STATUS OF THE LHC INSTABILITIES

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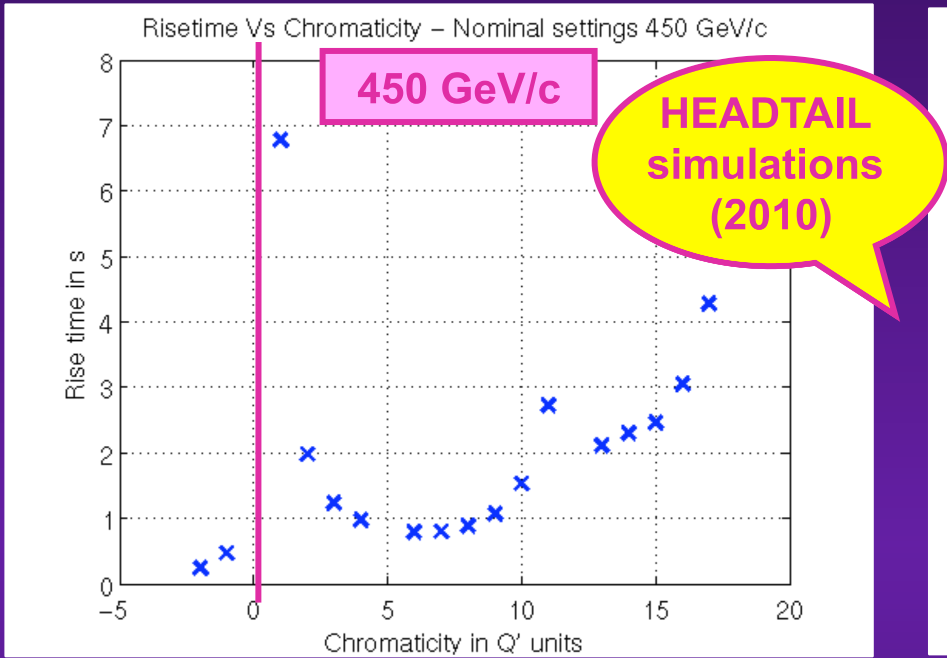
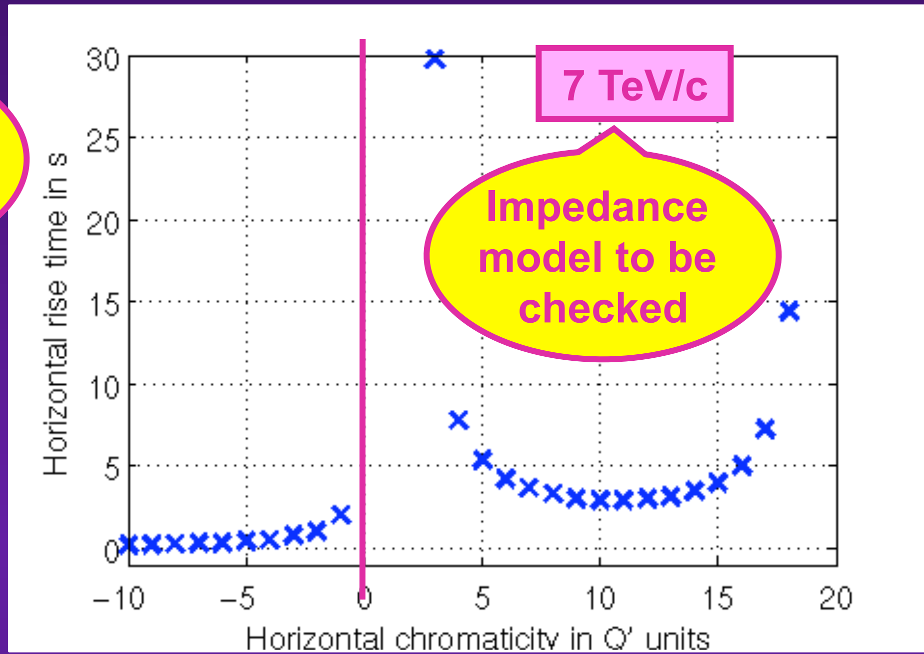
- **Reminder => 2 types of (coherent) instabilities observed**
  - **With only 1 bunch in a ring (no beam-beam) at high-energy without octupoles**
  - **Several bunches in stable-beam conditions (i.e. with beam-beam and also octupoles)**

