RHIC Run-13: Triumphs, Challenges and Disappointments

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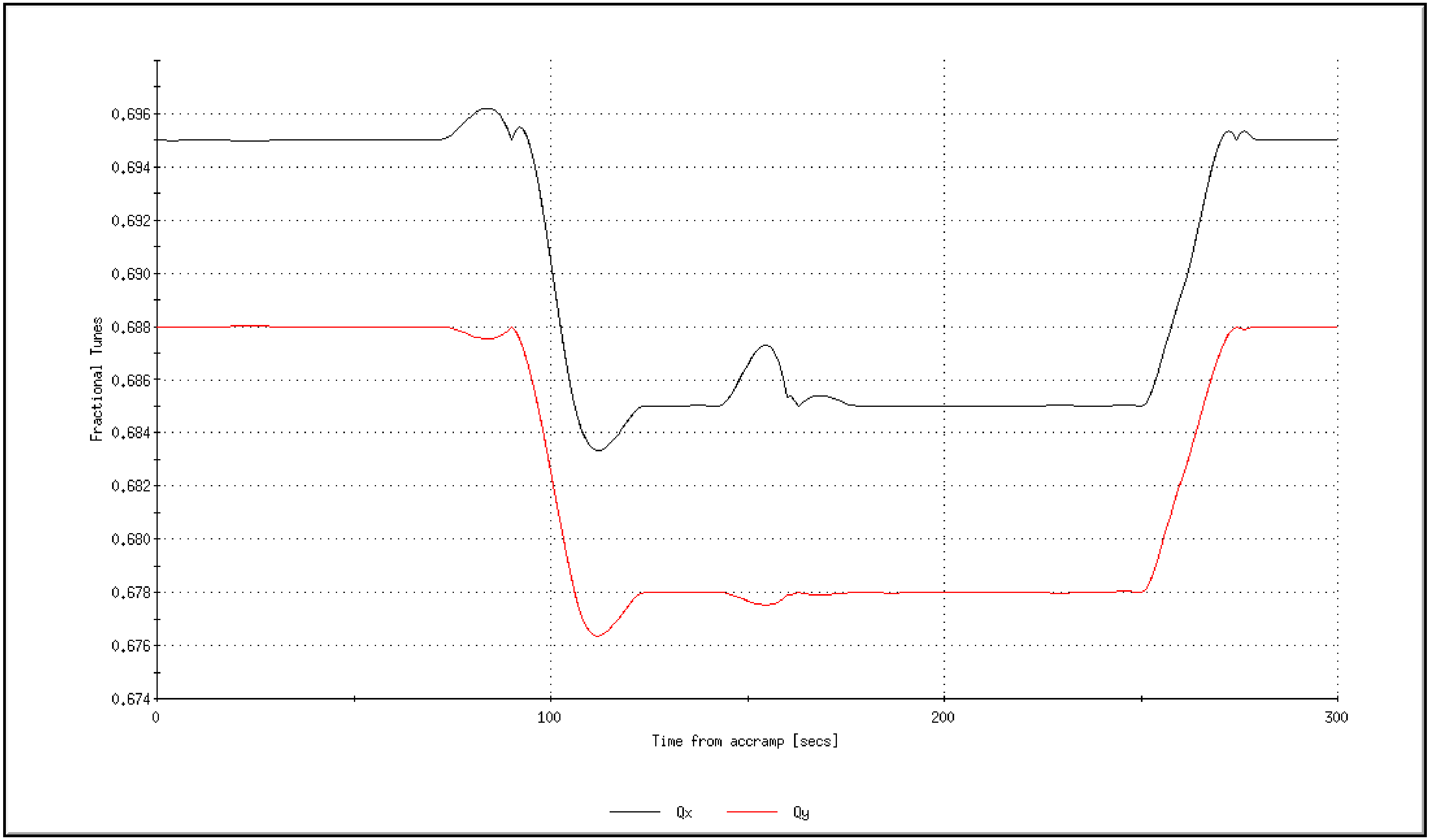
2013 RHIC Retreat

1. Ideal startup:
    - Unchanged timing, using kickers to inject (ATR and STAR beam pipe problems made setup of blue ring harder, achieving yellow circulating beam was very easy).
    - Ramping to any energy as soon as possible using old ramps.

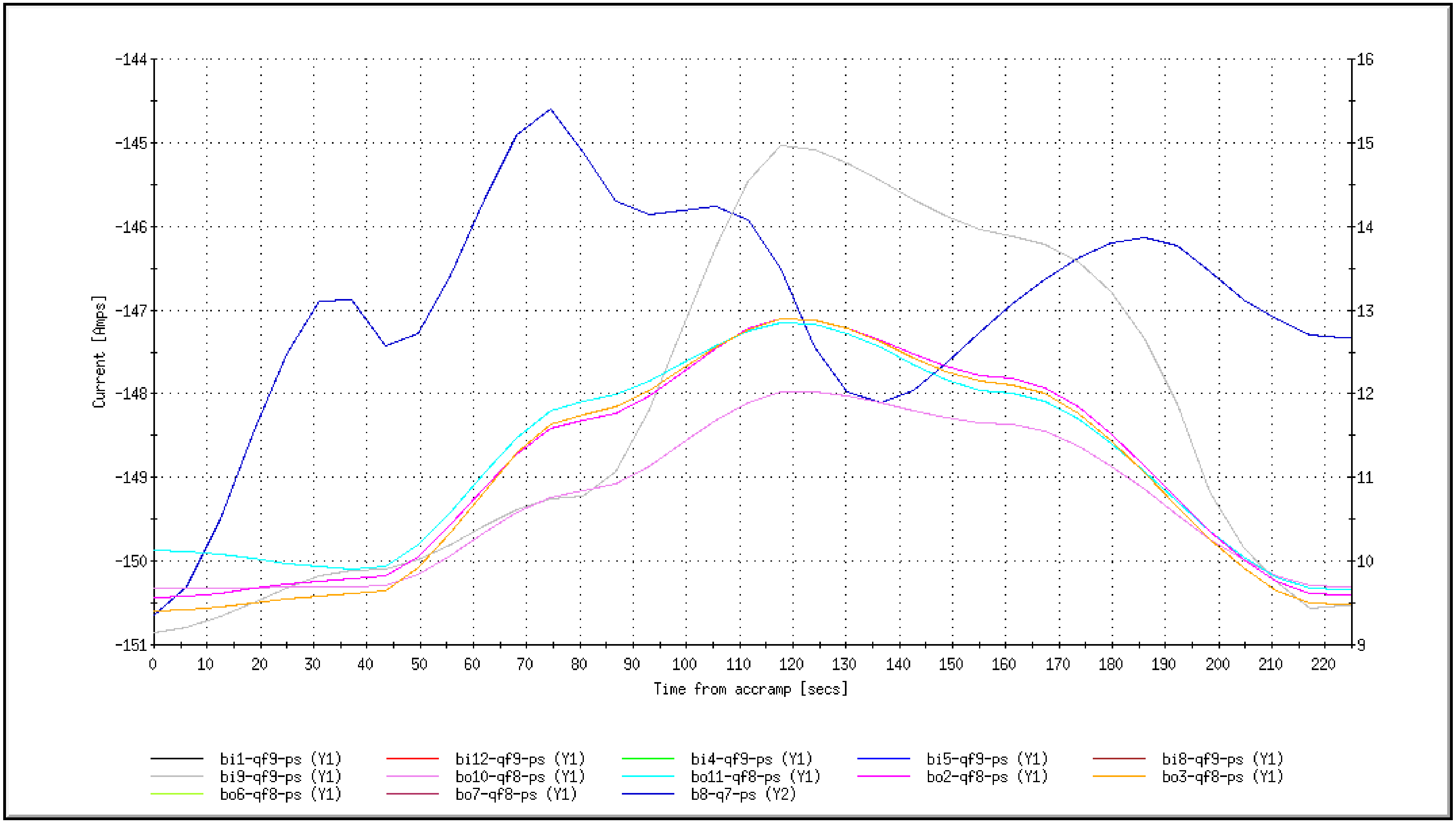
    This could have been the best run ever by far.
2. Wrong wire-up configuration of phase-shifter PS.
3. Not clear role of phase-shifter PS.
4. Problems related to beta squeeze during store ramp:
    - Quench detector tables,
    - Shifted time.
5. Problem with feed-forward of tunes due to different parametrization of quad strengths.
6. RampDesigner incident.
7. New main dipole PS regulator.
8. Failure of yellow main dipole DCCT.
9. Problems with global coupling.
10. Control of feedbacks moved from tape to wfgman.

