
13.26
14.08
14.89

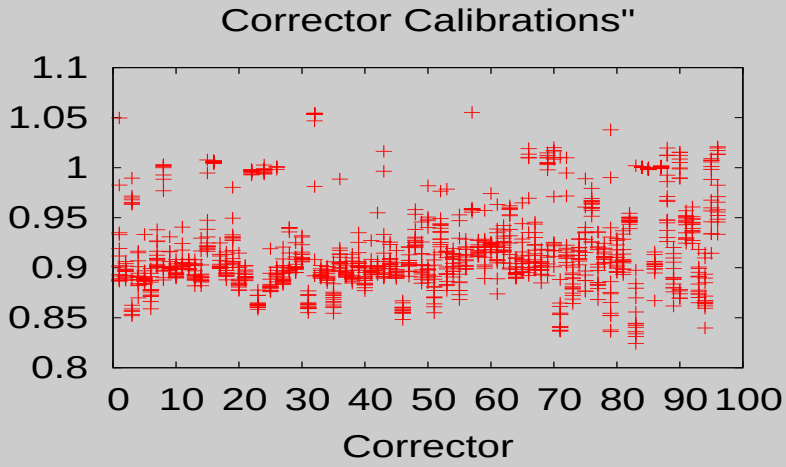

β_y
β_y(m)
24
22
20
18
16
14
12
10
8
6
4
3.10
4.18
5.22
6.21
7.17
8.10
9.01
9.89
10.75
11.60
12.44
13.26
14.08
14.89
0
100
200
300
400
s(m)

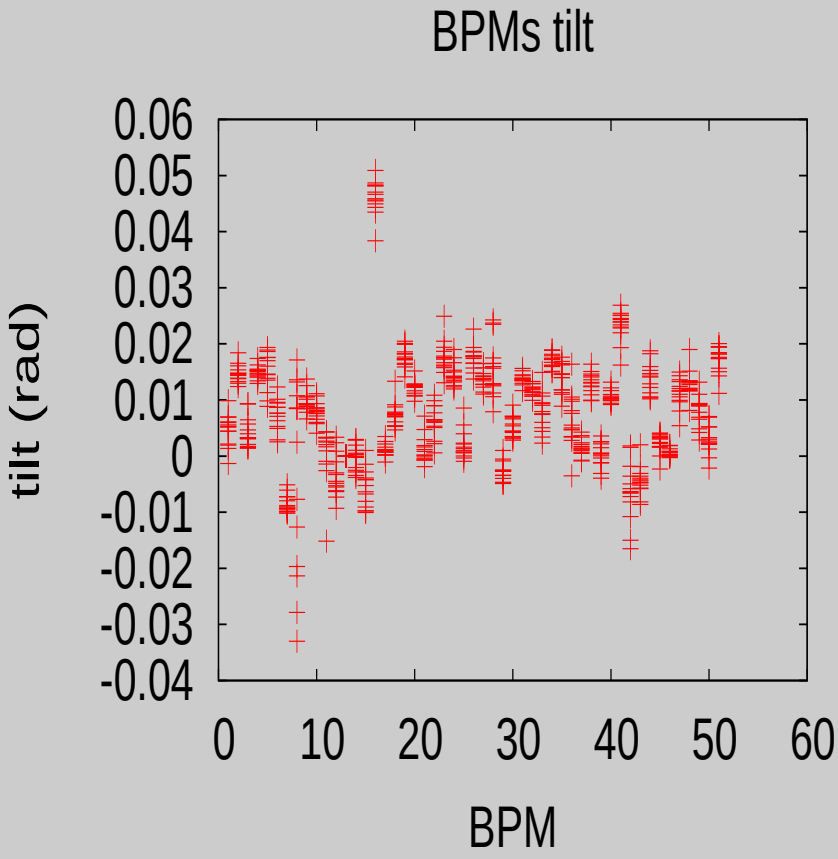

Dx
Dx(m)
s(m)
-1.5
-2
-2.5
-3
-3.5
-4
0
100
200
300
400
3.10
4.18
5.22
6.21
7.17
8.10
9.01
9.89
10.75
11.60
12.44
13.26
14.08
14.89

