BBQ StartUp and Run07

Al Della Penna

Outline

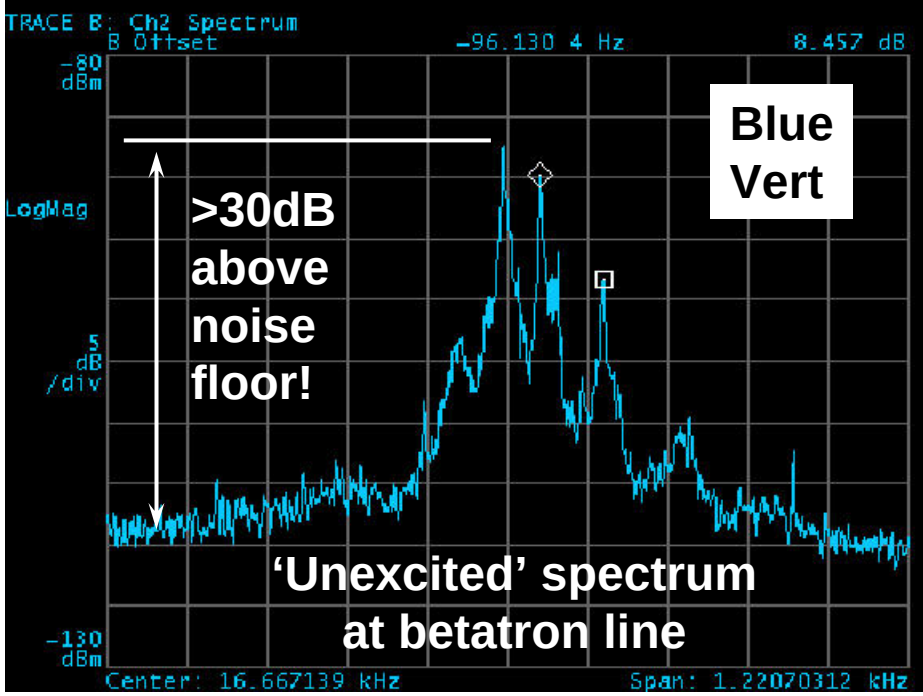
- The RHIC Run 7 commissioning experience
  - what could possibly go wrong???
- Changes for Run 8
- The plan for Run 8

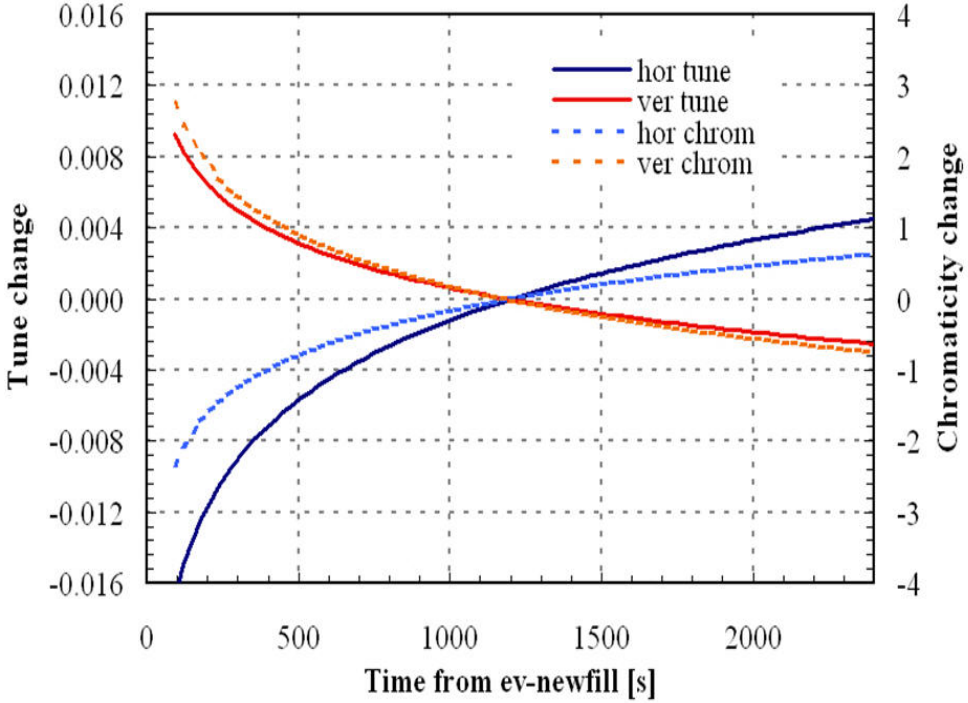
During Run 7 BBQ worked very well, despite many issues

0. **MAINS HARMONICS REMAIN THE PRIMARY OBSTACLE**
1. Anomalous beam transfer function – cause is not understood (next slide)
2. Tune, coupling, and chromaticity drifts due to persistent currents at injection (also next slide)
3. ‘Tune scalloping’
4. Mains harmonics plus tune scalloping gives a very tight ‘box’
5. Effect of chromaticity and tune scalloping on tune feedback
6. Large noise introduced when magnet loops were closed – again, from anomalous BTF? Kills chrom feedback at injection
7. A variety of other problems
   - IPM, Artus, injection damper, button monitor all turning themselves on at inappropriate times
   - 5 FEC VME crate would hang frequently
   - ‘cache corruption’ problem would break feedback ramps

Anomalous beam response at injection

- tunes separated and well decoupled
- not power line, synchrotron freqs
- similar in all 4 planes
- serious obstacle to acquiring lock
- serious contributor to 'noise'
- not seen with 245MHz PLL
- disappeared with start of ramp
- not understood – speculation on power supply regulation/phase shift at low current





This difficulty with acquiring lock was aggravated by persistent current decay, causing large and fast drifts at injection

- tune ~.02 (tunes cross!!!)
- coupling - full coupling
- chromaticity ~3 units

These drifts are compensated for Run 8?

The consequence of the previous slide - procedure to lock the tune trackers in the presence of multiple peaks and persistent current decay was ~40 steps!

1. take BTFs to determine where the optimum line is for locking
2. reduce proportional gains (can't acquire initial lock with optimal gains)
3. set the search windows so that H cannot lock on V, and V cannot lock on H
4. turn on the H kicker, acquire a lock. This inevitably is not a lock on the line you want, but rather a lock on the first line the BBQ comes to.
5. nudge the search window to push the BBQ onto the correct line. This often requires repeated nudges.
6. tweak the phase to optimize response amplitude - because of many peaks BTF app does not reliable give optimum phase information, has to be done manually
7. turn up proportional gain
8. adjust desired amplitude for kicker feedback
9. open the search windows
10. turn on kicker feedbacks
11. repeat steps 1-10 for vertical. If we are running both beams repeat this whole thing for the other ring
12. tell shift leader BBQ is ready

‘Tune Scalloping’ with TF loops open

Ramp 8245

- BBQ very precisely drives a slice up out of the tune distribution
- tune shifts as amplitude increases (sextupoles dominate? Large octupole for γ_t?) the slice moves off resonance, depopulates
- BBQ falls off that slice, locks back in the center of the distribution
- the process repeats