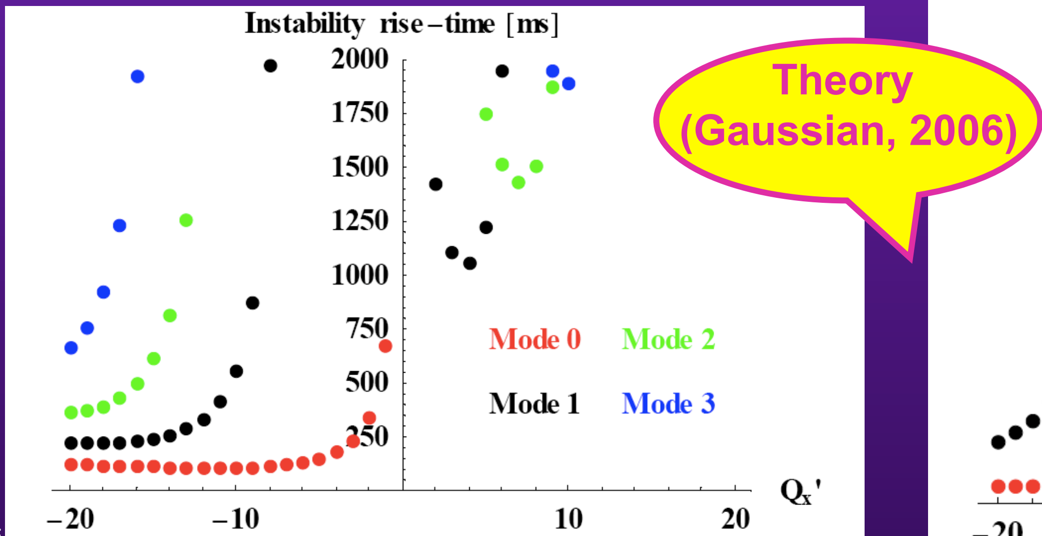
1^{st} INSTABILITY

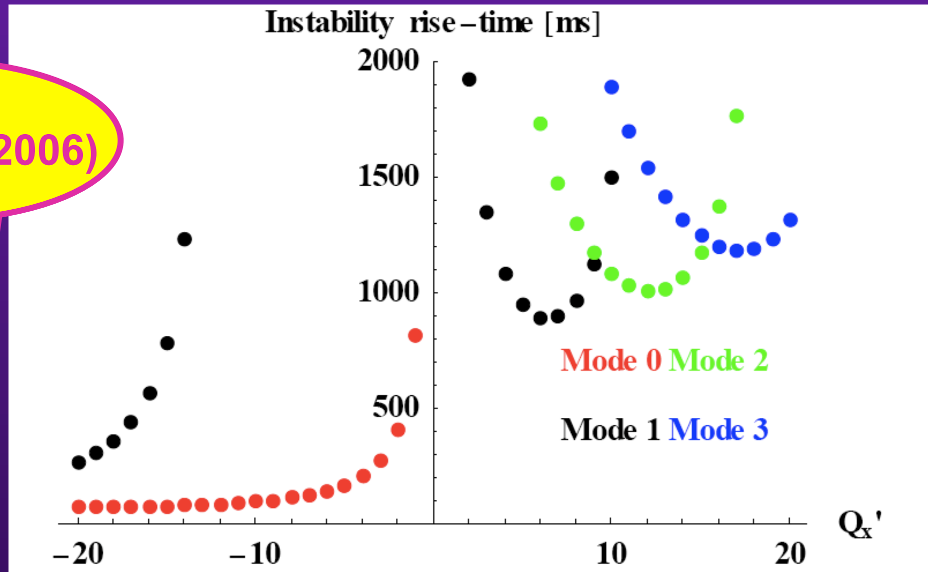
- Benchmark Theory (Gaussian bunches) vs. HEADTAIL simulations for the instability rise-times at 450 GeV/c and 7 TeV/c => Scan in chromaticity
- Evolution of the modes vs. time from the instability measurement performed on MO 17/05/2010 at 3.5 TeV/c
- Evolution of the modes vs. time from HEADTAIL simulations in the case of the nominal beam at 7 TeV/c => Without and with beam losses (i.e. aperture)
- Effect of the octupoles' current on the single-bunch instability at 3.5 TeV/c with Q'x = + 6: HEADTAIL vs. theory
- Conclusions and next steps

Benchmark Theory (Gaussian bunches) vs. HEADTAIL simulations for the inst. rise-times at 450 GeV/c and 7 TeV/c