11. Setup of instrumentation improved, only IPM hard to setup.
12. Store orbit corrections and collision rates:
    - do not capture b4, b5 BPMs.
    - do not use dependent / inconsistent BPMs in orbit correction.
    - correct orbit at IP using b1 or dx BPMs.
    - pay more attention to selecting goal orbits.

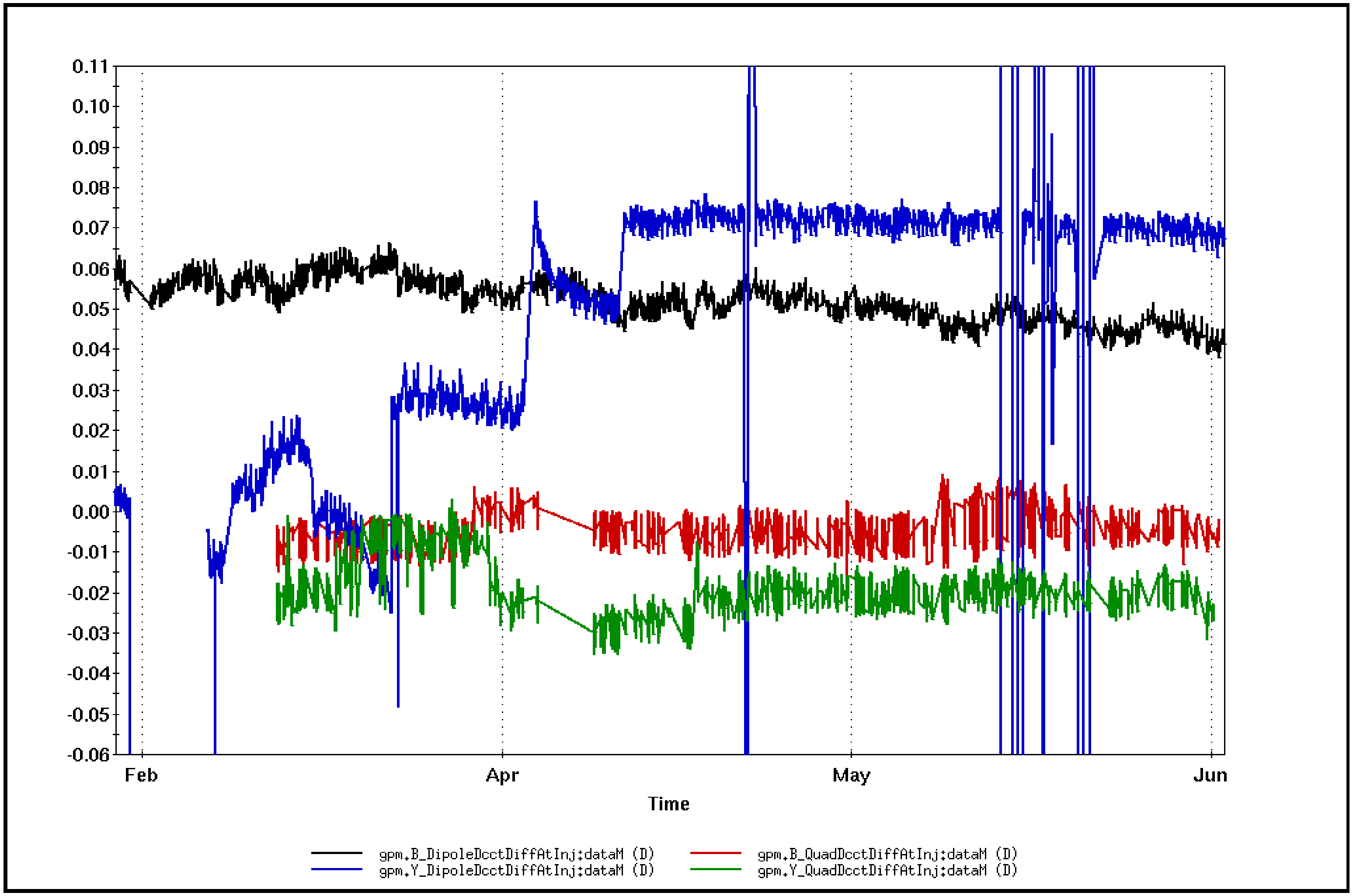
Shifted time



Non-smooth design currents



Main PS DCCTs



This picture shows the difference between primary and redundant DCCTs of RHIC main dipole and quad PS at injection during Run 13. The large changes happened on:

- Mar-22-2013: Carl wiggled the cable on the back of the DCCT.
- Apr-03-2013: Don changed yellow dipole DCCT head electronics.
- Apr-11-2013: Main PS crash button was pressed.