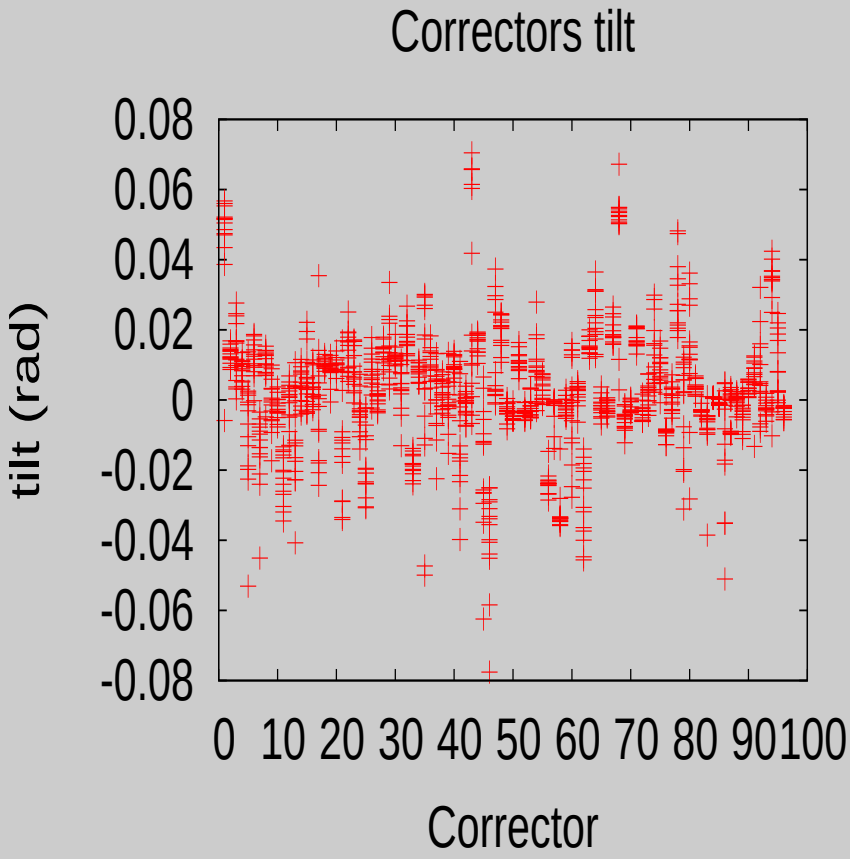

Dy
Dy(m)
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
0
100
200
300
400
s(m)
3.10
4.18
5.22
6.21
7.17
8.10
9.01
9.89
10.75
11.60
12.44
13.26
14.08
14.89


BPM gain (h)
1.25
1.2
1.15
1.1
1.05
1
0.95
0.9
0.85
0.8
0.75
0
10
20
30
40
50
60
BPM