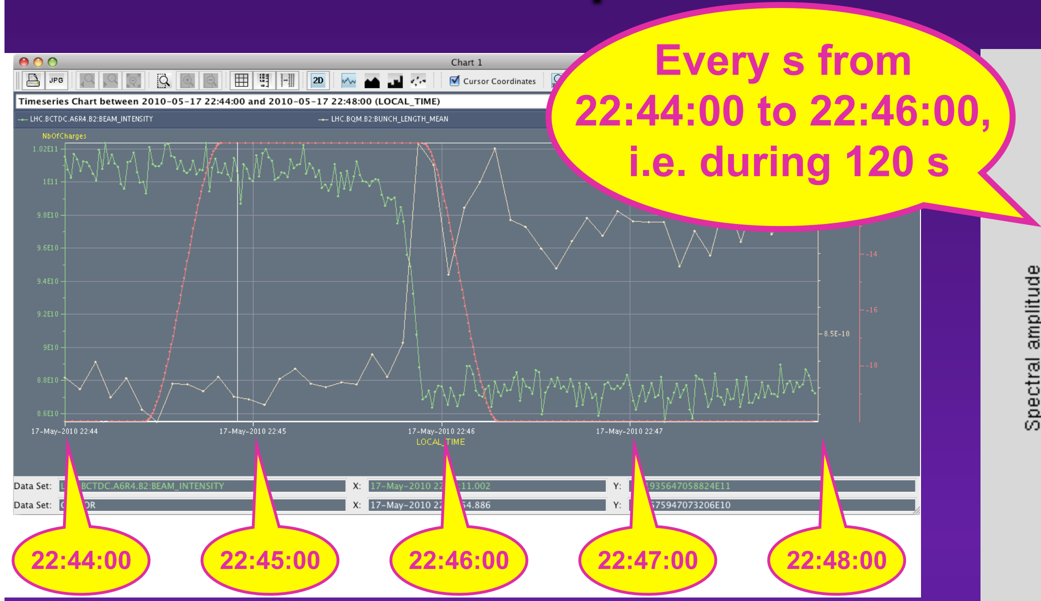


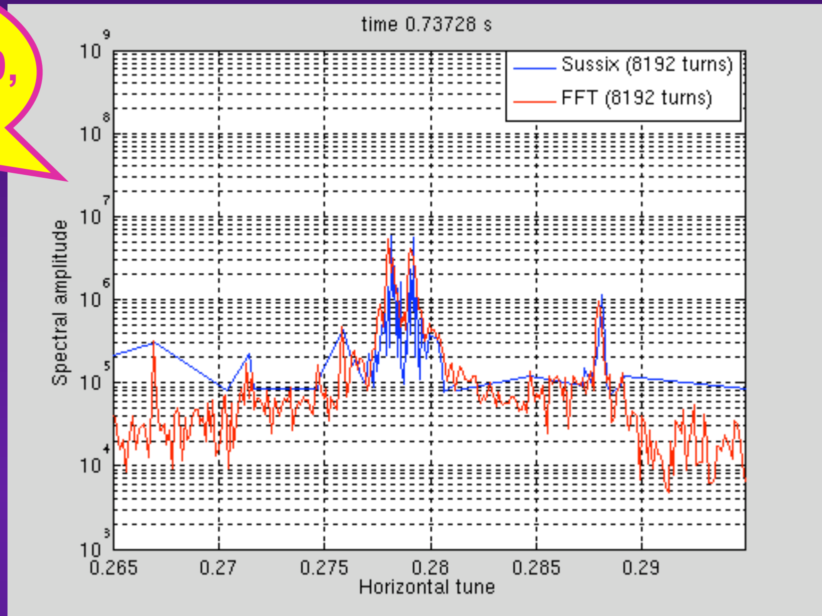


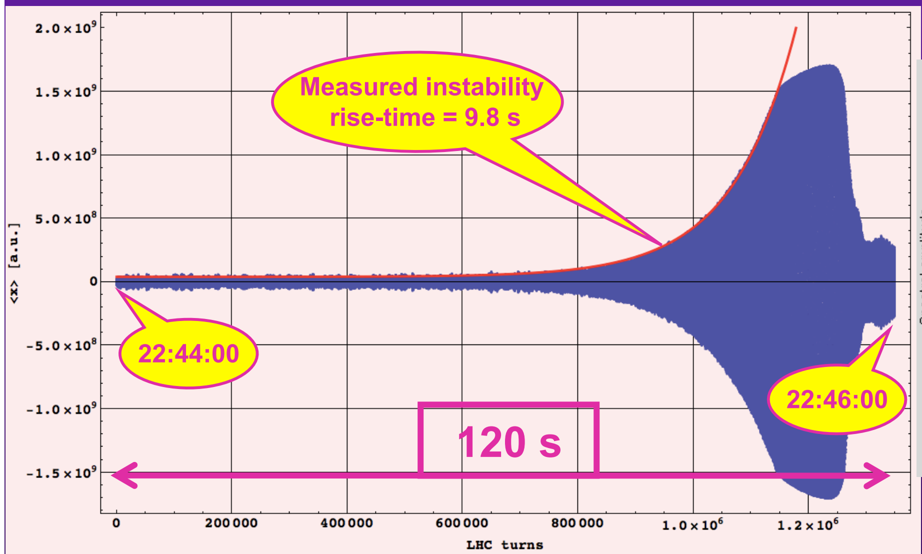


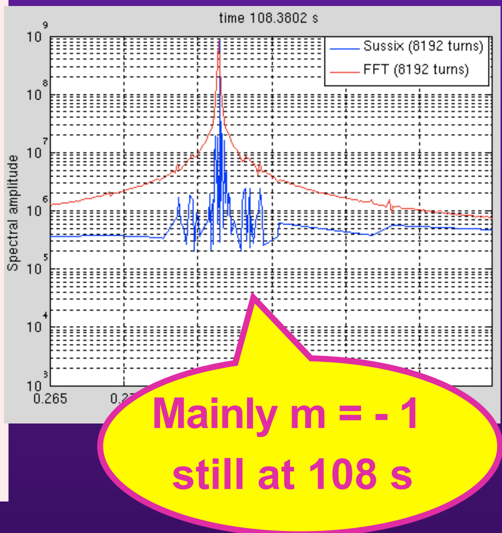


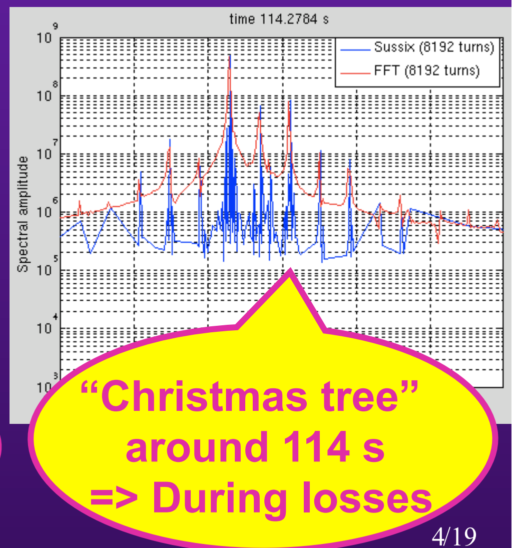
Evolution of the modes vs. time from the instability measurement performed on MO 17/05/2010 at 3.5 TeV/c