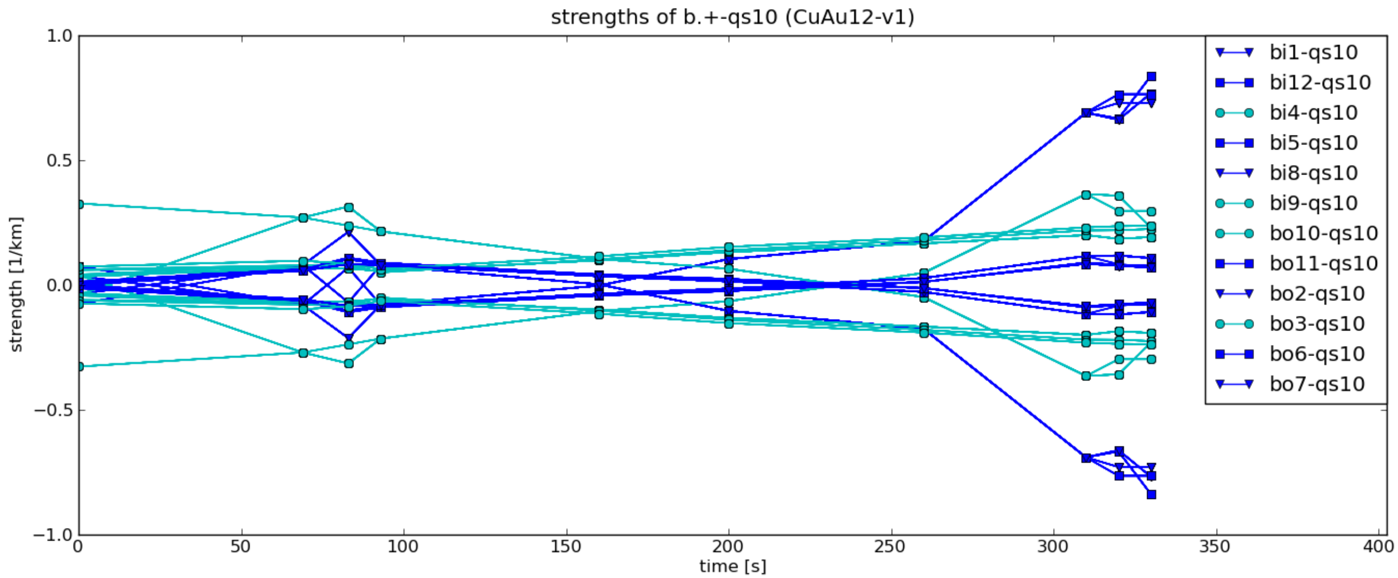
Yellow dipole DCCT also failed during Run 12 (causing QLI), but at that time we did not know that. Malfunction of DCCT caused tune and beam radius instability during e-lens part of the run.

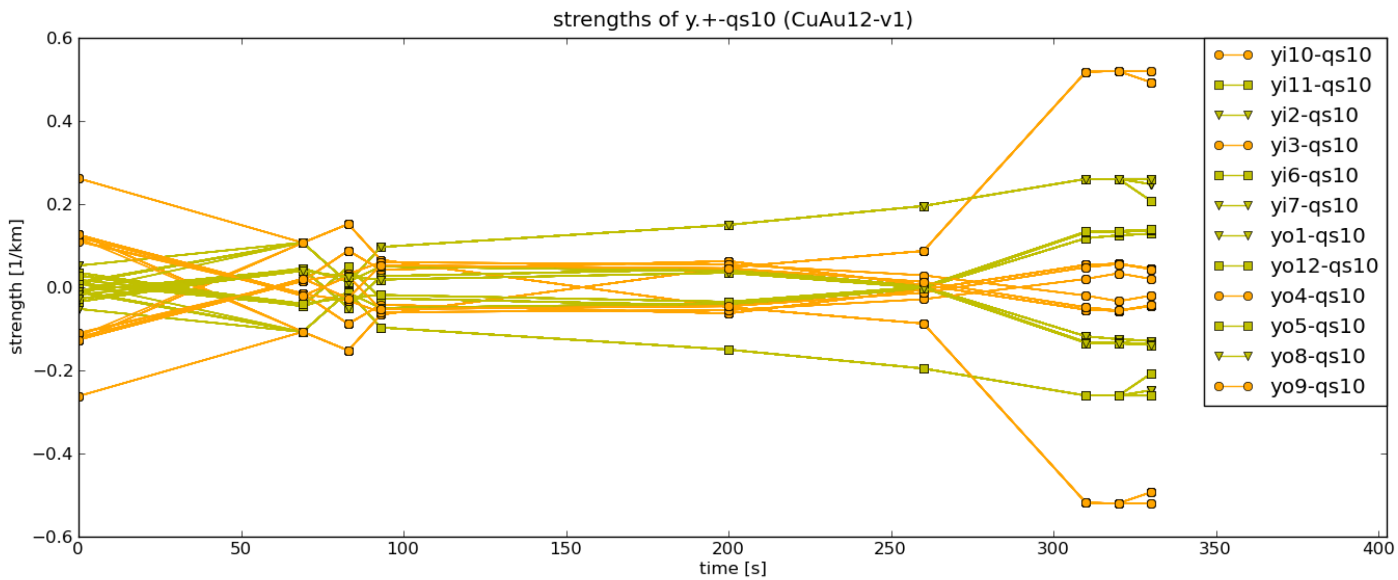
Global coupling

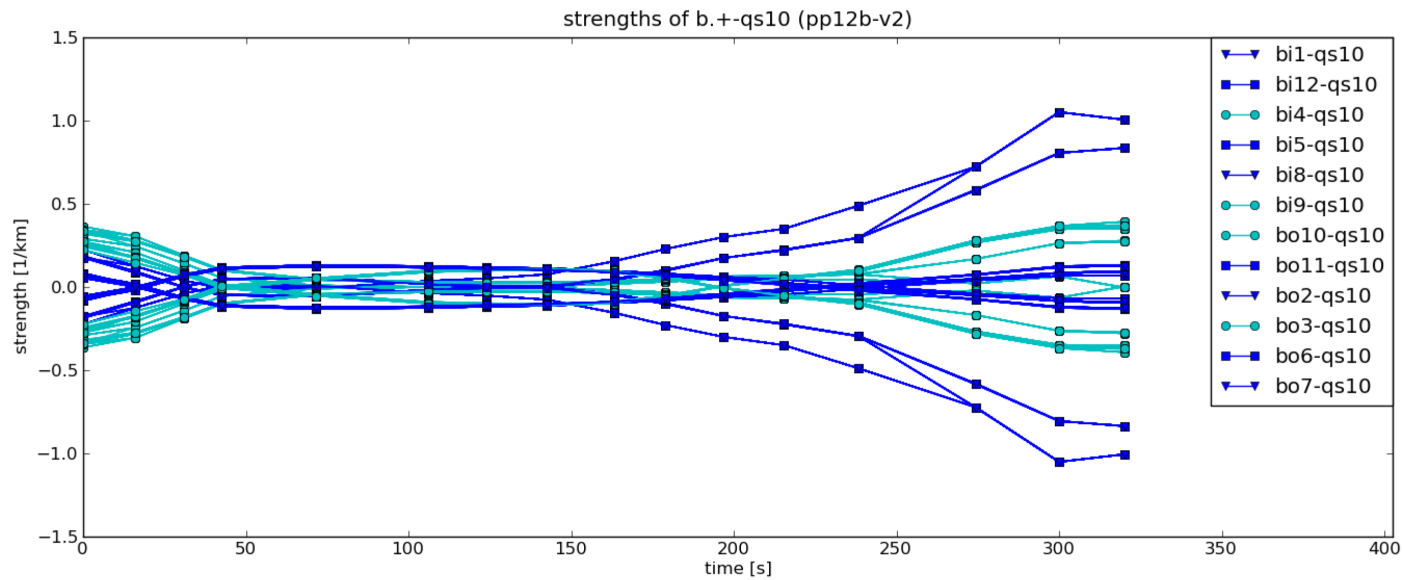
The following pictures show all global skew quad settings which selected ramps from Run 12 and 13 had at one time. All settings are shown in order to illustrate how they changed in time.