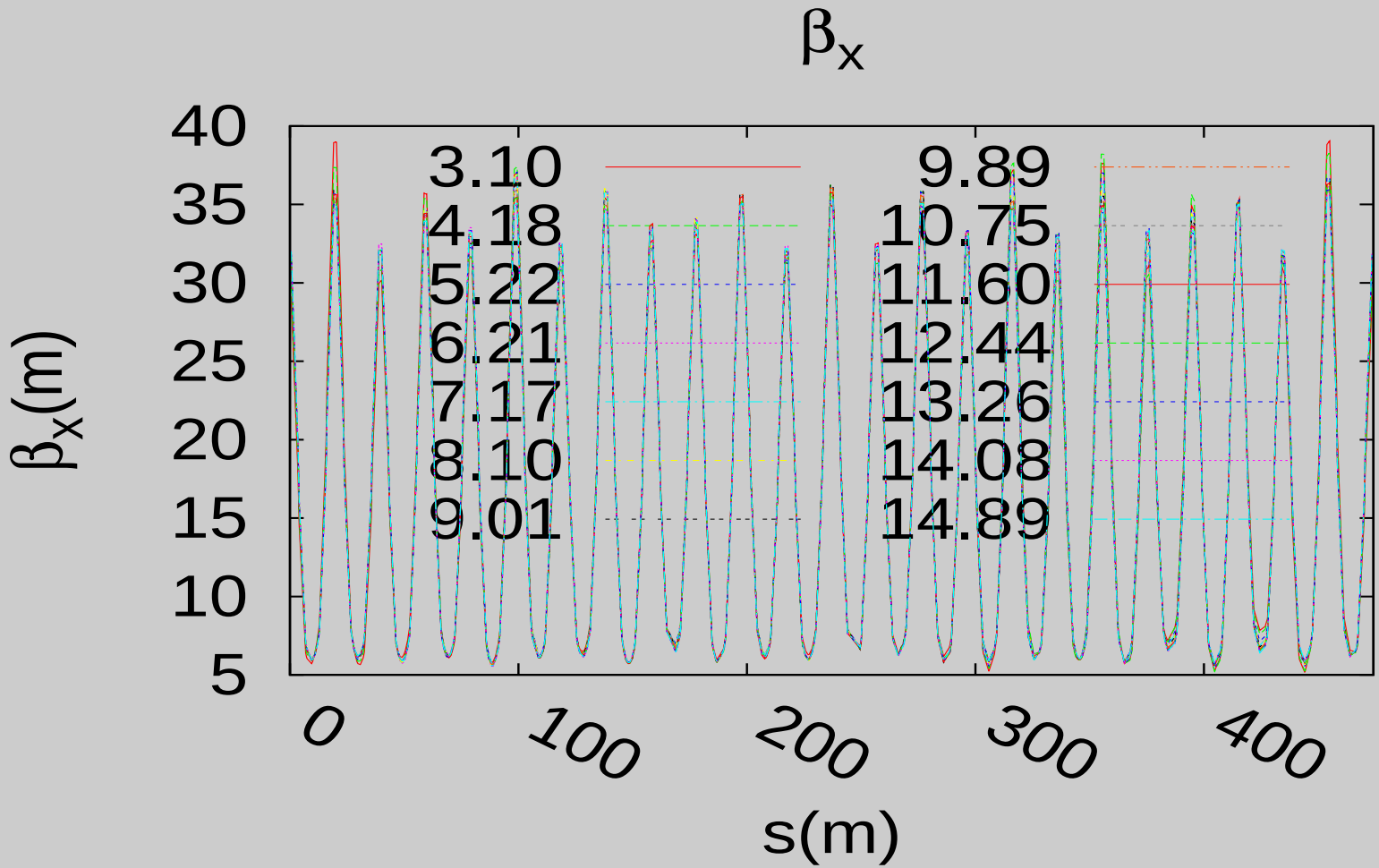

BPM gain (v)
1.15
1.1
1.05
1
0.95
0.9
0.85
0.8
0.75
0
10
20
30
40
50
60
BPM