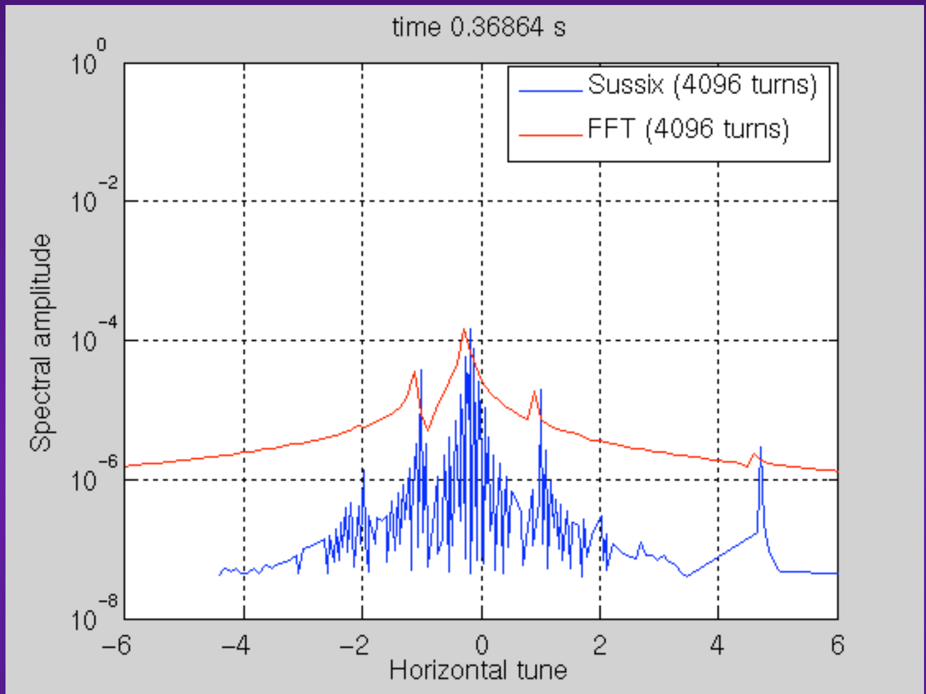




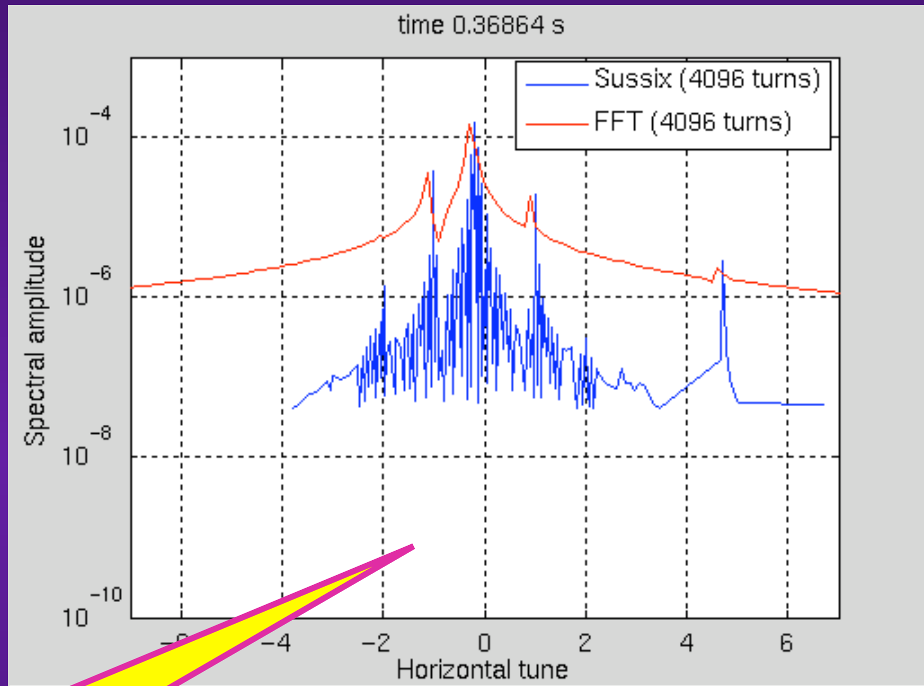


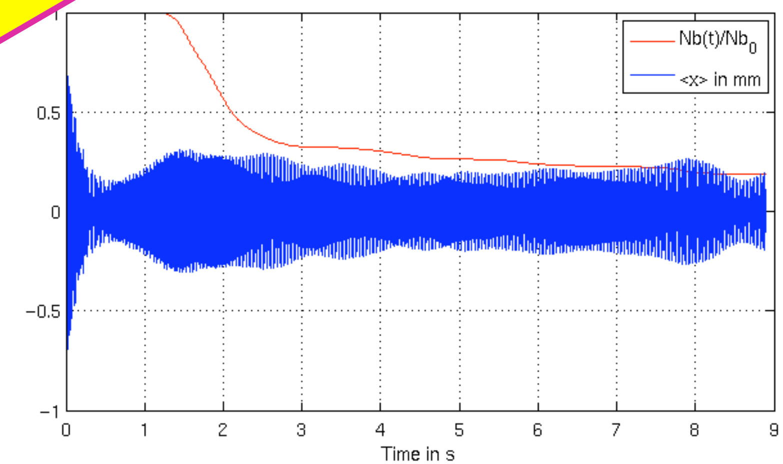
Evolution of the modes vs. time from HEADTAIL simulations in the