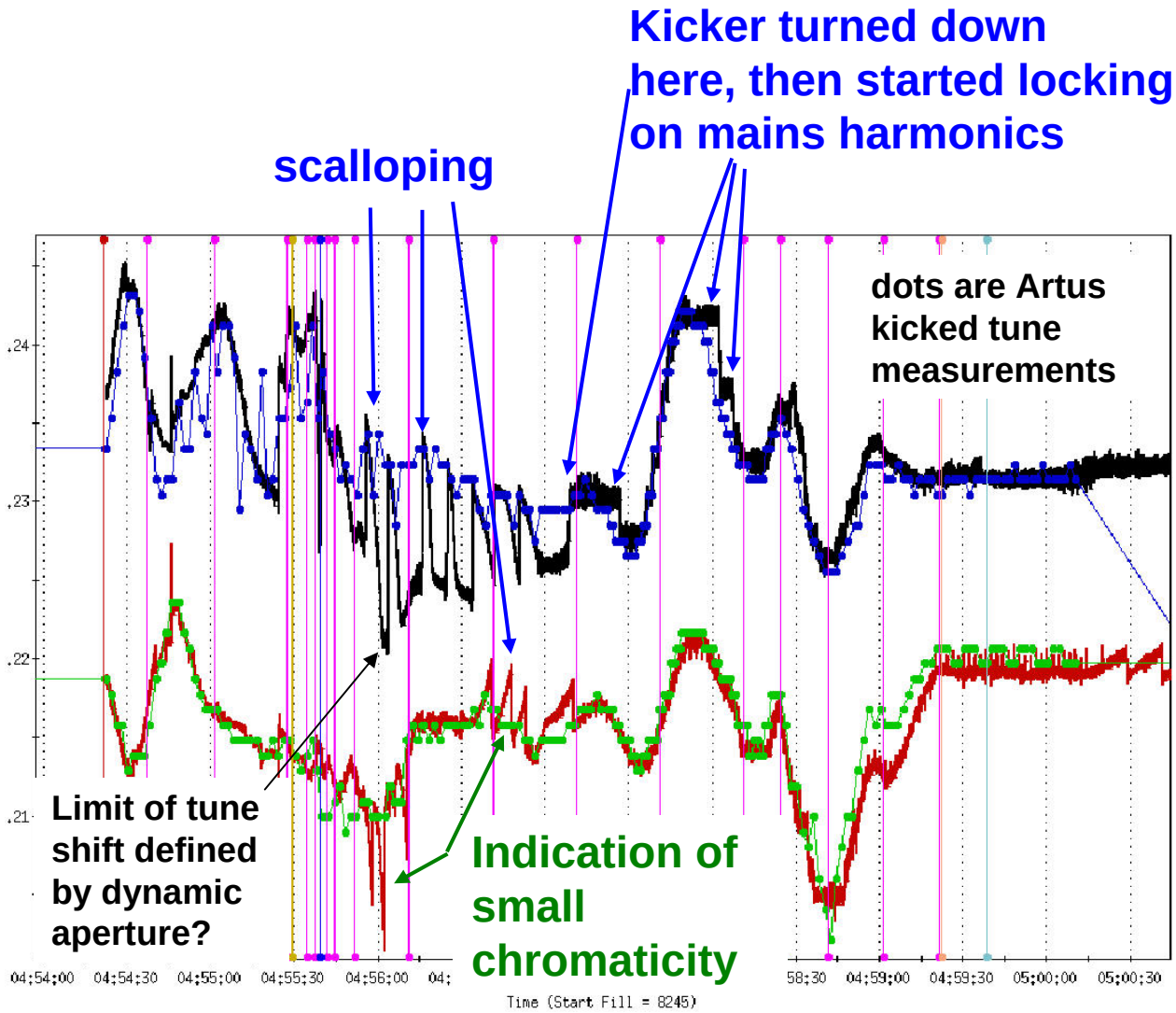
Contributing factors

- large kicker excitation
- large loop gains
- small chromaticity

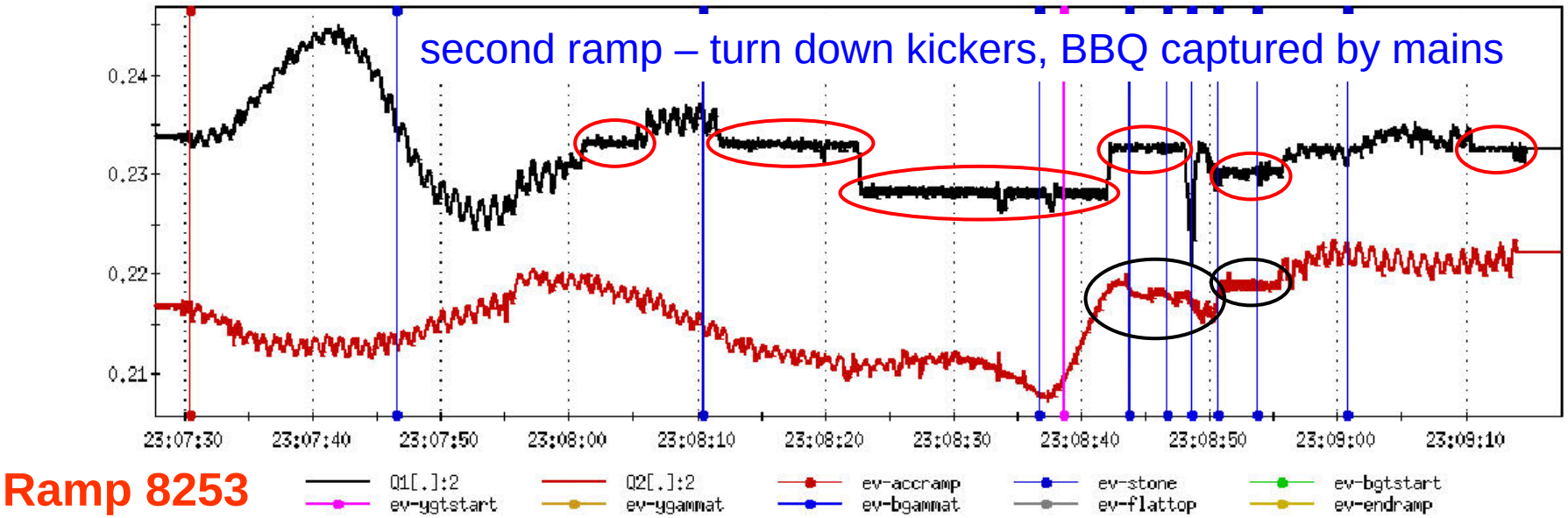
Makes for a tight ‘box’

- need large kicker excitation because of mains harmonics
- need large loop gains for reliable tracking of fast tune changes
- chromaticity feedback not yet implemented – chrom control is not particularly good