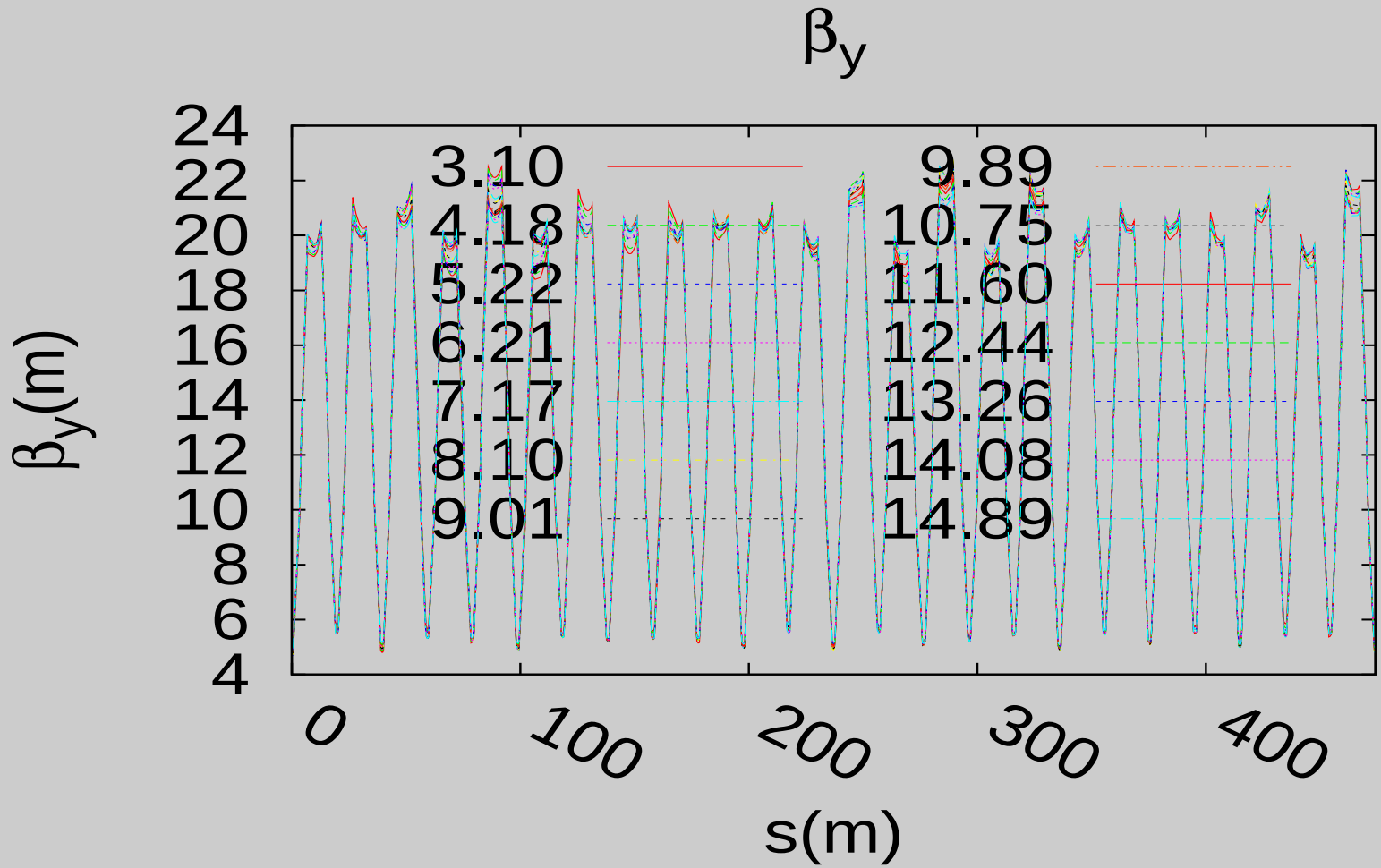

Corrector Calibrations"
1.1
1.05
1
0.95
0.9
0.85
0.8
0
10
20
30
40
50
60
70
80
90
100
Corrector