the case of the nominal beam at 7 TeV/c

WITHOUT LOSSES



WITH LOSSES





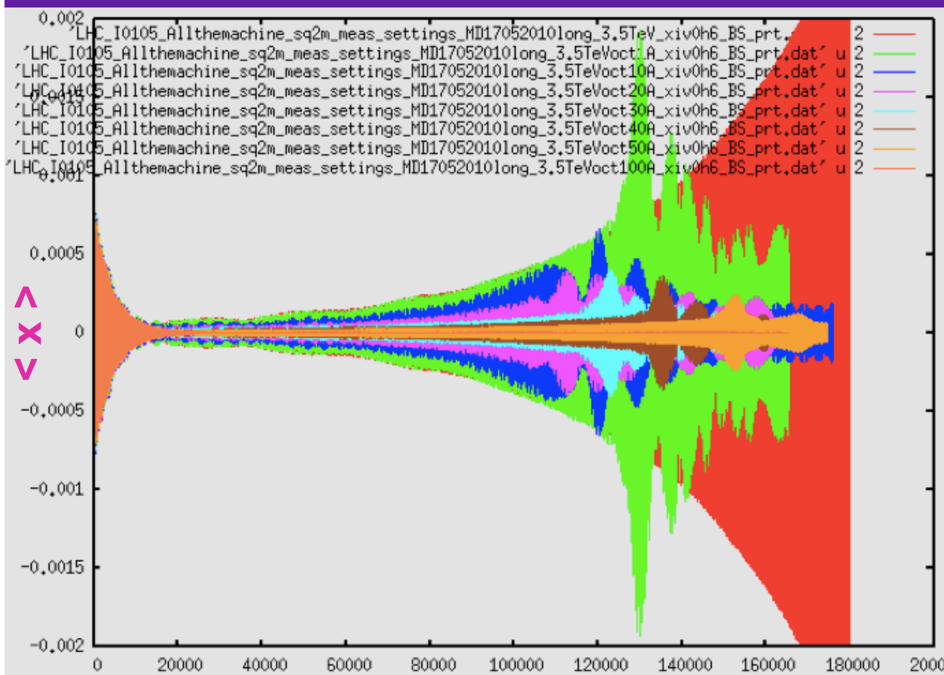
A similar "Christmas tree" seems to be reproduced with the losses included