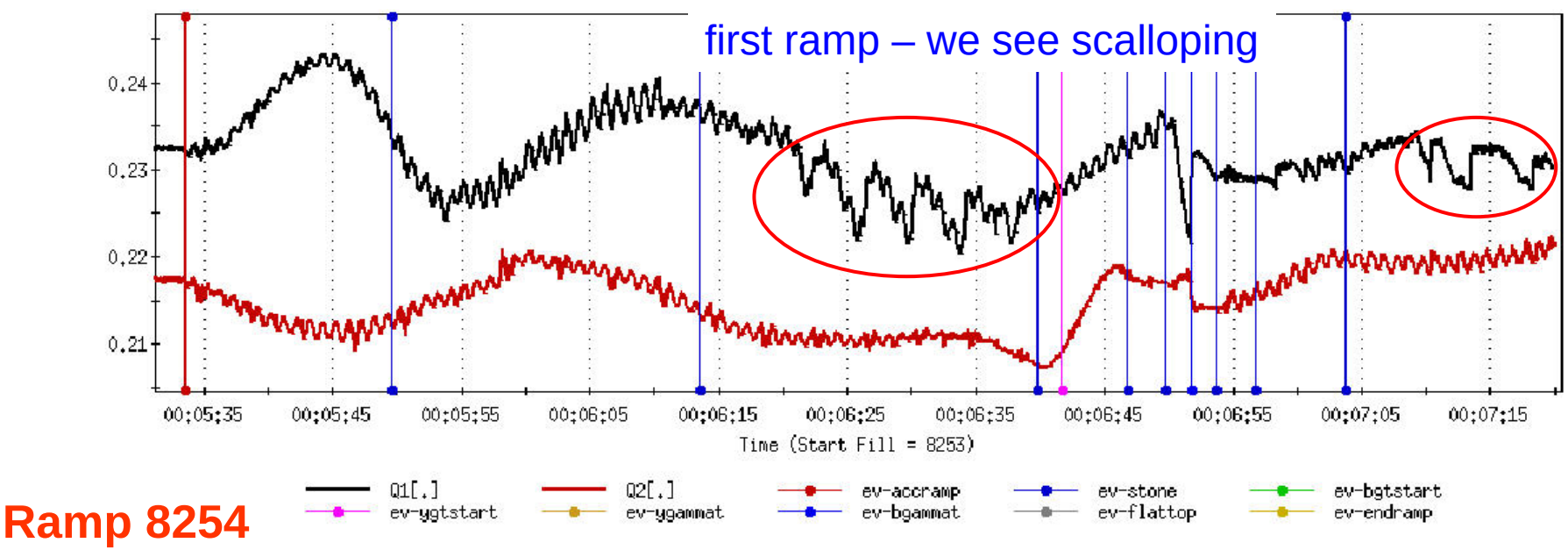
A delicate balance to tune the tracking



Three successive wiggles ramps during beam commissioning

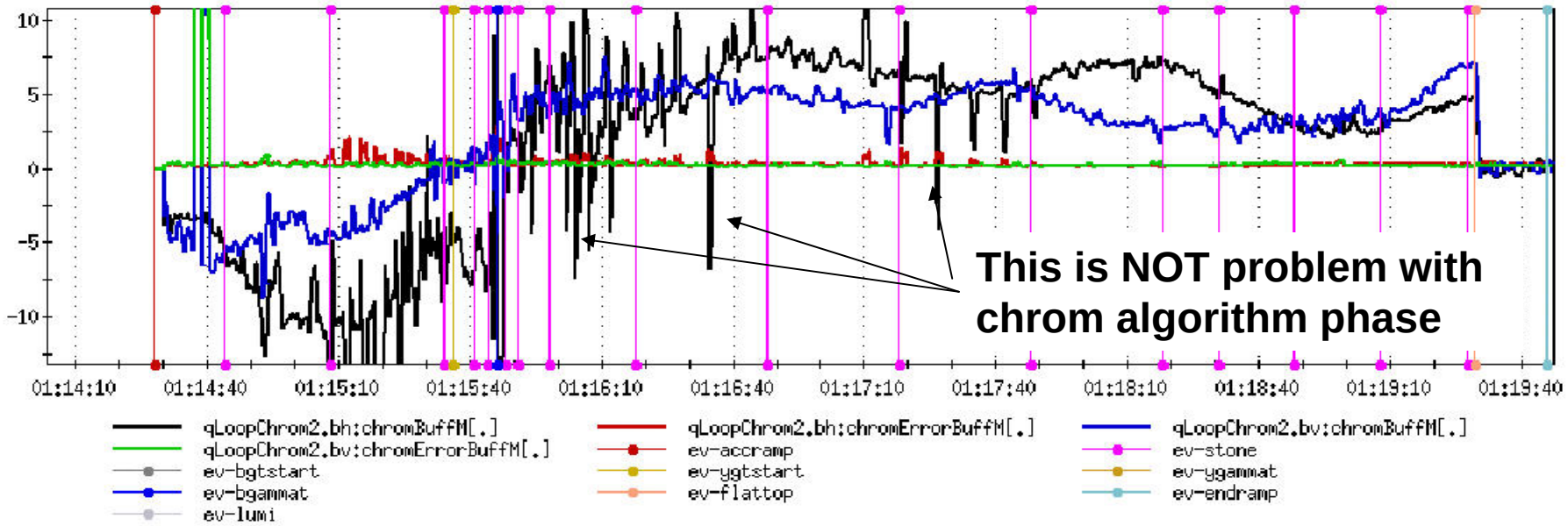


Ramp 8253

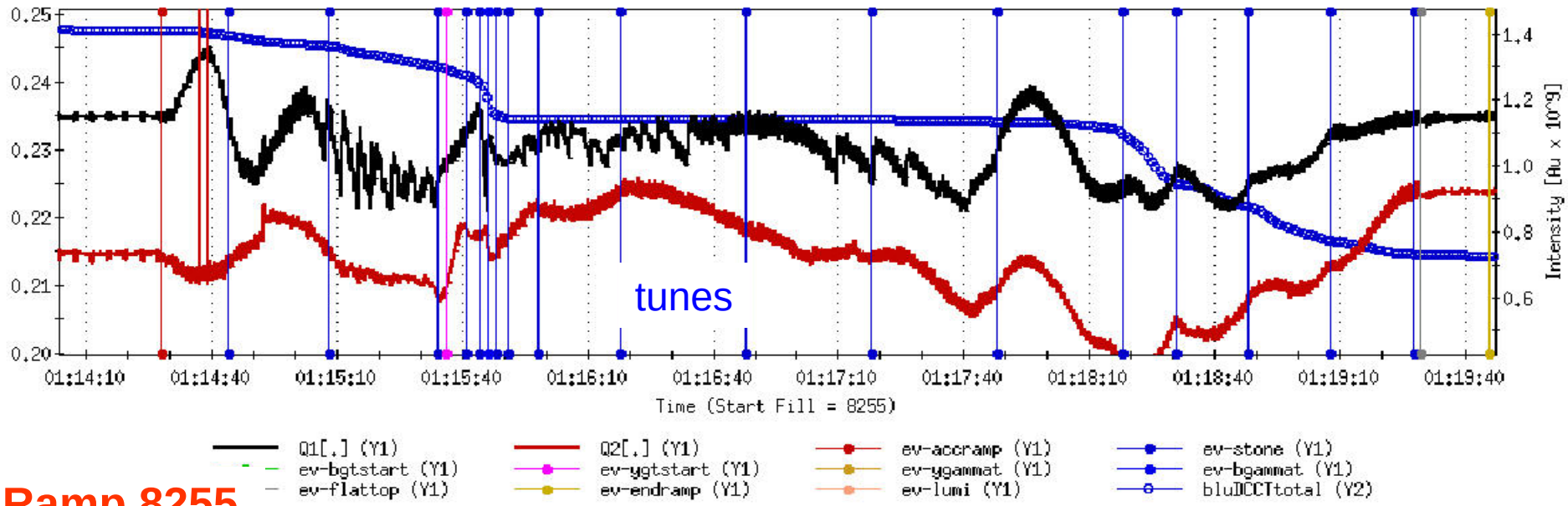


Ramp 8254

Third ramp, and effect of scalloping on chrom measurement



third ramp – turn kickers back up, again see scalloping



Ramp 8255

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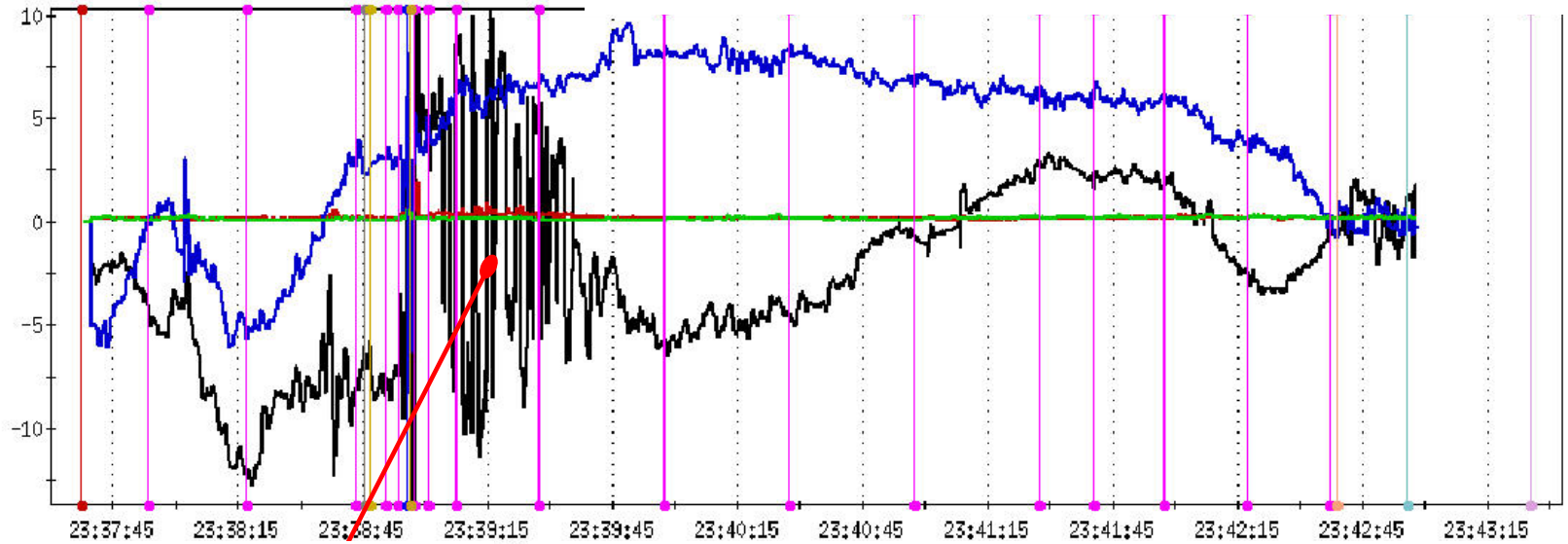
3. 'Tune scalloping'
4. Mains harmonics plus tune scalloping gives a very tight 'box'
5. **Effect of chrom and scalloping on tune/chrom measurement/feedback**
6. Large noise introduced when magnet loops were closed – again, from anomalous BTF? Kills chrom feedback at injection
7. A variety of other problems
   - IPM, Artus, injection damper, button monitor all turning themselves on at inappropriate times
   - 5 FEC VME crate would hang frequently
   - 'cache corruption' problem would break feedback ramps

Sat Mar 10 23:07:18 - Sat Mar 10 23:46:39

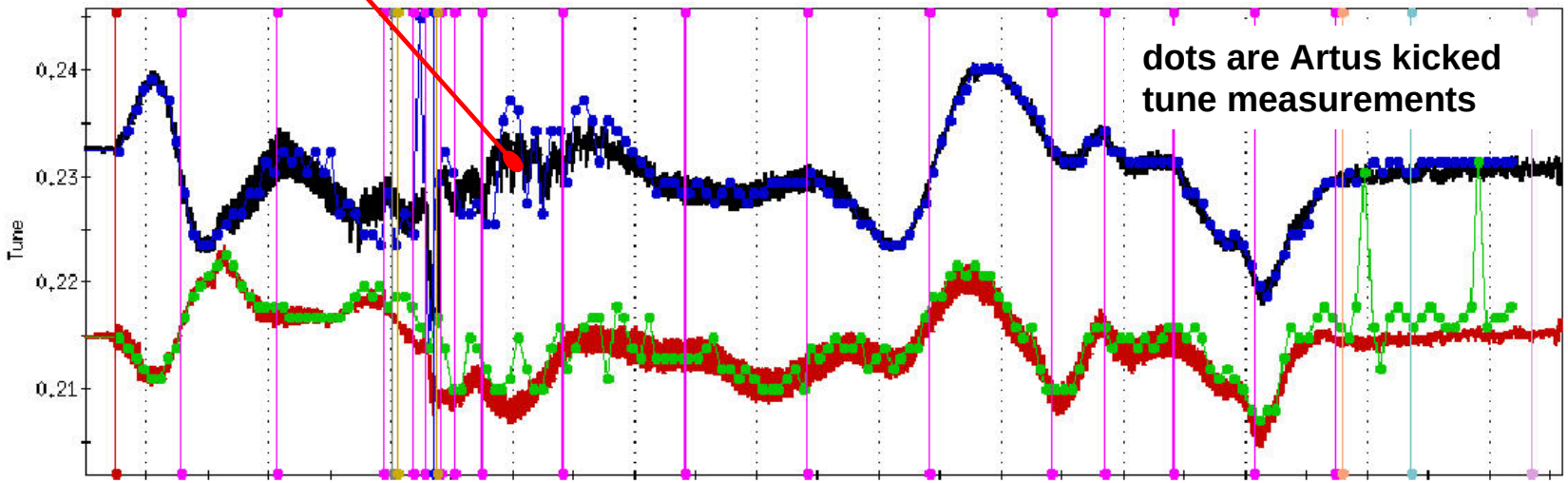
Window Event Analysis

Saturday – ramp 8211 (the first wiggles ramp)
Chromaticities and tunes

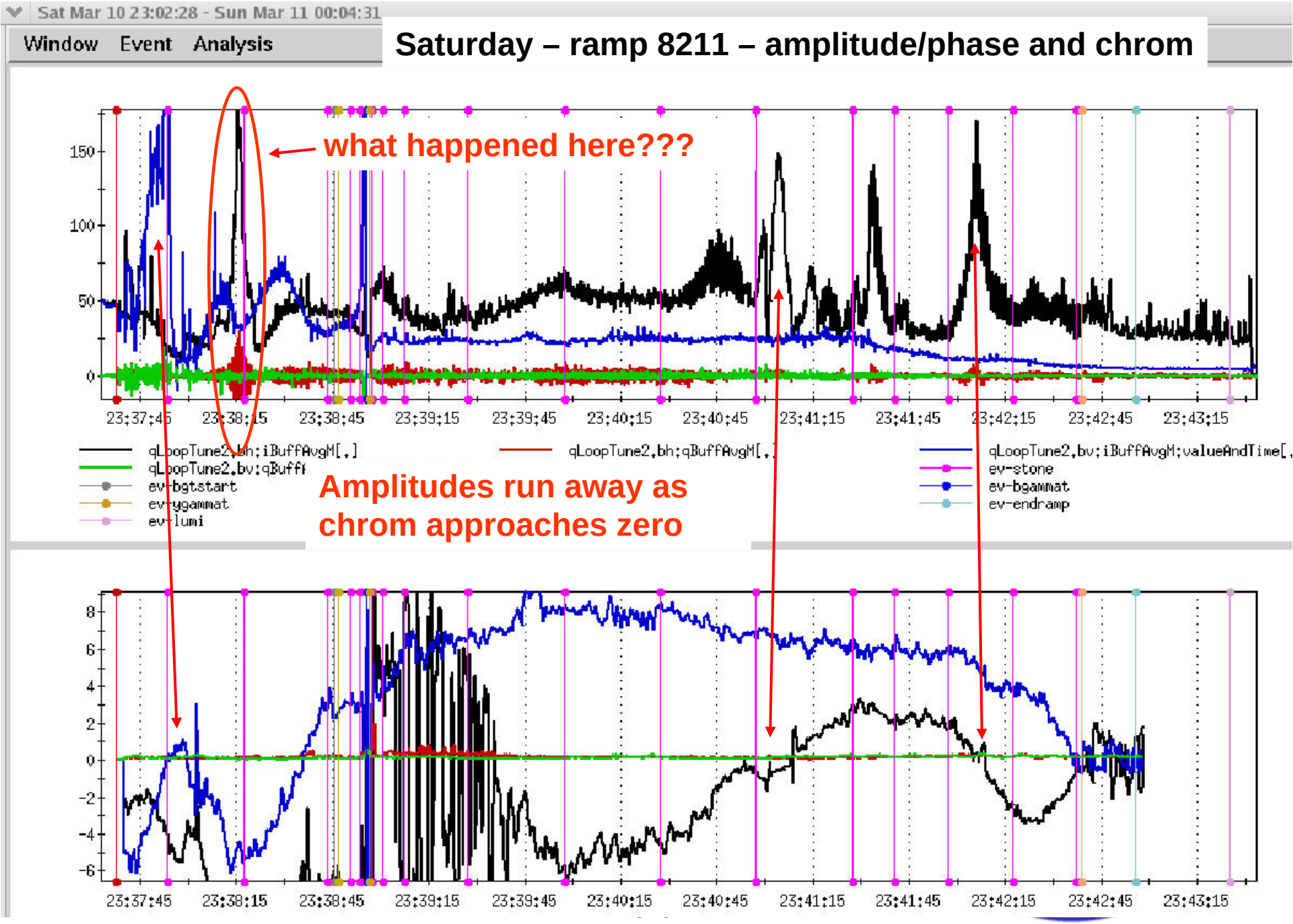


Chrom measurement affected by tune scalloping here

The first wiggles ramp came 10 ramps after the first successful TF ramp. Chrom was not corrected until the following Wednesday evening