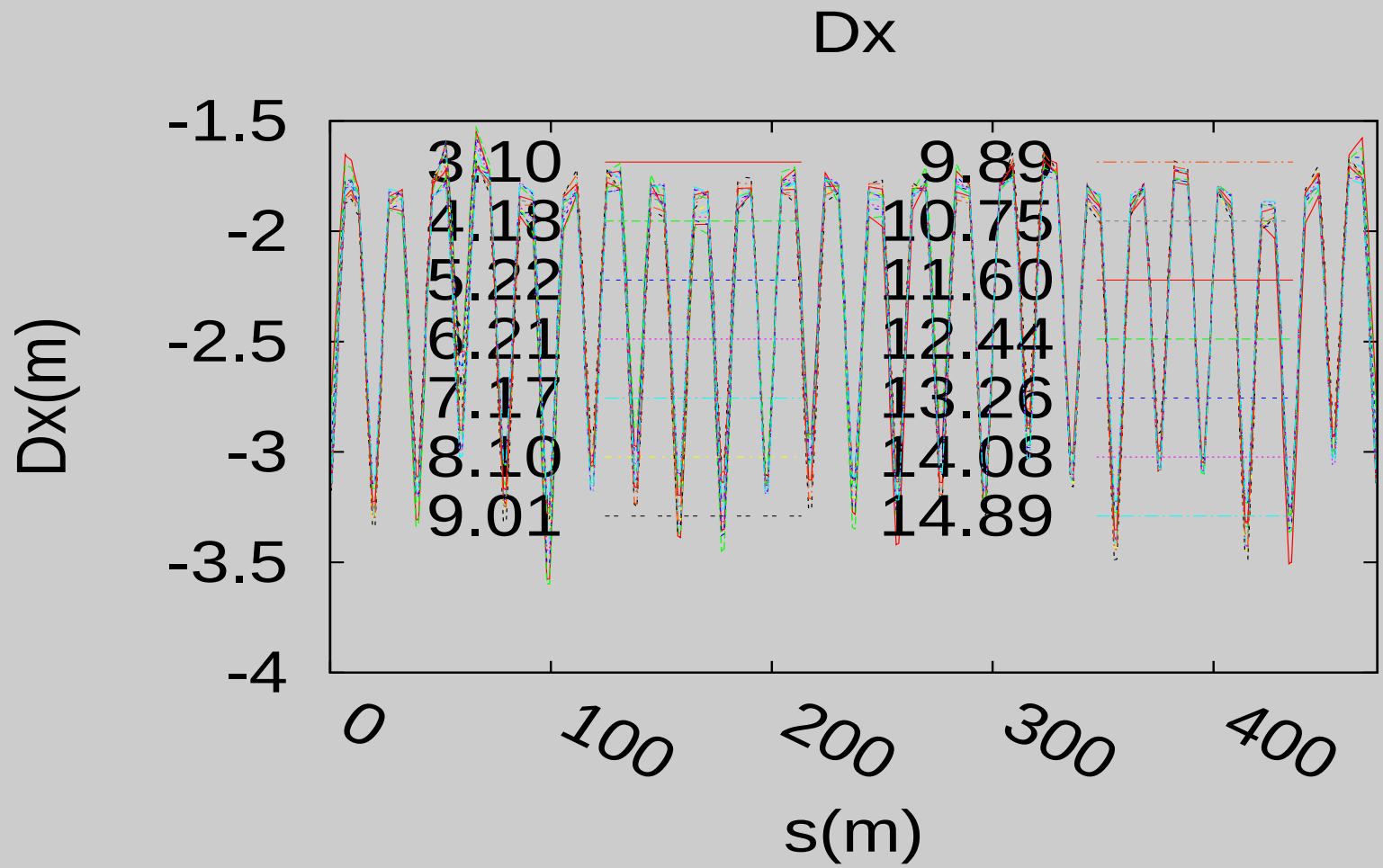

BPMs tilt
tilt (rad)
0.06
0.05
0.04
0.03
0.02
0.01
0
-0.01
-0.02
-0.03
-0.04
0
10
20
30
40
50
60
BPM