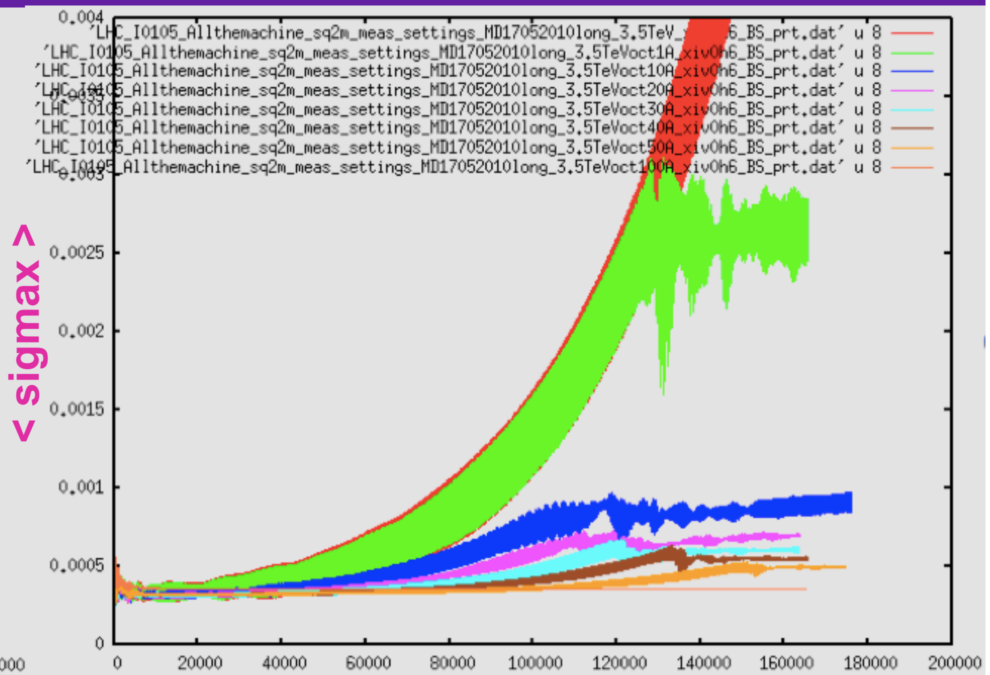
Effect of the octupoles' current on the single-bunch inst. at 3.5 TeV/c with Q'x = + 6: HEADTAIL vs. THEORY (1/2)

MD settings 17 May 2010 – 3.5 TeV/c - 1.05 10^{11} – ε_x = 3.75 μm

During the MD it was ~ 5 microm

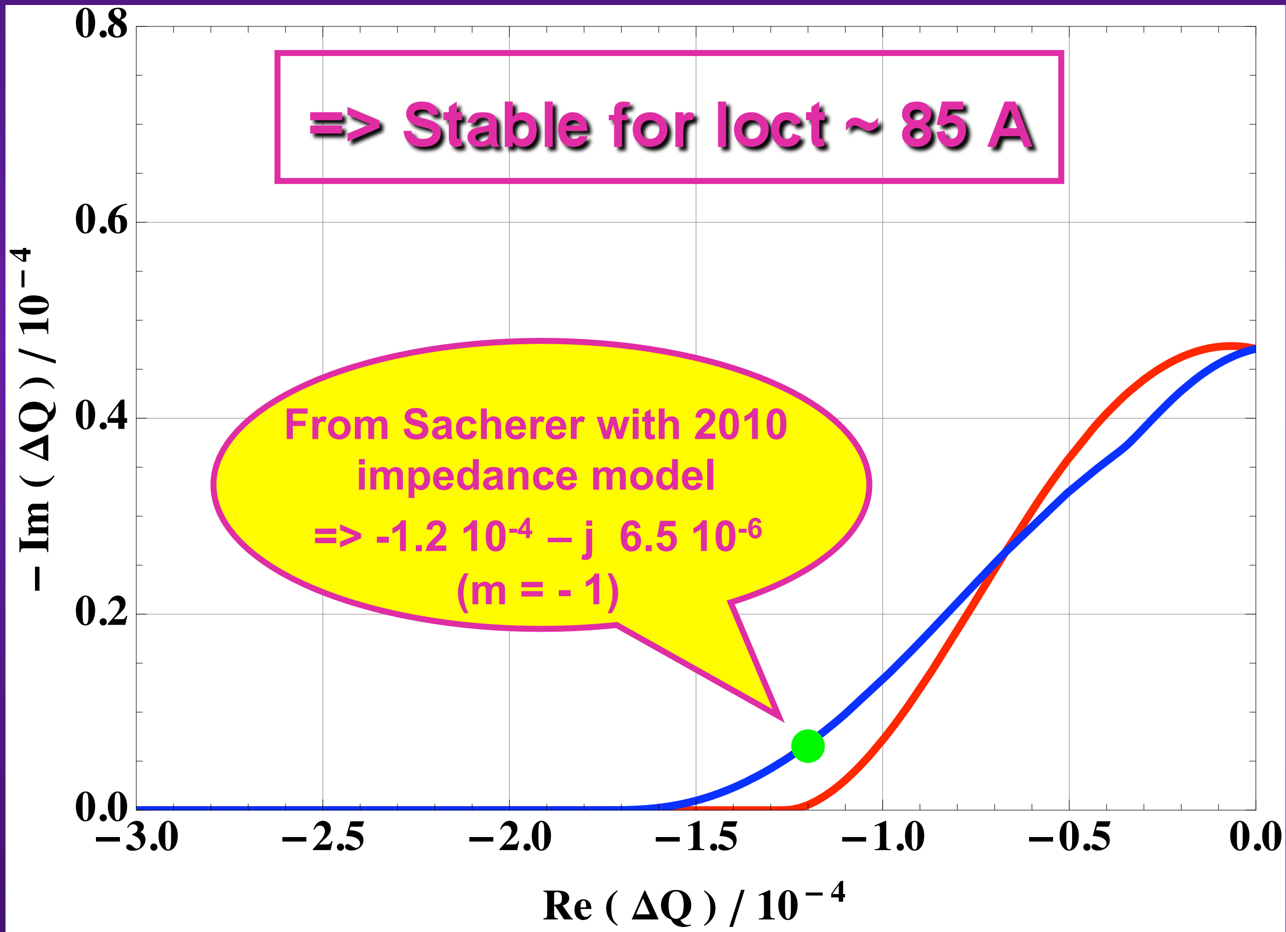
=> Fully stable for +50 A < Ioct < +100 A (i.e. +3 < K3F = K3D < +6) from HEADTAIL