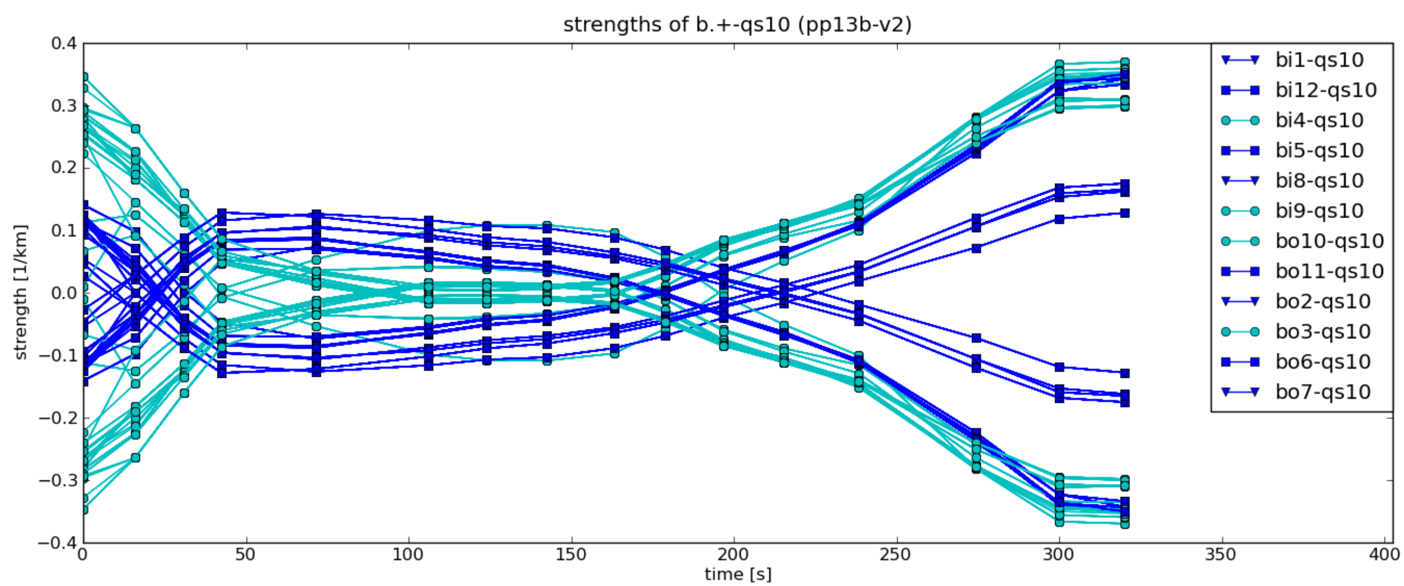
- The first 2 pictures show the reduction of global skew quad strengths in CuAu12-v1 ramp when local skew quad settings were changed.
- The next 4 pictures compare the global skew quad settings of pp12b-v2 and pp13b-v2 ramps for blue and yellow rings. The different local skew quad settings in those ramps led to the reduction of global skew quad strengths. Global skew quad strengths in pp13b-v2 ramp show increase when bi8-qs3 PS was replaced.
- The last 2 pictures show that global skew quad settings in the blue ring in pp13e-v4 ramp were abnormally large. For pp13e-v4 ramp skew quad magnets had to be paired into families differently

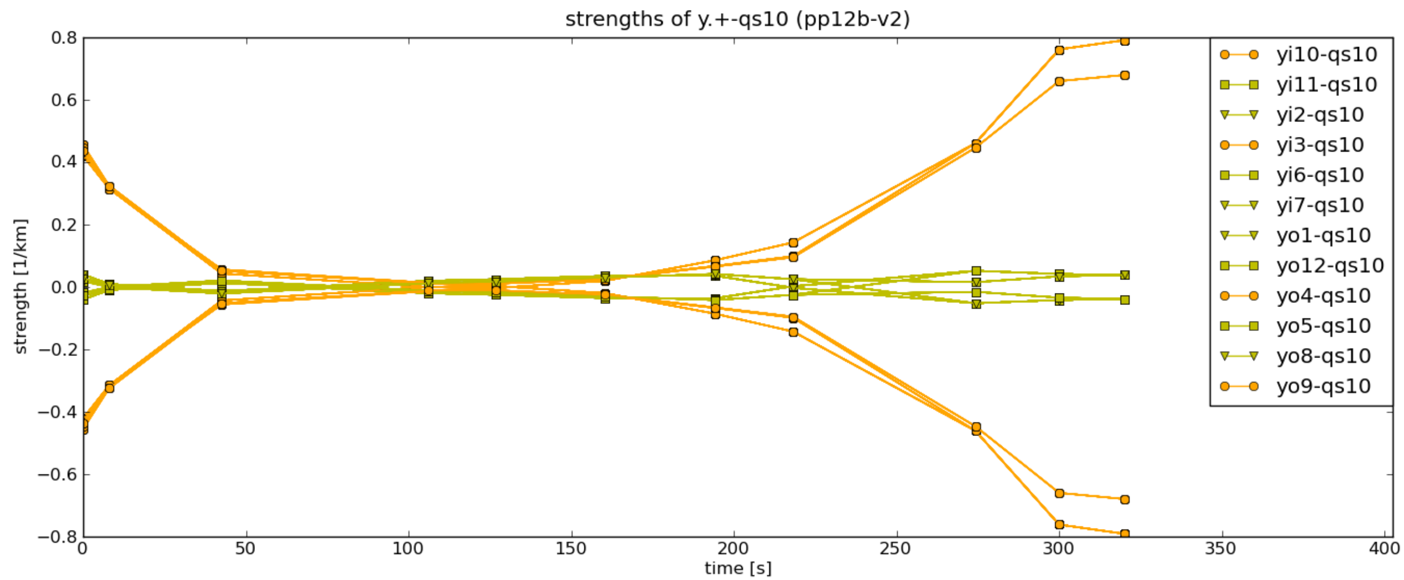
due to different range of goal tunes: in pp13e-v4 ramp integer part of horizontal and vertical tunes in blue ring were 27 and 29 respectively, while for other ramps integer part of horizontal and vertical tunes were 28 and 29 respectively.