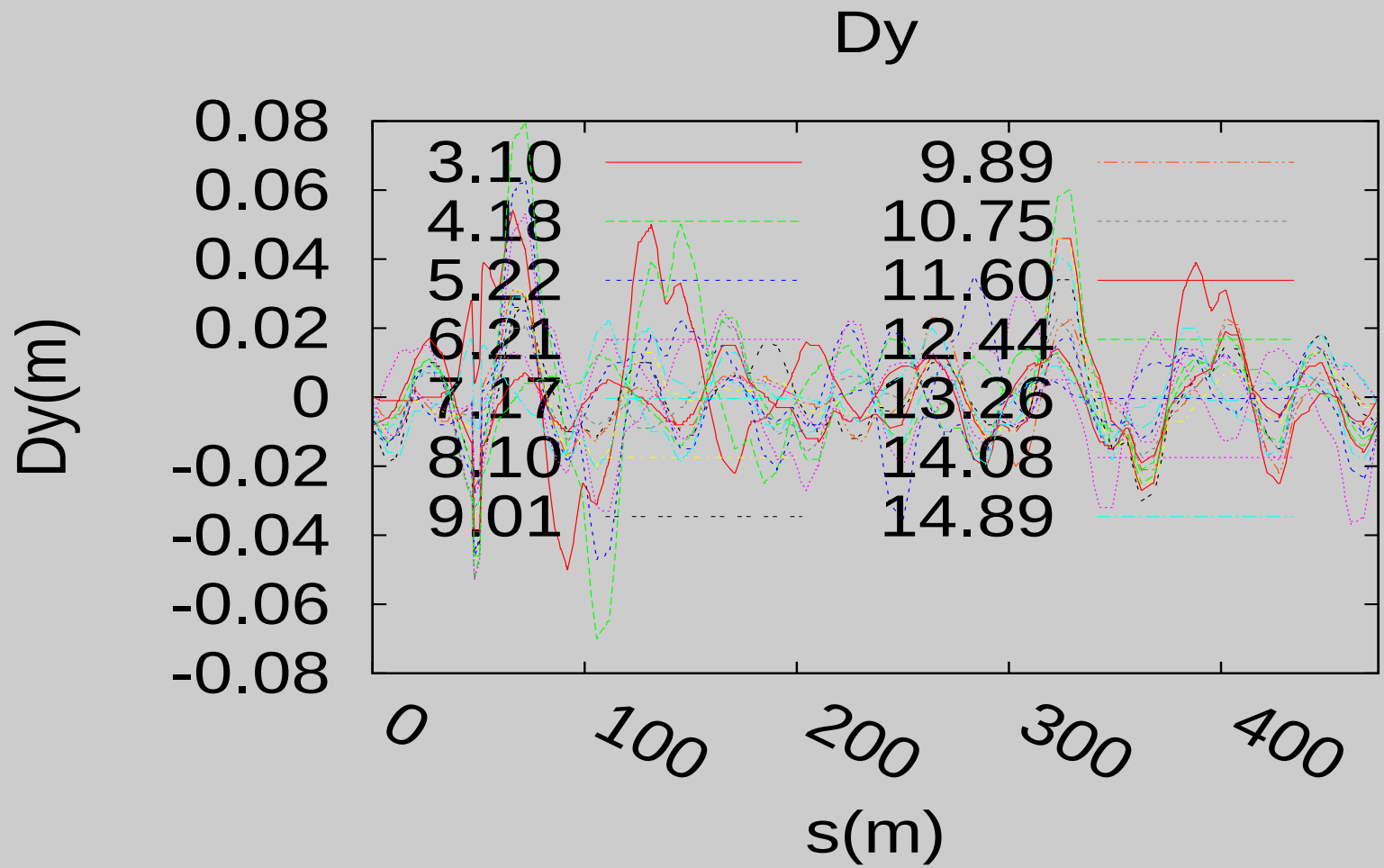

Correctors tilt
tilt (rad)
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
0
10
20
30
40
50
60
70
80
90
100
Corrector

April 3

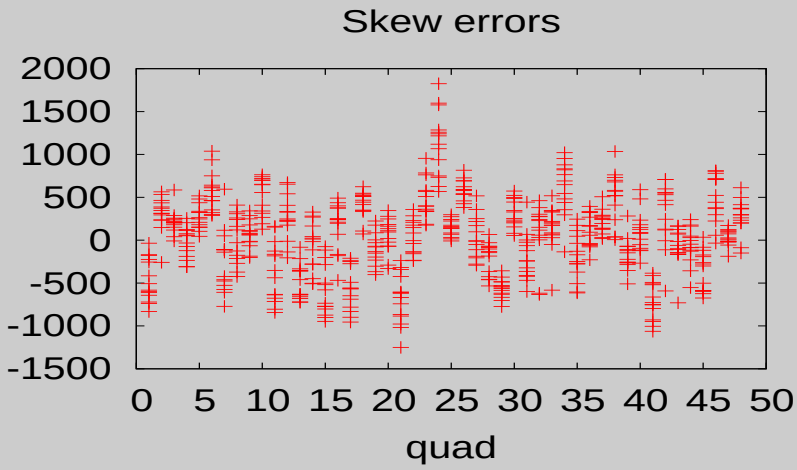

β_x
β_x(m)
40
35
30
25
20
15
10
5
0
100
200
300
400
s(m)
3.10
4.18
5.22
6.21
7.17
8.10
9.01
9.89
10.75
11.60
12.44
13.26
14.08
14.89