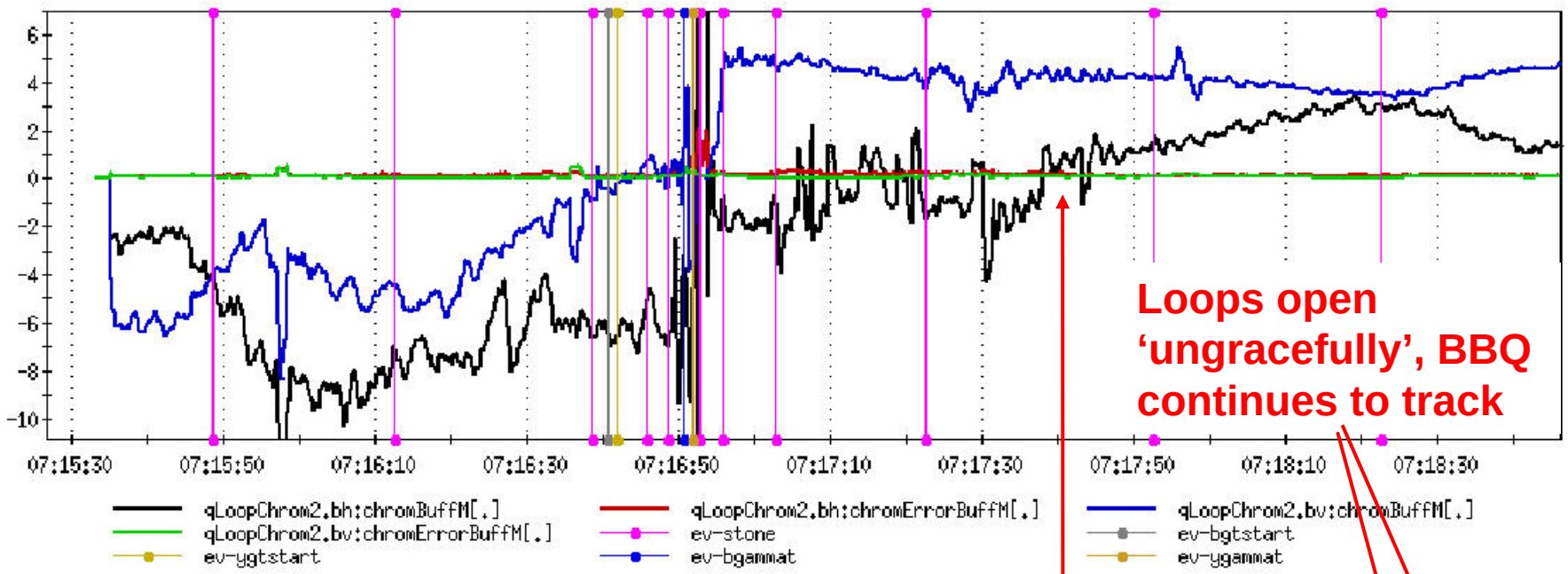
Saturday – ramp 8211 – amplitude/phase and chrom



Sun Mar 11 07:15:33 - Mon Mar 12 04:37:48

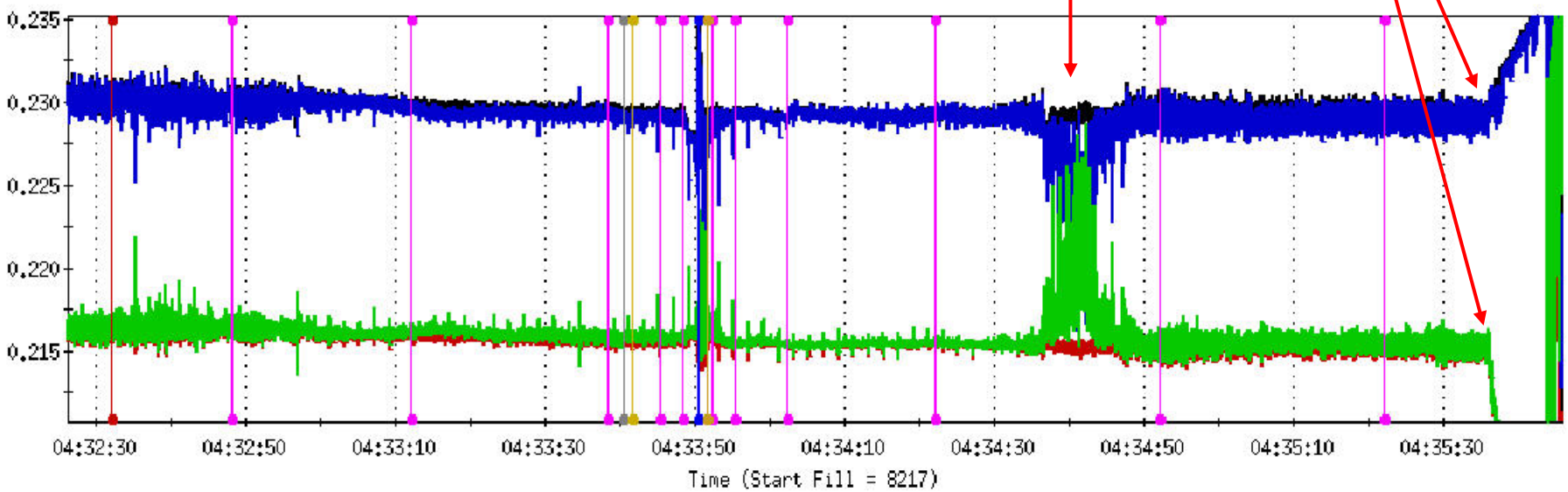
Window Event Analysis

Effect of chrom on Tune and Coupling Feedback – ramp 8217



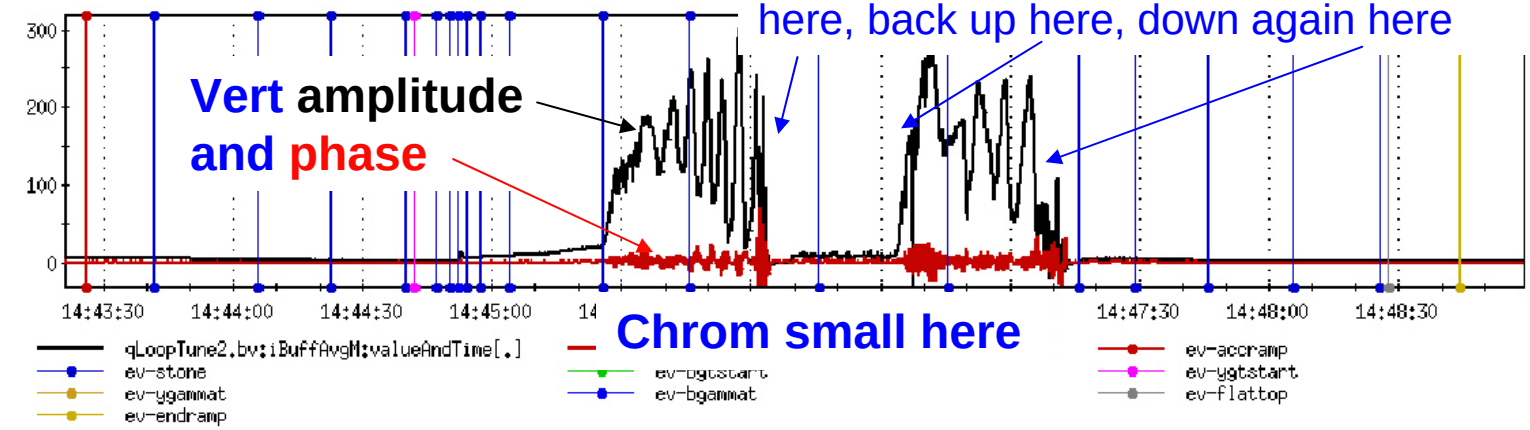
Loops open 'ungracefully', BBQ continues to track