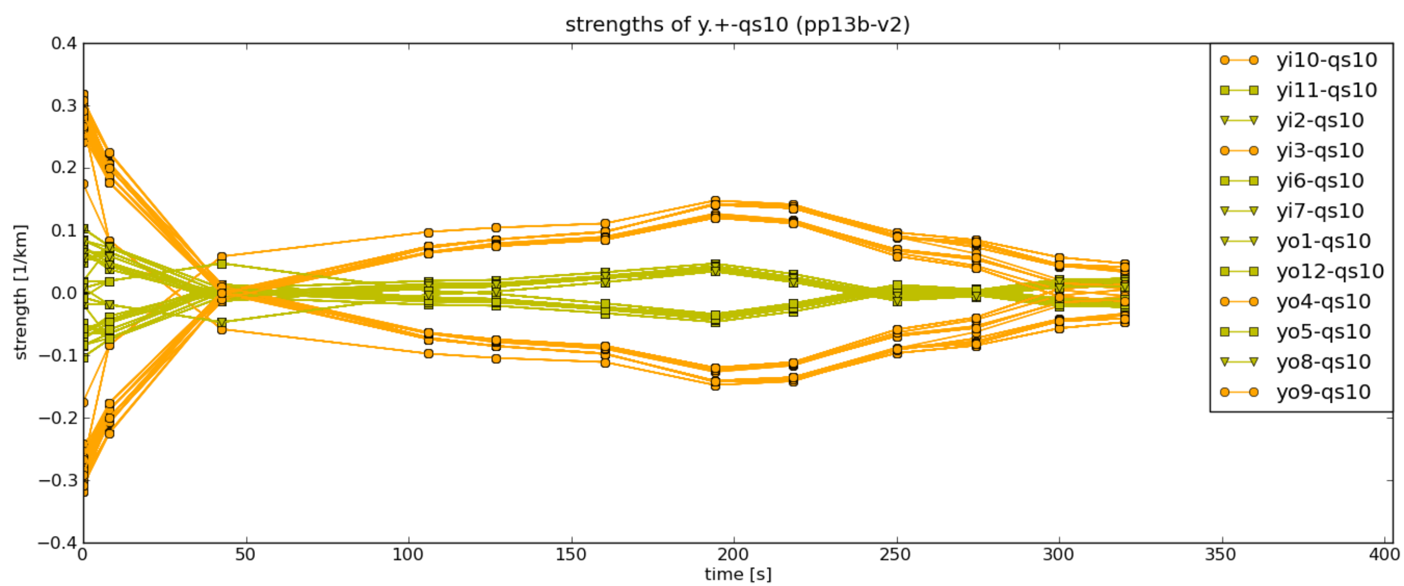

strengths of b.+-qs10 (CuAu12-v1)
strength [1/km]
time [s]
1.0
0.5
0.0
−0.5
−1.0
0
50
100
150
200
250
300
350
400
bi1-qs10
bi12-qs10
bi4-qs10
bi5-qs10
bi8-qs10
bi9-qs10
bo10-qs10
bo11-qs10
bo2-qs10
bo3-qs10
bo6-qs10
bo7-qs10

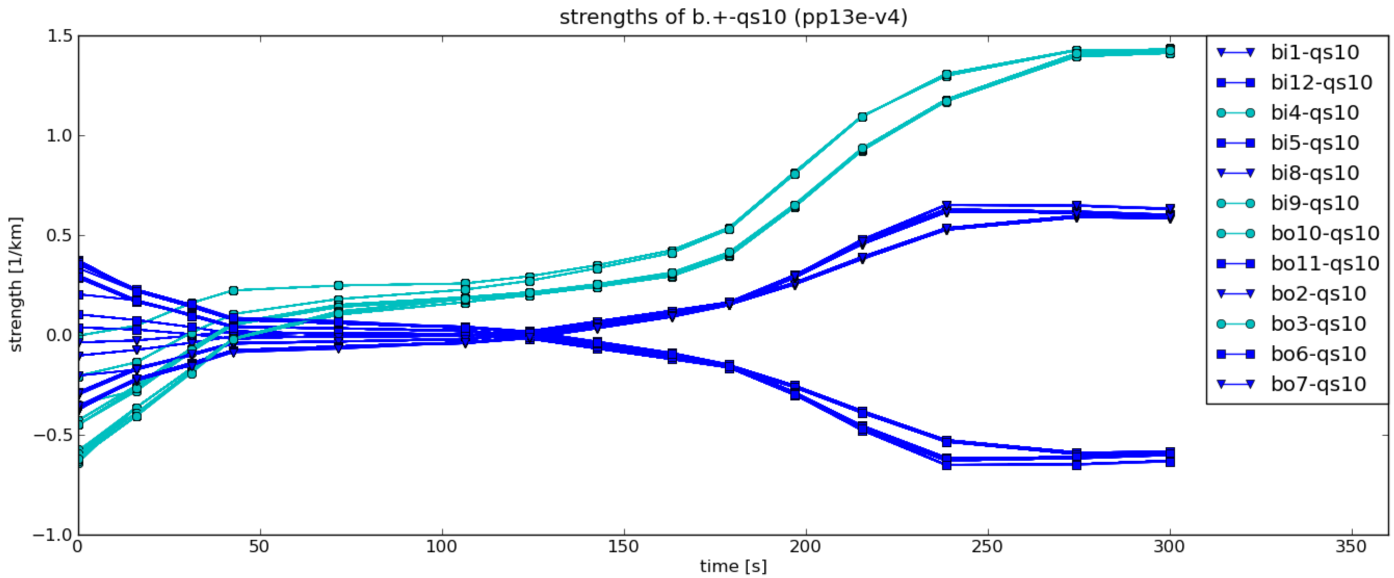

strengths of y.+-qs10 (CuAu12-v1)
strength [1/km]
time [s]
0.6
0.4
0.2
0.0
−0.2
−0.4
−0.6
0
50
100
150
200
250
300
350
400
yi10-qs10
yi11-qs10
yi2-qs10
yi3-qs10
yi6-qs10
yi7-qs10
yo1-qs10
yo12-qs10
yo4-qs10
yo5-qs10
yo8-qs10
yo9-qs10


strengths of b.+-qs10 (pp12b-v2)
strength [1/km]
time [s]
bi1-qs10
bi12-qs10
bi4-qs10
bi5-qs10
bi8-qs10
bi9-qs10
bo10-qs10
bo11-qs10
bo2-qs10
bo3-qs10
bo6-qs10
bo7-qs10