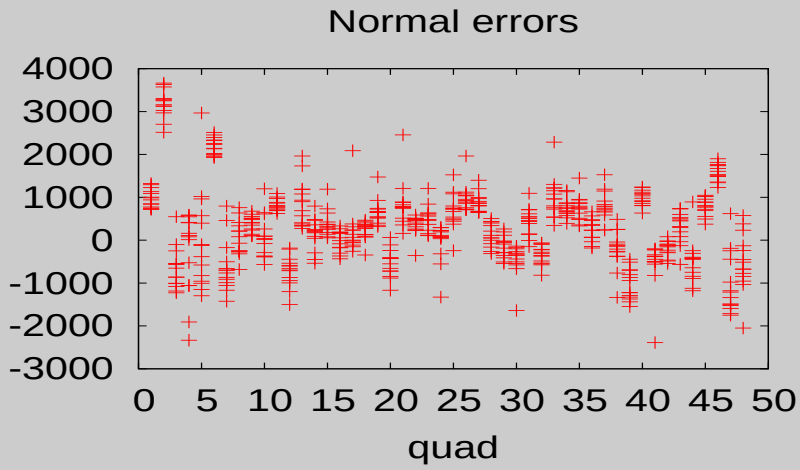

β_y
β_y(m)
24
22
20
18
16
14
12
10
8
6
4
3.10
4.18
5.22
6.21
7.17
8.10
9.01
9.89
10.75
11.60
12.44
13.26
14.08
14.89
0
100
200
300
400
s(m)


Dx
Dx(m)
-1.5
-2
-2.5
-3
-3.5
-4
0
100
200
300
400
s(m)
3.10
4.18
5.22
6.21
7.17
8.10
9.01
9.89
10.75
11.60
12.44
13.26
14.08
14.89

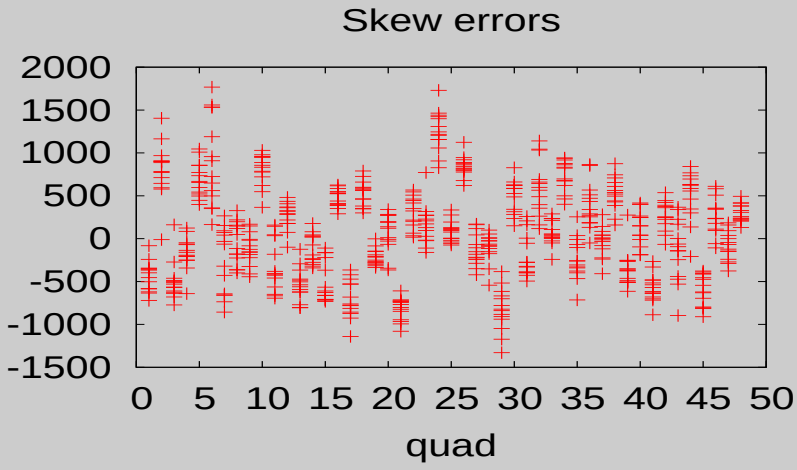

Dy
Dy(m)
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
3.10
4.18
5.22
6.21
7.17
8.10
9.01
9.89
10.75
11.60
12.44
13.26
14.08
14.89
0
100
200
300
400
s(m)

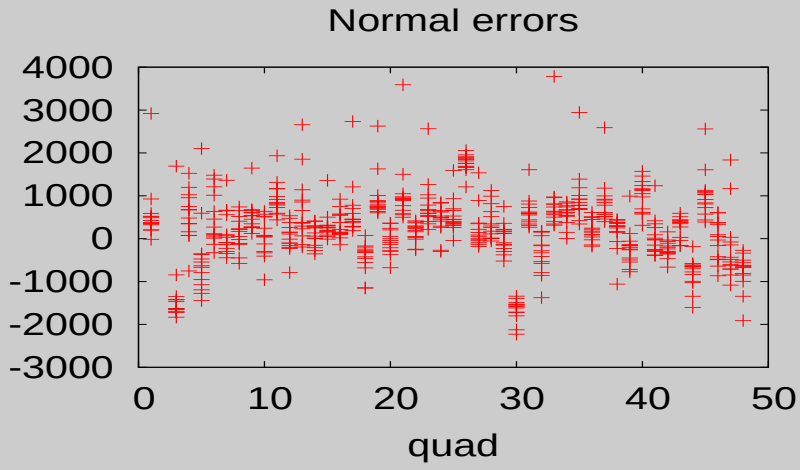
March 28





April 3





Summary and Outlooks

- The Booster optics looks fine!
- Try to simplify and clean up as much as possible.
- Write documentation.
- Move away from heimdall.
- Restore uncoupled machine status. Test it with B38.