Effect of chrom on TF

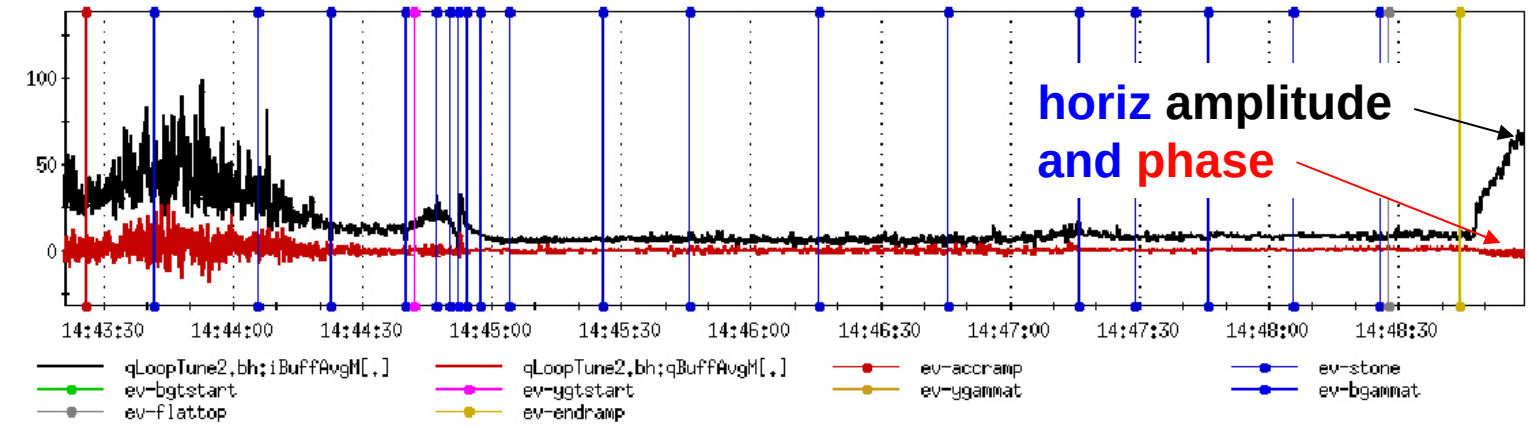


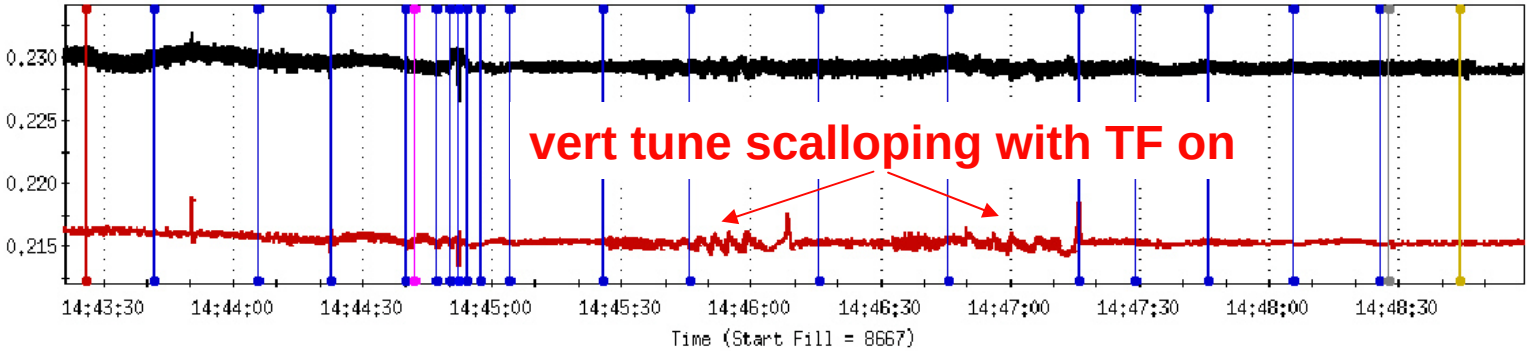
Scalloping with TF loops closed

Loop gains and kicker excitation turned down here, back up here, down again here



Ramp 8667
IBS lattice

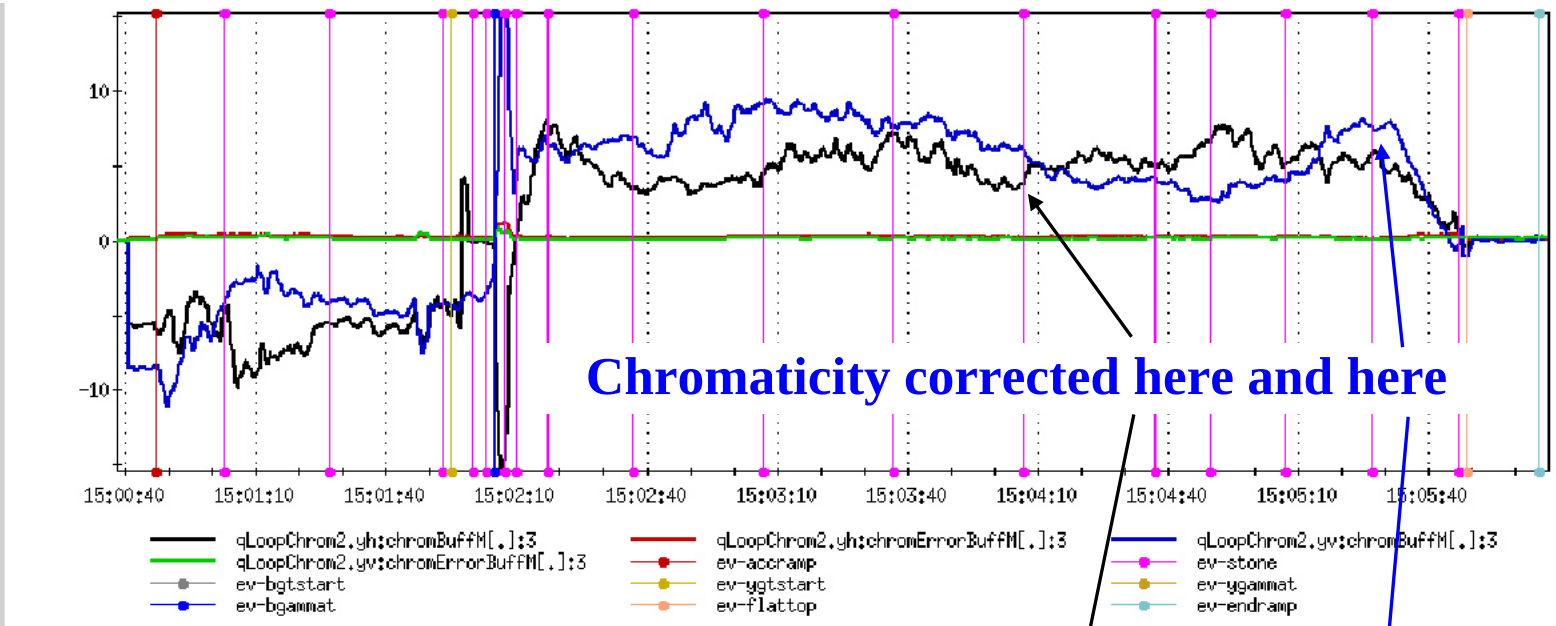




H tune

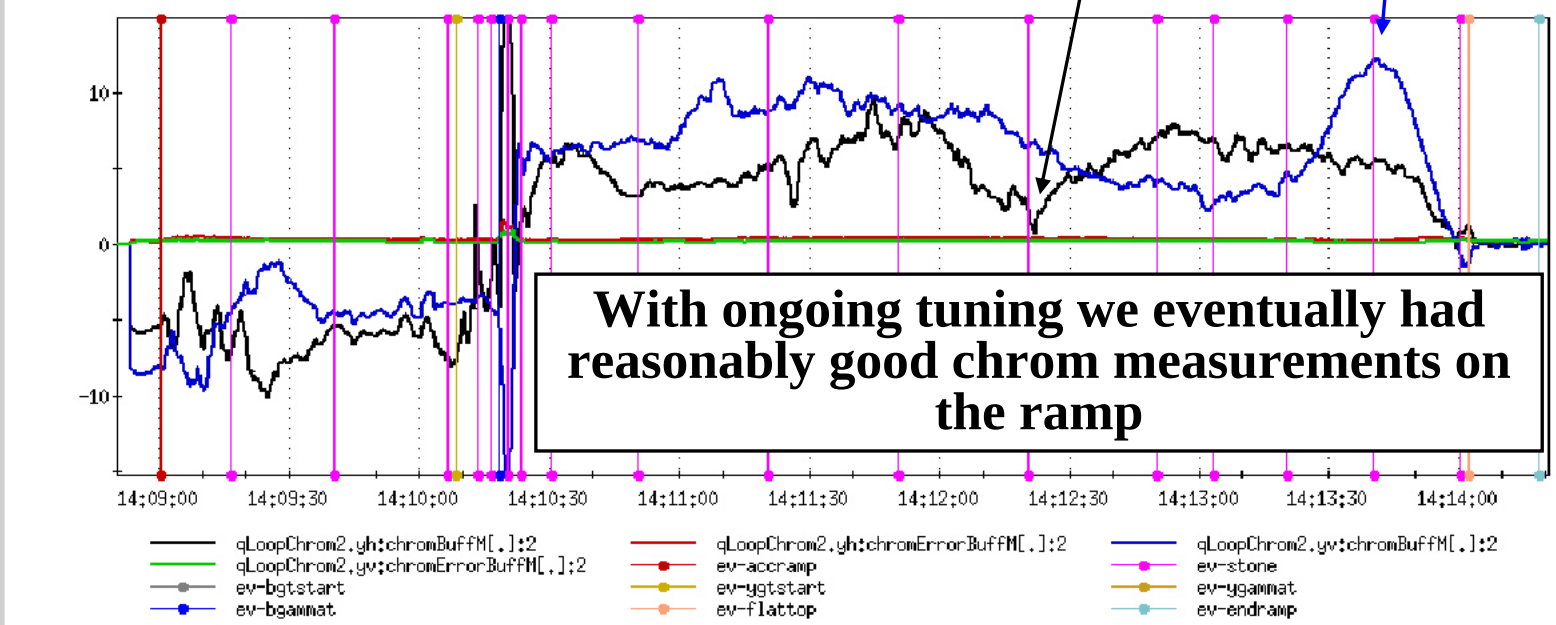
V tune

Chromaticity via radial modulation with BBQ in RHIC Run 7
two successive ramps for correcting and measuring result



second ramp

Chromaticity corrected here and here



first ramp

With ongoing tuning we eventually had reasonably good chrom measurements on the ramp