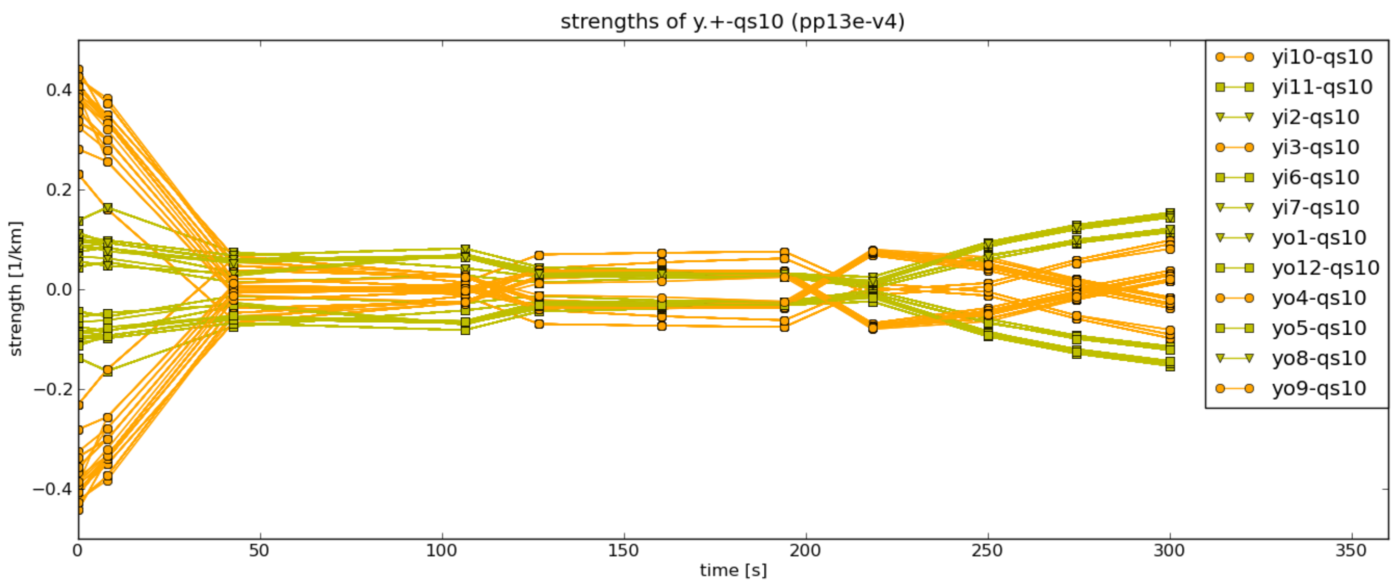

strengths of b.+-qs10 (pp13b-v2)
strength [1/km]
time [s]
bi1-qs10
bi12-qs10
bi4-qs10
bi5-qs10
bi8-qs10
bi9-qs10
bo10-qs10
bo11-qs10
bo2-qs10
bo3-qs10
bo6-qs10
bo7-qs10


strengths of y.+-qs10 (pp12b-v2)
strength [1/km]
time [s]
yi10-qs10
yi11-qs10
yi2-qs10
yi3-qs10
yi6-qs10
yi7-qs10
yo1-qs10
yo12-qs10
yo4-qs10
yo5-qs10
yo8-qs10
yo9-qs10


strengths of y.+-qs10 (pp13b-v2)
strength [1/km]
time [s]
yi10-qs10
yi11-qs10
yi2-qs10
yi3-qs10
yi6-qs10
yi7-qs10
yo1-qs10
yo12-qs10
yo4-qs10
yo5-qs10
yo8-qs10
yo9-qs10

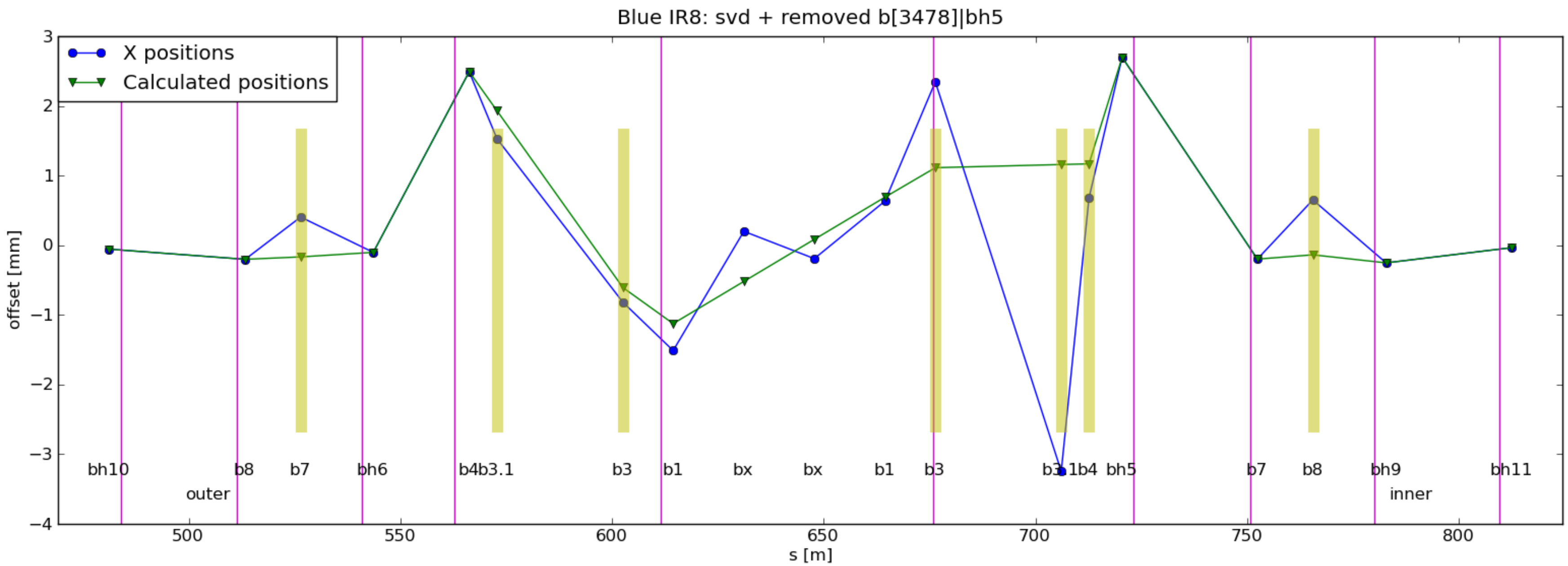


strengths of b.+-qs10 (pp13e-v4)
strength [1/km]
time [s]
bi1-qs10
bi12-qs10
bi4-qs10
bi5-qs10
bi8-qs10
bi9-qs10
bo10-qs10
bo11-qs10
bo2-qs10
bo3-qs10
bo6-qs10
bo7-qs10



strengths of y.+-qs10 (pp13e-v4)
strength [1/km]
time [s]
yi10-qs10
yi11-qs10
yi2-qs10
yi3-qs10
yi6-qs10
yi7-qs10
yo1-qs10
yo12-qs10
yo4-qs10
yo5-qs10
yo8-qs10
yo9-qs10

Store orbit corrections



In the figure above the blue line is the measured horizontal orbit at IP8, the green line is the calculated orbit, the purple lines indicate the positions of dipole correctors, the labels show the positions of BPMs and yellow bars mark the BPMs which are excluded from the

correction. Calculated orbits are the orbits calculated from the strengths obtained by applying SVD correction algorithm to the measured orbits. At locations where calculated and measured positions are equal, SVD correction, if applied, would correct the orbit. At locations where calculated and measured positions are not equal, SVD correction can not correct the orbit.
This picture shows that positions of b7/b8, b3/b4 and b3/b4/b5 BPMs are dependent. The next picture shows what happens if dependent BPMs are used in orbit correction: the achieved positions are combinations of the desired positions at those BPMs (resulting in the drift of the positions by ~1mm during single store) and what happens if they are excluded, i.e. beam positions at those BPMs become stable (vary by ~100 um).

b4 BPMs are near rotators and in order to keep orbit through rotators constant, we must control orbit at b4.