Effect of the octupoles' current on the single-bunch inst. at 3.5 TeV/c with Q'x = + 6: HEADTAIL vs. THEORY (2/2)

From THEORY



Conclusions and next steps (1/2)

- A similar "Christmas tree" as the one observed in the CCC (when beam losses appear) seems also to be obtained from HEADTAIL simulations when the beam losses are included (i.e. introducing an aperture) => But the instability responsible for the beam losses should be a head-tail with m = - 1
- This can be checked by reproducing the MD done on MO 17/05/10 and looking at the signals inside the bunch, turn after turn (Headtail monitor)
- HEADTAIL simulations confirmed that one should try and reduce the chromaticities as much as we can (still > 0 if no transverse feedback or slightly negative with a transverse feedback)
- A good agreement is obtained between theoretical predictions and HEADTAIL simulations for the beam stabilization of the instability at 3.5 TeV/c
  - HEADTAIL simulations => Fully stable for +50 A < Ioct < +100 A (i.e. +3 < K3F = K3D < +6)
  - Theoretical predictions => ~ +85 A

Conclusions and next steps (2/2)

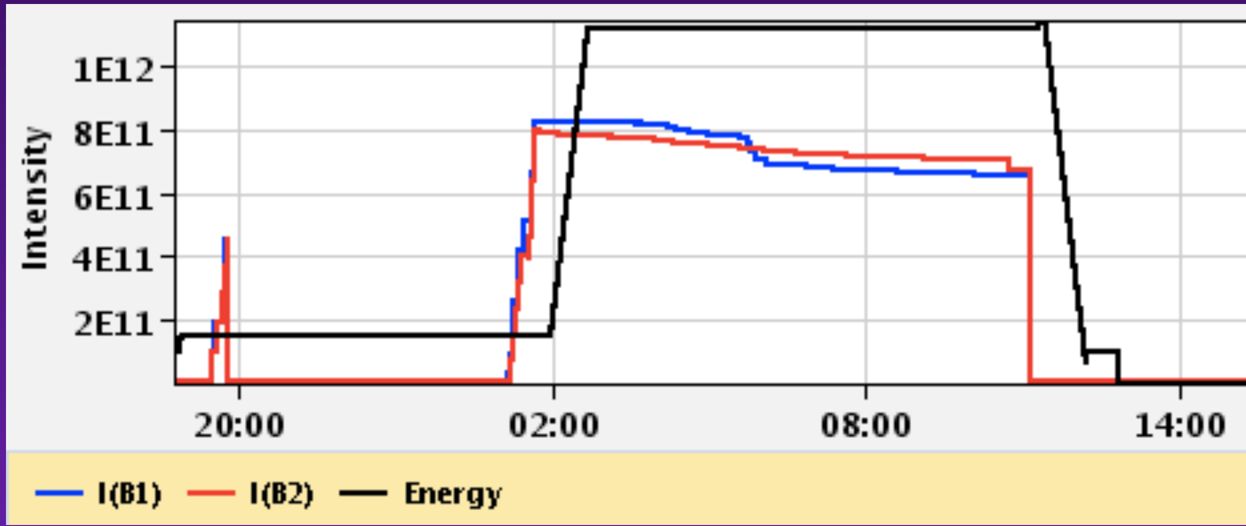
- **Next steps:**
  - **Finish the scan in the octupoles' current (60, 70, 80 and 90 A) for the HEADTAIL simulations**
  - **Redo the octupole analysis with negative gradients (as we suggested to use negative ones after discussion with StephaneF) => K3F = K3D = - 6 is currently used at 3.5 TeV/c**