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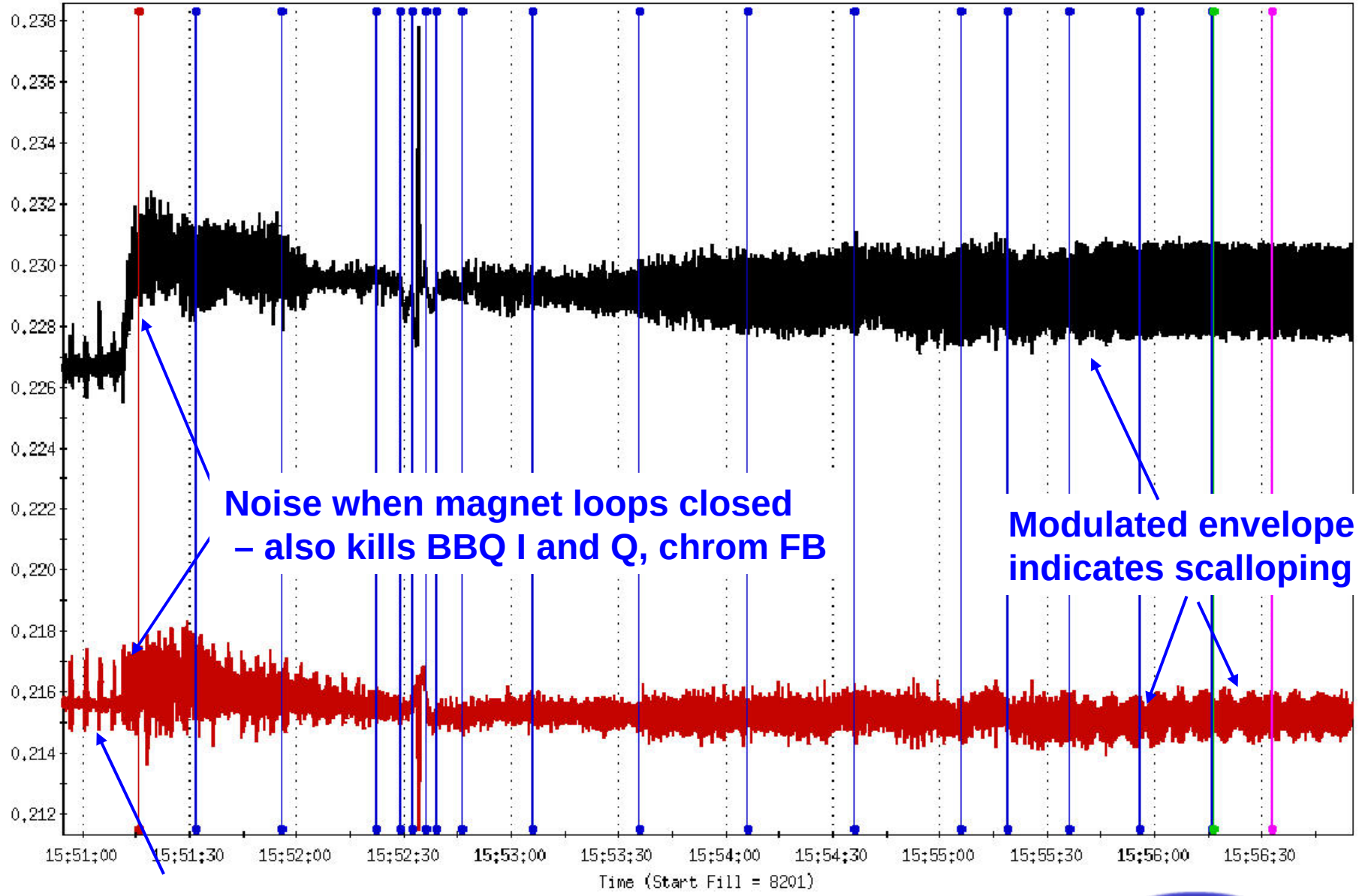
ramp 8201 – First TF ramp



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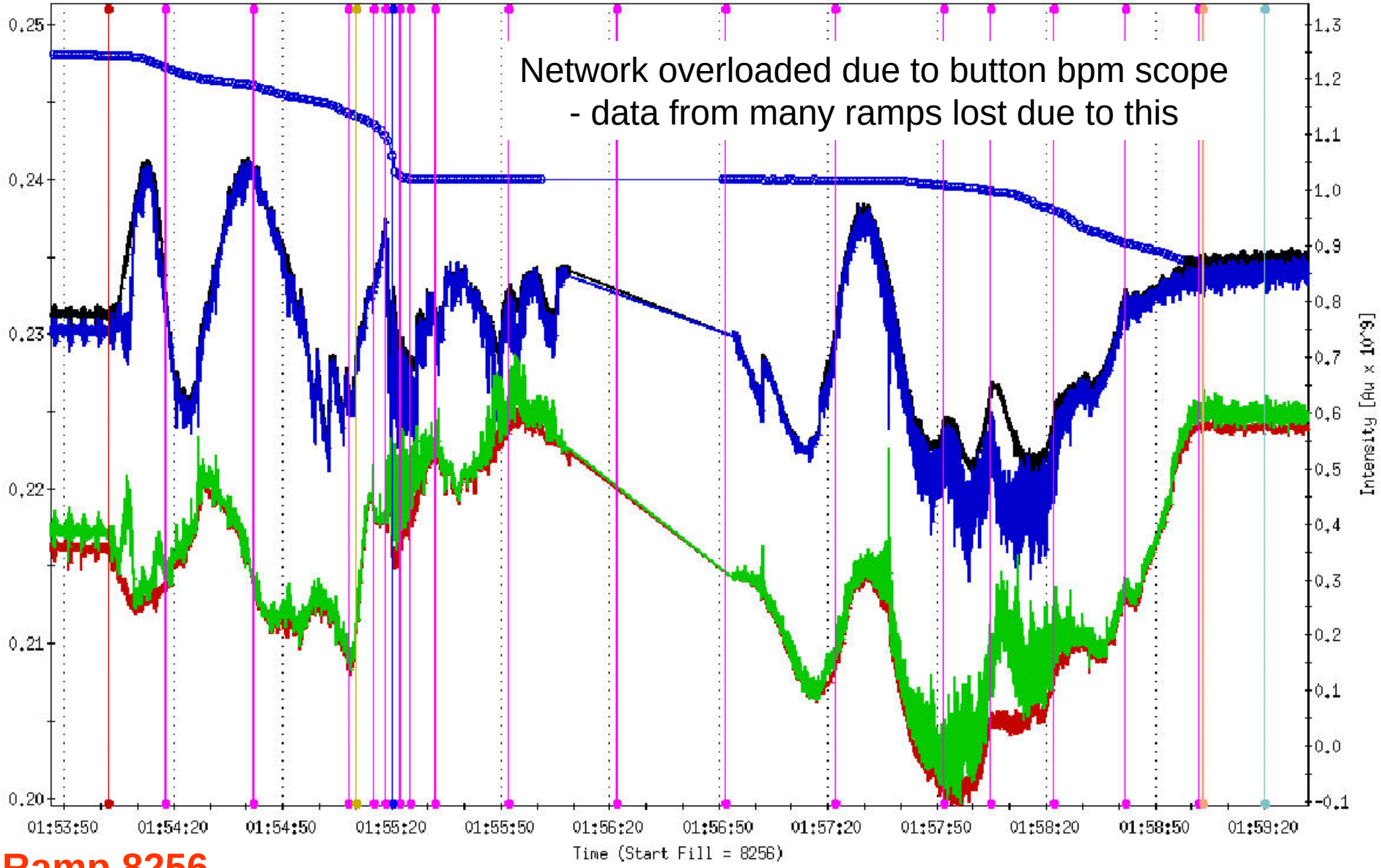
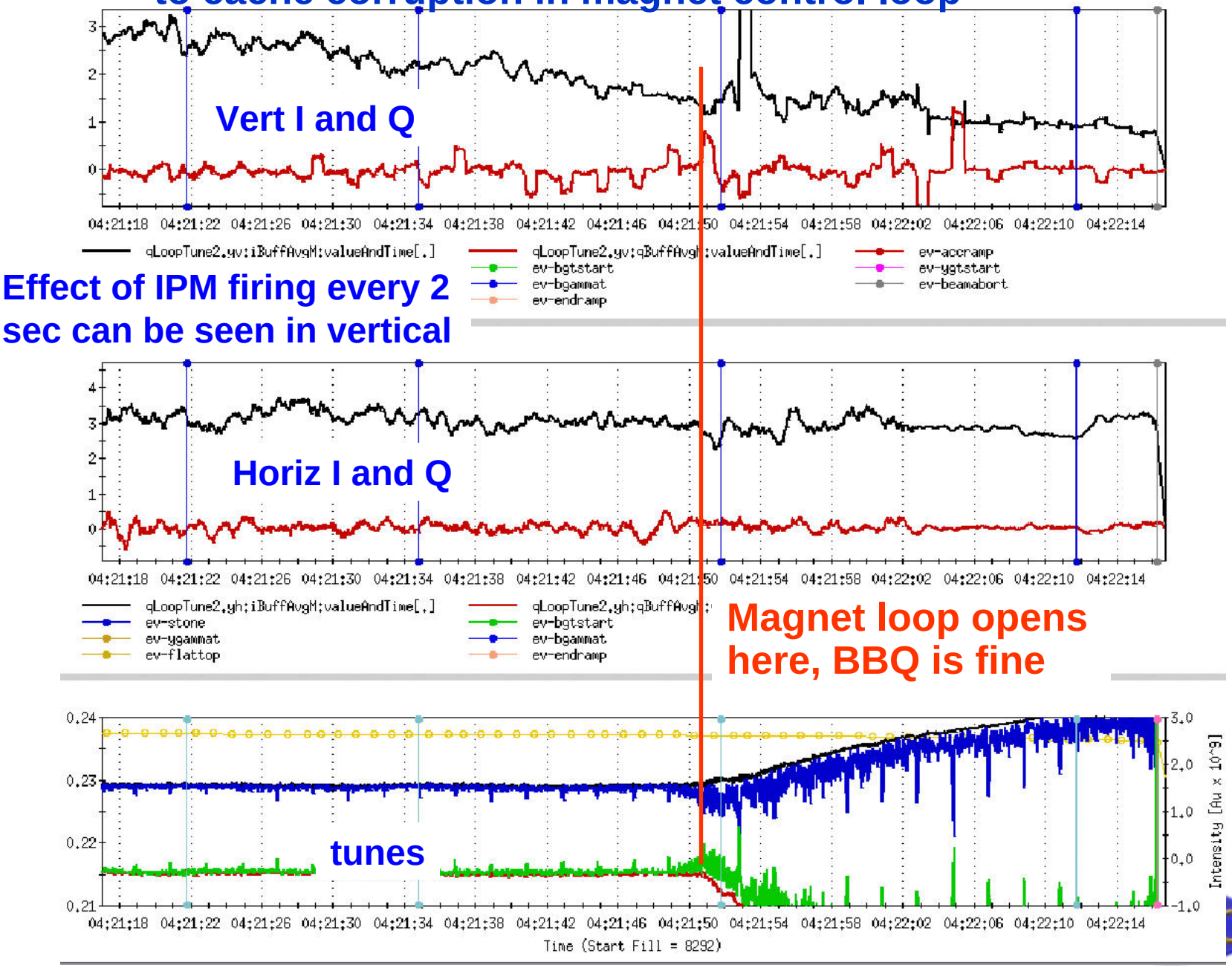