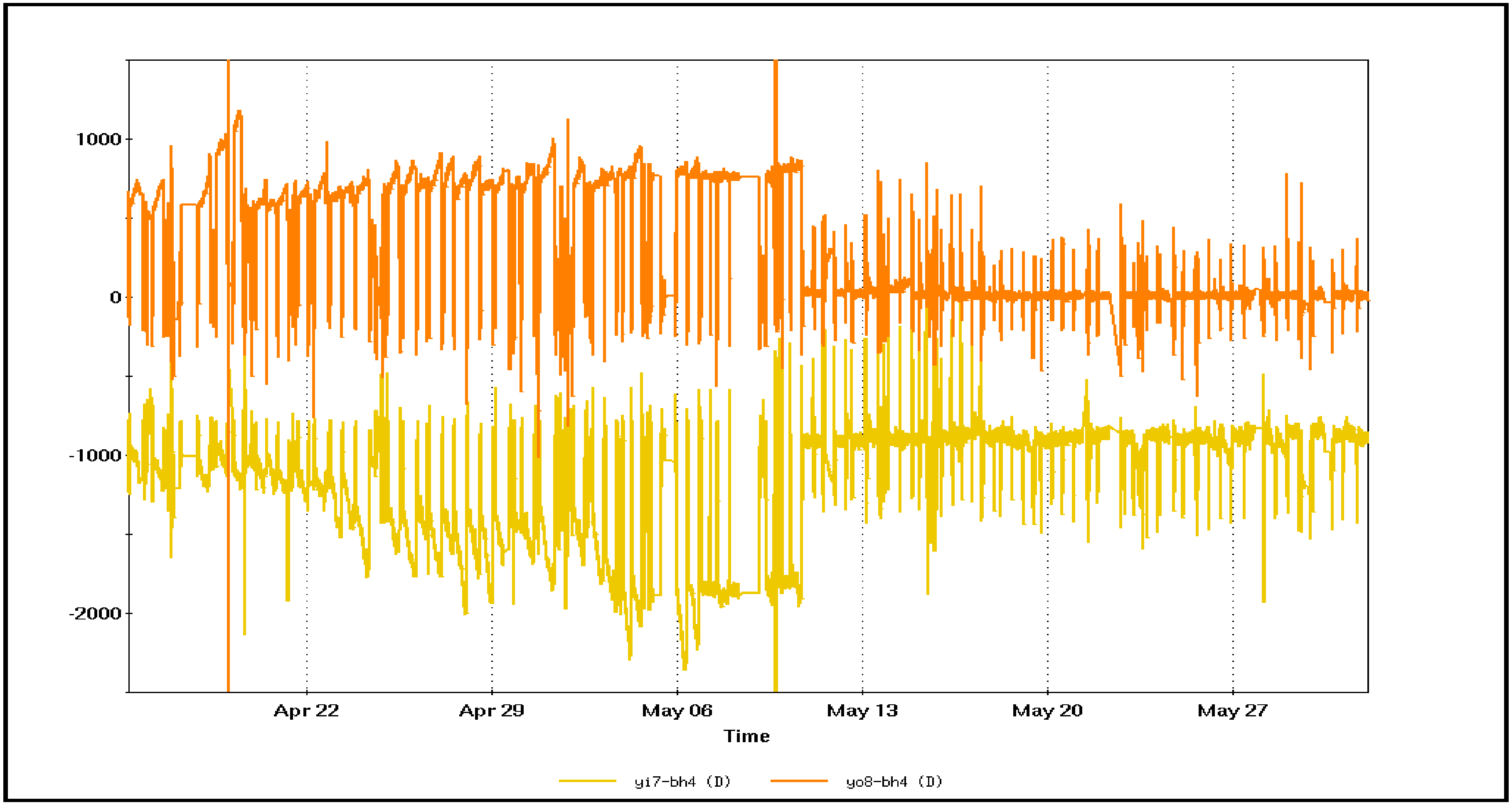
During early part of Run 13, beam positions at all BPMs between dipole correctors used for collision optimizations were “captured”, i.e. they were used as goal positions for subsequent orbit corrections. That was a mistake. Only b1/dx BPMs on both sides of IP should have been used (because only orbits between those BPMs affect collision rates). By using other correctors, beam positions at b4/b5 BPMs can be changed without affecting collision rates.

For the next run:

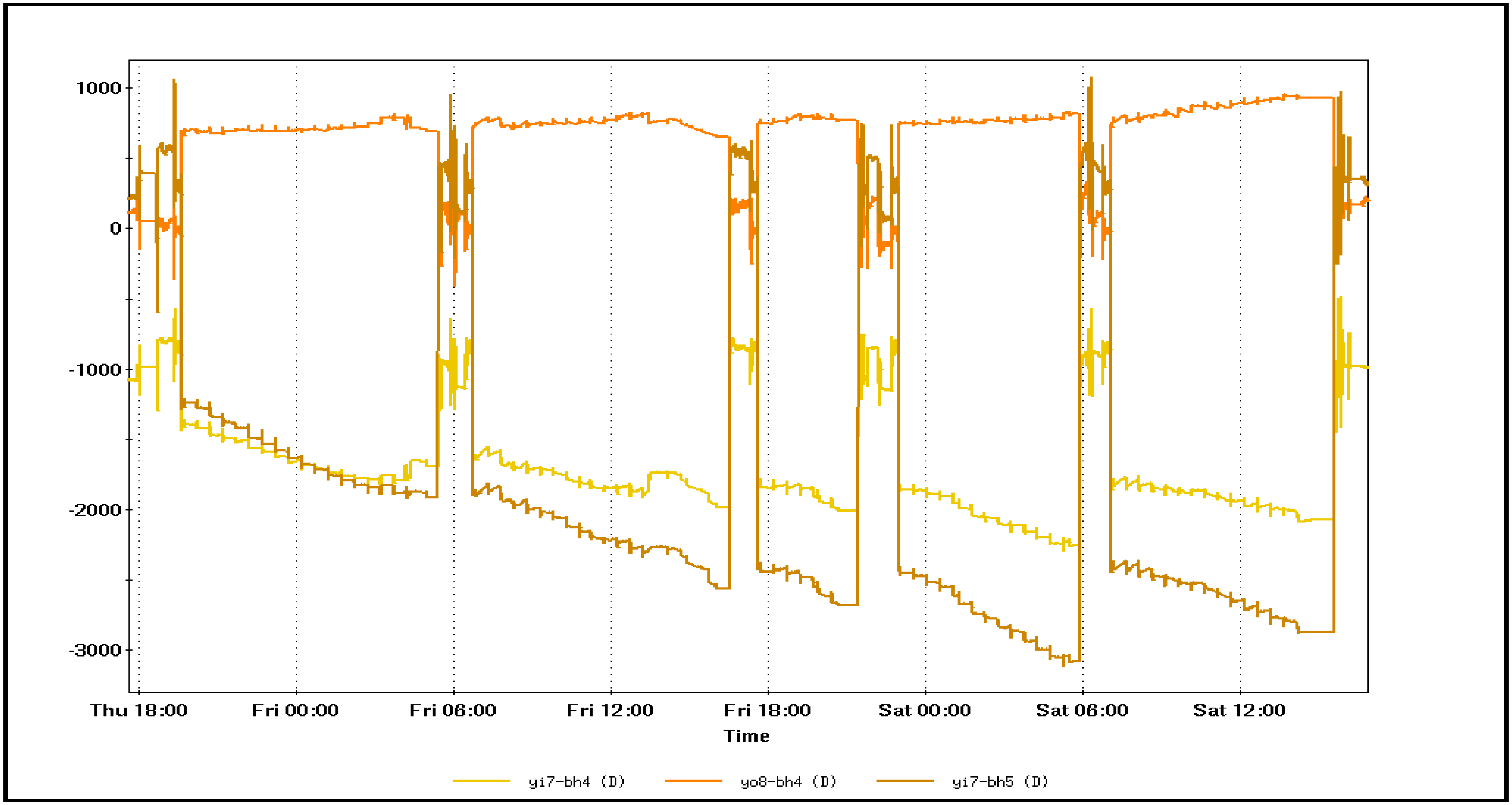
- All dependent BPMs should be excluded from corrections (if dependent BPMs are used, their positions should be made consistent).
- Goal positions for b4 and b5 BPMs at IP6 and IP8 should be 0.

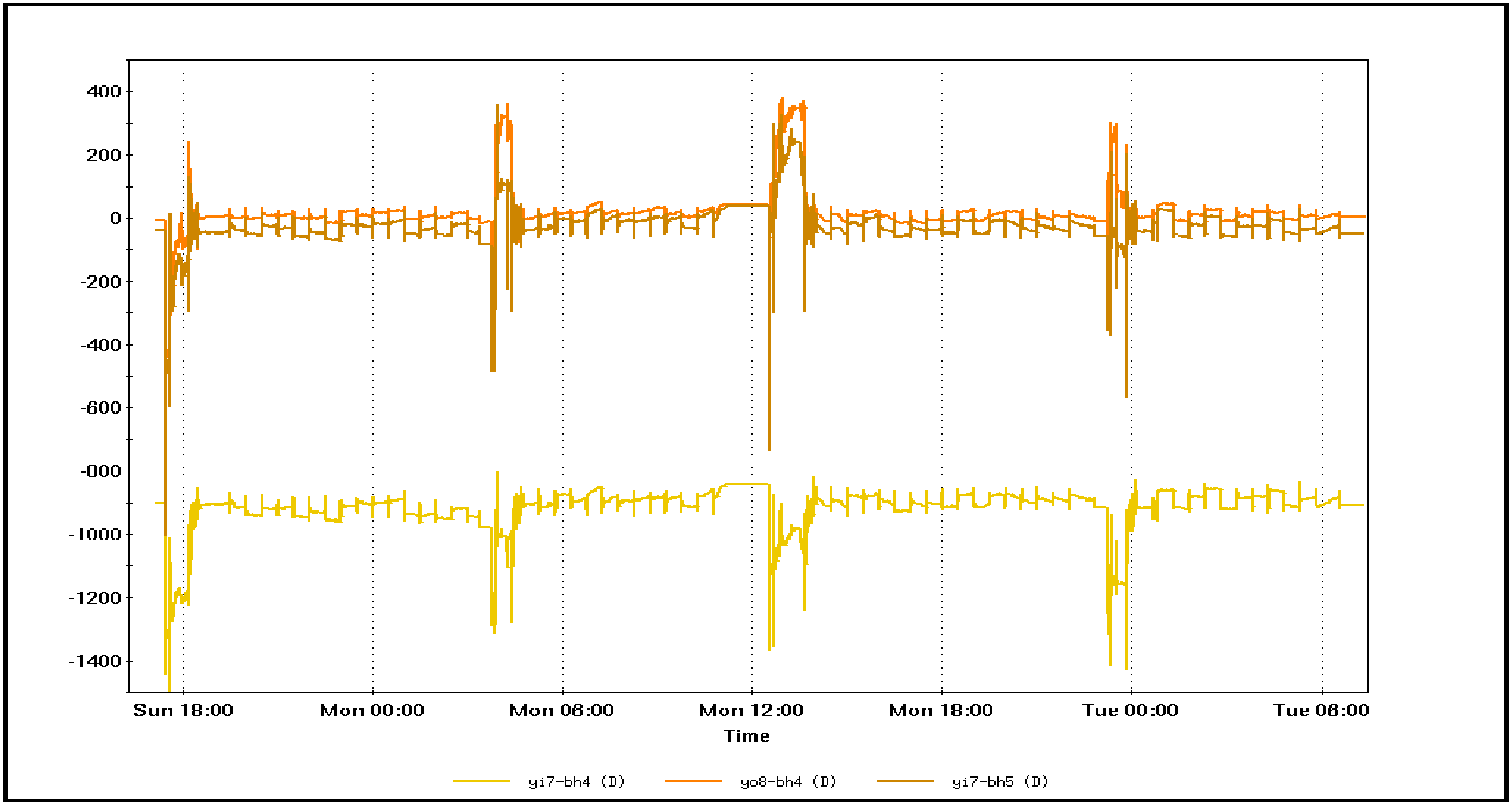
After this is done, currents in rotators and snakes should be adjusted.

Another problem during the run was that some goal orbits were too different from previous goal orbits. For the next run we should ensure that goal orbits are more similar.



1000
0
-1000
-2000
Apr 22
Apr 29
May 06
May 13
May 20
May 27
Time
yi7-bh4 (D)
yo8-bh4 (D)


1000
0
-1000
-2000
-3000
Thu 18:00
Fri 00:00
Fri 06:00
Fri 12:00
Fri 18:00
Sat 00:00
Sat 06:00
Sat 12:00
Time
yi7-bh4 (D)
yo8-bh4 (D)
yi7-bh5 (D)


400
200
0
-200
-400
-600
-800
-1000
-1200
-1400
Sun 18:00
Mon 00:00
Mon 06:00
Mon 12:00
Mon 18:00
Tue 00:00
Tue 06:00
Time
yi7-bh4 (D)
yo8-bh4 (D)
yi7-bh5 (D)