Network overloaded due to button bpm scope
- data from many ramps lost due to this
0.25
0.24
0.23
0.22
0.21
0.20
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
-0.1
Intensity [Au x 10^9]
01:53:50
01:54:20
01:54:50
01:55:20
01:55:50
01:56:20
01:56:50
01:57:20
01:57:50
01:58:20
01:58:50
01:59:20
Time (Start Fill = 8256)
Q1[.] (Y1)
ev-stone (Y1)
ev-flattop (Y1)
Q2[.] (Y1)
ev-bgtstart (Y1)
ev-endramp (Y1)
qx[.] (Y1)
ev-ygtstart (Y1)
ev-lumi (Y1)
qy[.] (Y1)
ev-ygammat (Y1)
bluDCCTtotal (Y2)
ev-accramp (Y1)
ev-bgammat (Y1)

Ramp 8256

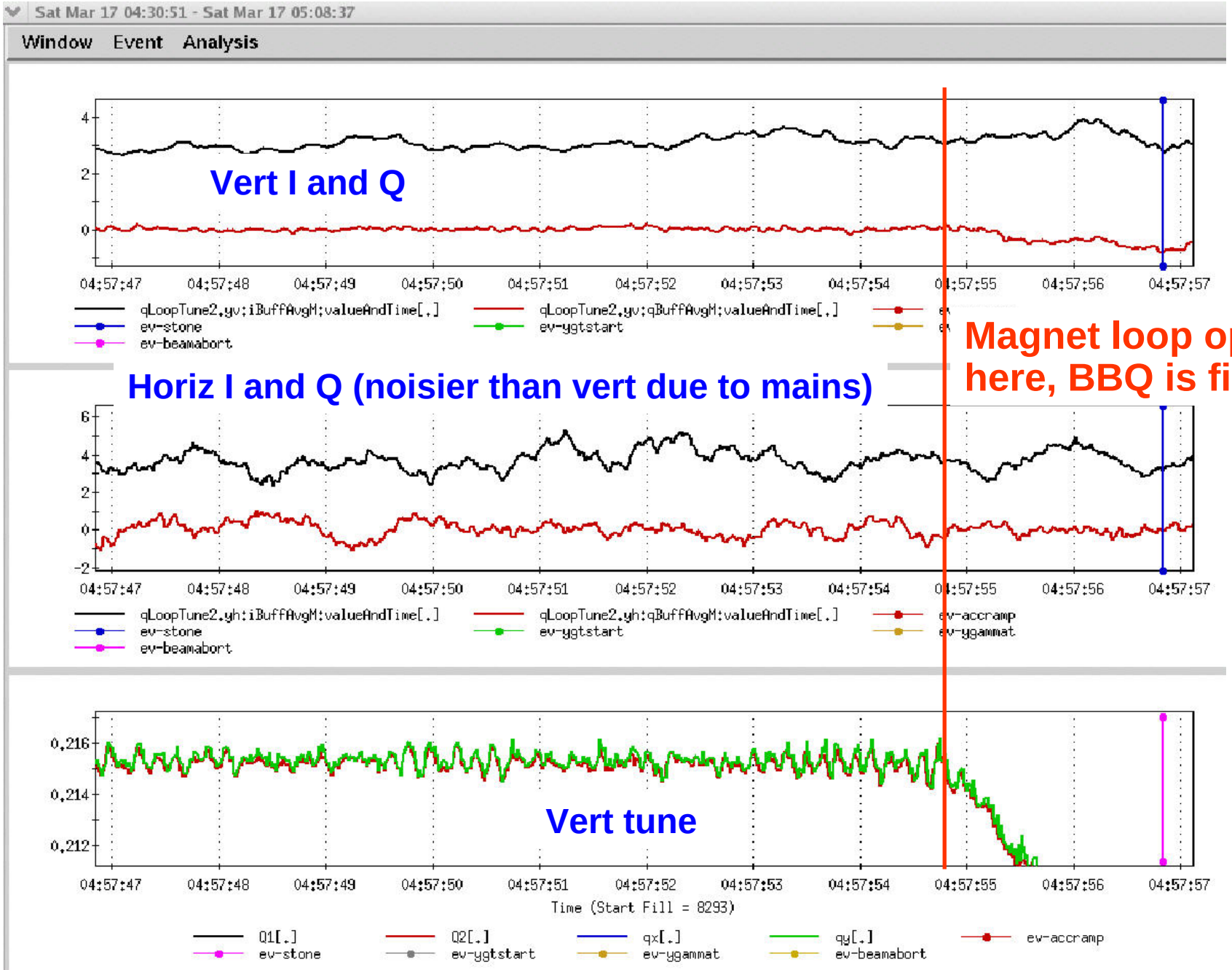
BBQ lock clean, but feedback ramp lost due to cache corruption in magnet control loop

Ramp 8292

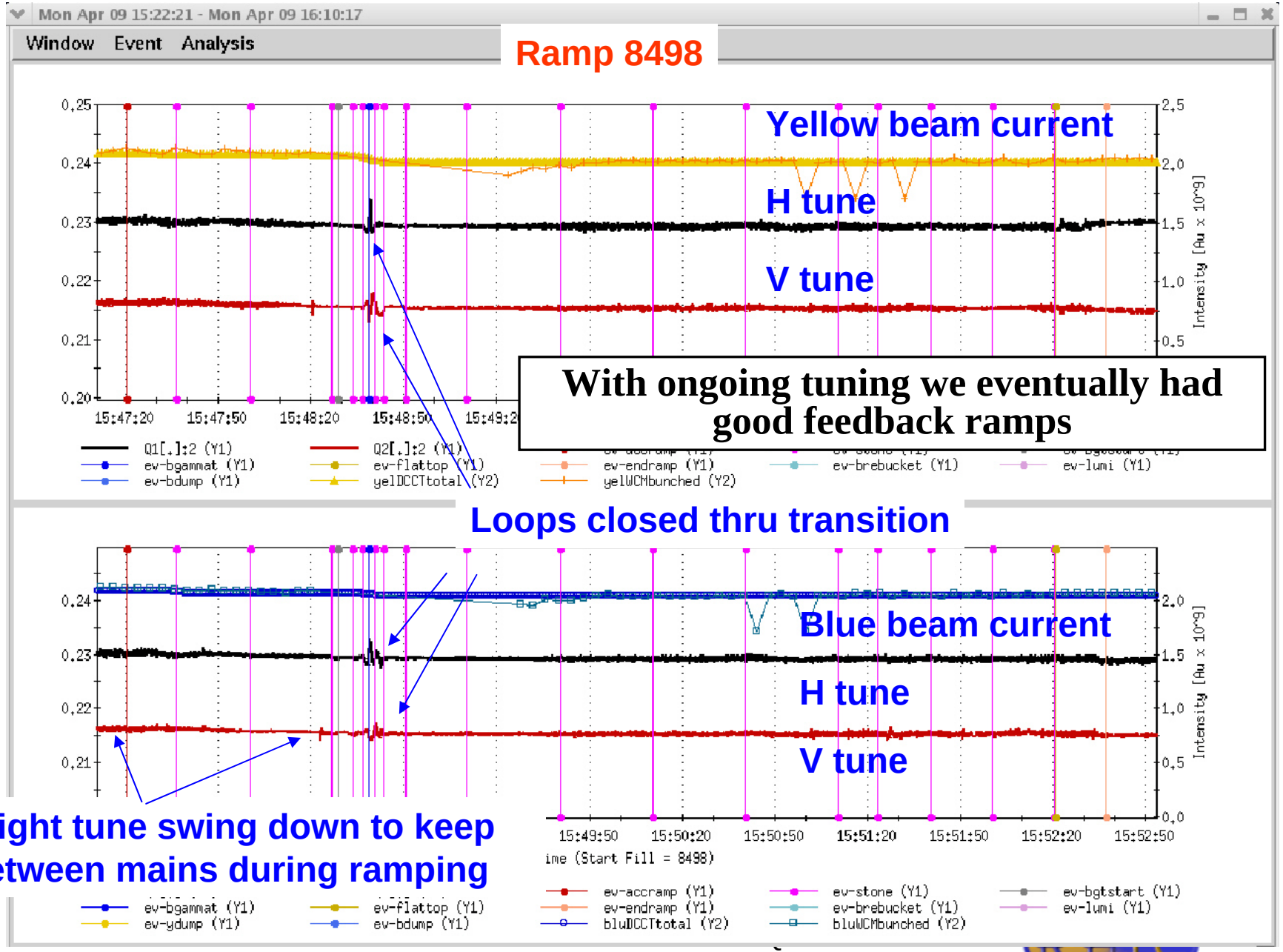


Same thing on next ramp, more clear with IPMs off

Ramp 8293



Simultaneous tune and coupling feedback in both rings , ~97% transmission



Slight tune swing down to keep between mains during ramping

Summary of Run 7 Issues for Run 8

0. **MAINS HARMONICS REMAIN THE PRIMARY OBSTACLE** **no change**
1. Anomalous BTF –not understood, hope of improvement w/ IBS lattice
2. persistent current drifts at injection – done?
3. 'Tune scalloping' – unlike Run 7 commissioning, we are now aware of this mechanism and what (limited) things we can do about it
4. Mains harmonics plus tune scalloping gives a very tight 'box' - ditto
5. Effects of chromaticity
   - Run 7 - many ramps before wiggles ramp – wiggle early this year
   - Run 7 - 4 days elapsed before chrom was corrected – measure, then FIX
   - BBQ and TF are ***surprisingly robust*** in presence of poor chrom, scalloping,…
6. Large noise introduced when magnet loops were closed – again, from anomalous BTF? Kills chrom feedback at injection – no change?
7. A variety of other problems
   - IPM, Artus, injection damper, button monitor all turning themselves on at inappropriate times - done?
   - 5 FEC VME crate would hang frequently – system split to 2 crates
   - 'cache corruption' problem would break feedback ramps - done

The plan for Run 8

- Basically the same as for Run 7, but with a lot of new knowledge
  - Run 7 was the first run with ions for BBQ (245MHz was above coherent spectrum, did not see mains harmonics, anomalous BTF, tune scalloping,… but was killed by dynamic range at transition)
- Lots of little problems (they did all add up, tho) beyond the BBQ that were encountered during Run 7 commissioning are (hopefully) fixed
- Chrom Feedback work to take place during machine development/APEX

Commissioning Plan – beam in Blue at injection

1.	verify BBQ system operation, tune tracking,…	~1hr
2.	verify coupling phases, measurement,…	~1hr Yun, Larry,…
3.	decouple, measure and correct chromaticity	~1hr Yun, Larry,…
4.	check chrom app phase	~1hr Steve T.
5.	turn on radial modulation, verify chromaticity measurement with tune/coupling feedback off	~1hr Steve, Larry
6.	turn on tune/coupling loops, verify system operation	~1hr Larry, Yun
7.	with tune/coupling feedback on, turn on radial modulation, verify chromaticity measurement (BTF?)	~2hr Larry, Carl, Steve
8.	*Ramp* with feedbacks off, *wiggles on*, high loop gains	~1hr Steve T
9.	*Ramp* with *wiggles on*, tune and coupling feedback on	~1hr Steve, Larry

Backup material

Feedback Ramp Tunes

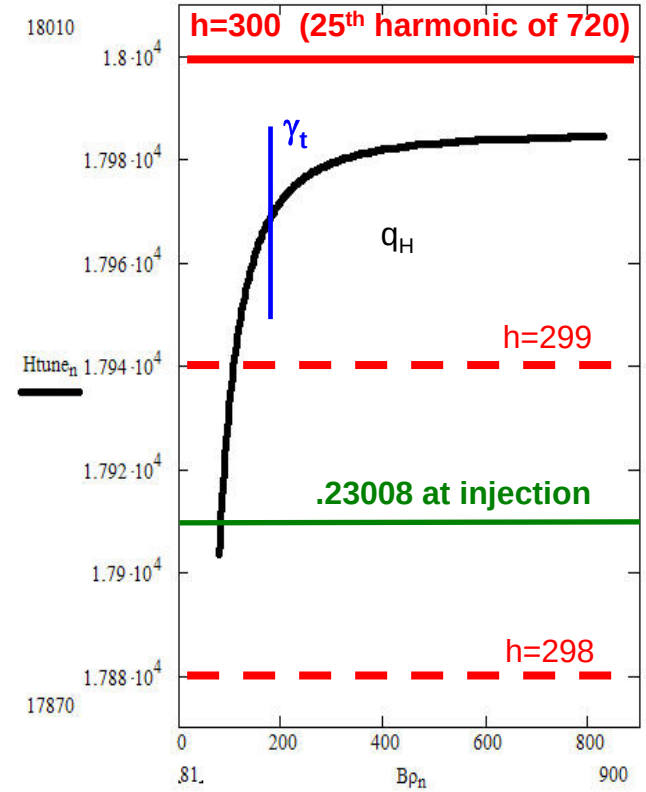
$$Frev_{max} = \frac{c}{2\pi R}$$

$$Frev = Frev_{max}\sqrt{1-\frac{1}{\left(\frac{Q\cdot B\rho\cdot c}{m}\right)^2+1}}$$

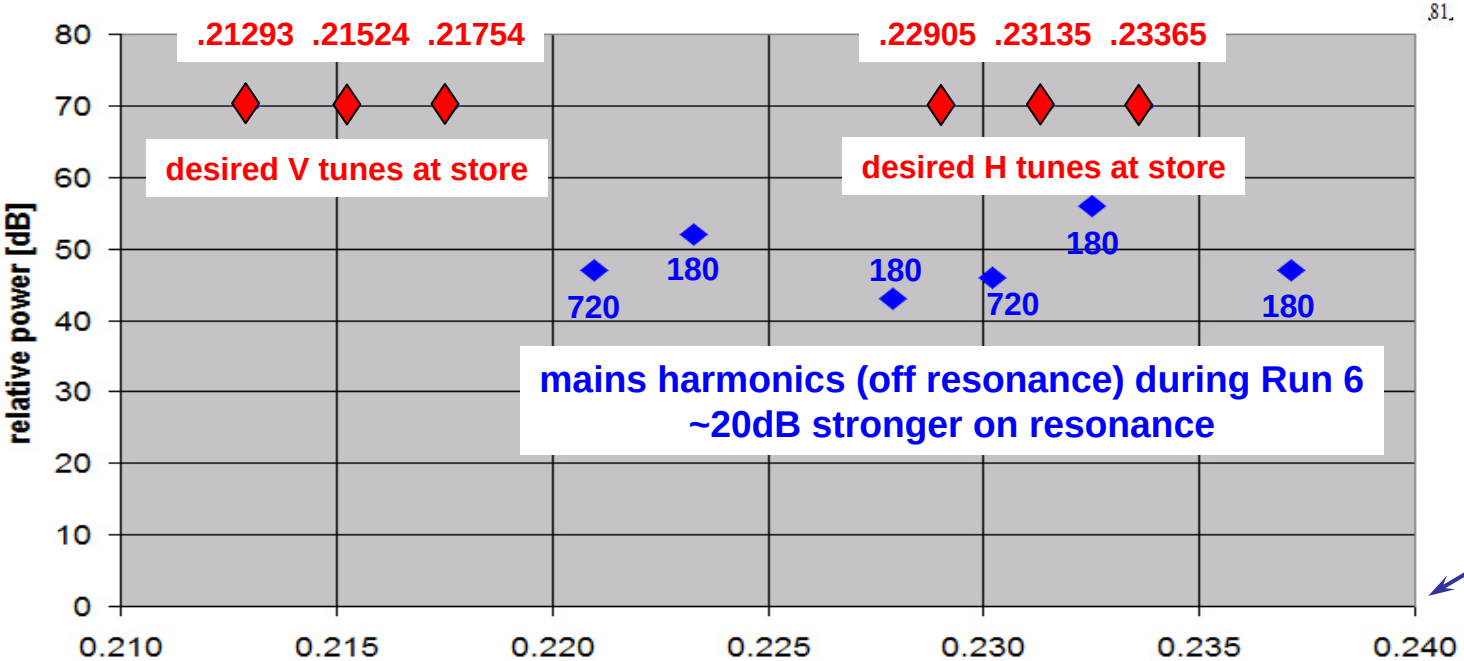
$$\nu_{ramp} = \frac{\nu_{store}\cdot Frev_{store}}{Frev} \qquad \nu_{rampH} = \frac{17910\,Hz}{Frev} \qquad \nu_{rampV} = \frac{16830\,Hz}{Frev}$$

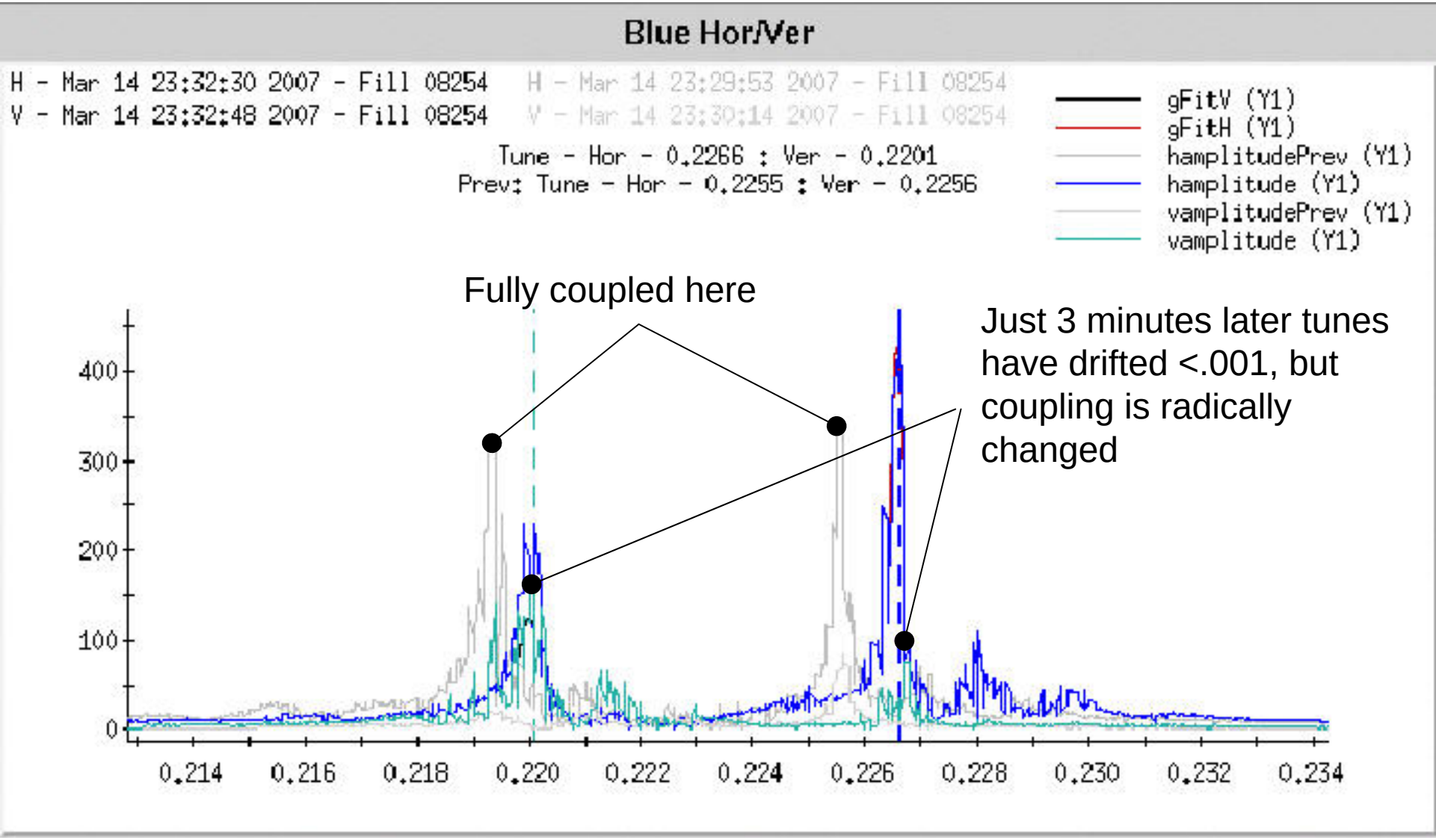
injection tunes .23008, .21621

store tunes .22905, .21524



Blue horizontal mains harmonics on ramp 5 May 2006



BBQ noise floor

Coupling Drift at Injection