- **For more info on this subject => See for instance: https://impedance.web.cern.ch/impedance/documents/SBInstabilityStudiesInTheLHCAt3500GeV_LCU.pdf**

2nd INSTABILITY

- This is followed up by WH and EL (and also FS in the future) => 2 presentations by WH at the LHC Beam Commissioning Working Group
  - https://lhc-commissioning.web.cern.ch/lhc-commissioning/meetings/20100706/LHC-BC-WG-Min06July10.pdf
  - https://lhc-commissioning.web.cern.ch/lhc-commissioning/meetings/20100713/LHC-BC-WG-Min13July10.pdf
- Some discussions on the observations made on FR 09/07/2010
- Preliminary conclusions and next steps

Measurements on FR 09/07/2010 (1/8)



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> LHC OP CREATOR > Shift Summary

shift summary:

*) Filled the machine with 10 bunches and put them into stable beams.

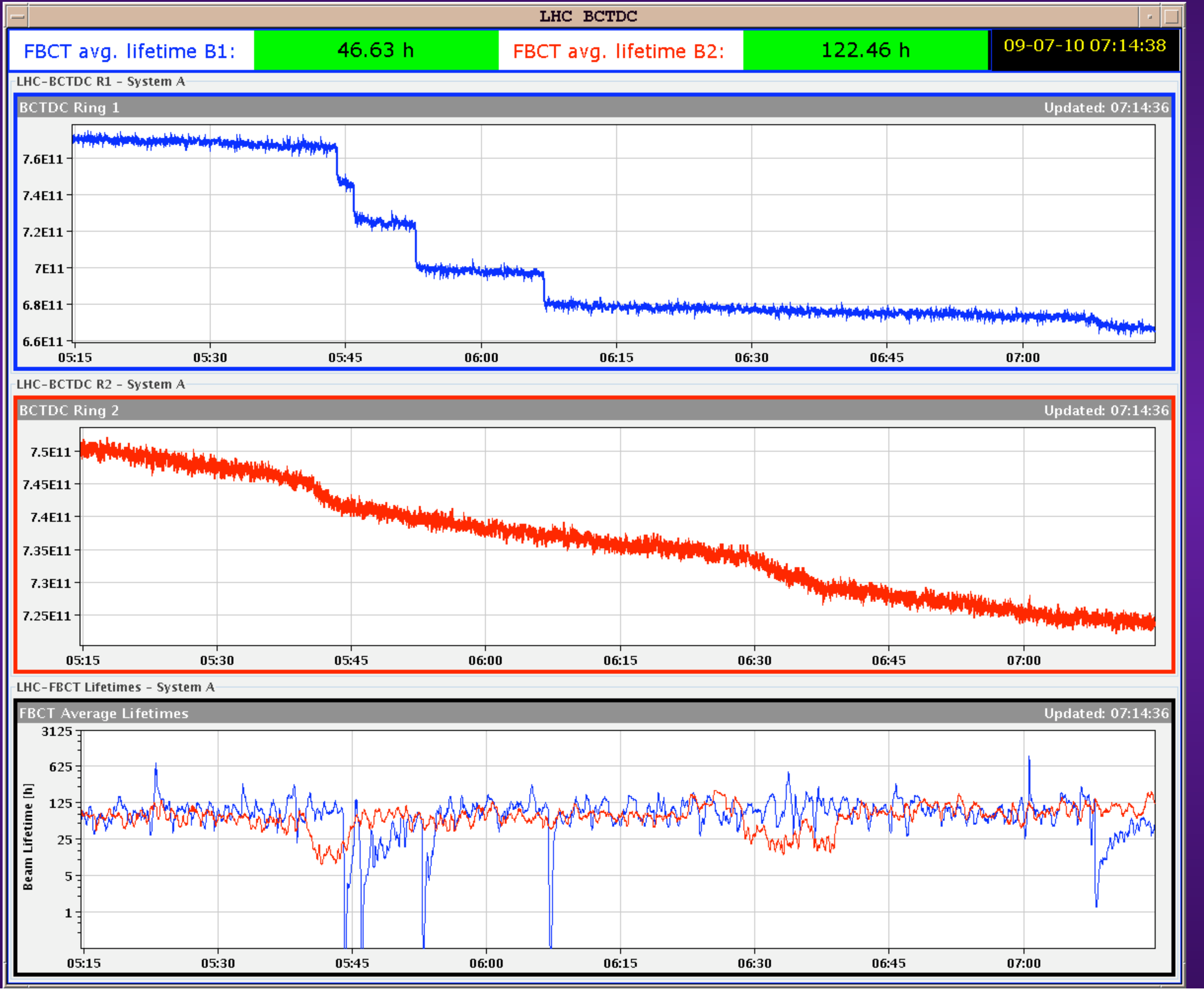
*) Max luminosity was more than 6x10^29.

*) 4 steep lifetime drops on beam 1 reduced the luminosity to about half their max value in CMS and ATLAS. The bunches for the LHCb collisions stay unaffected.

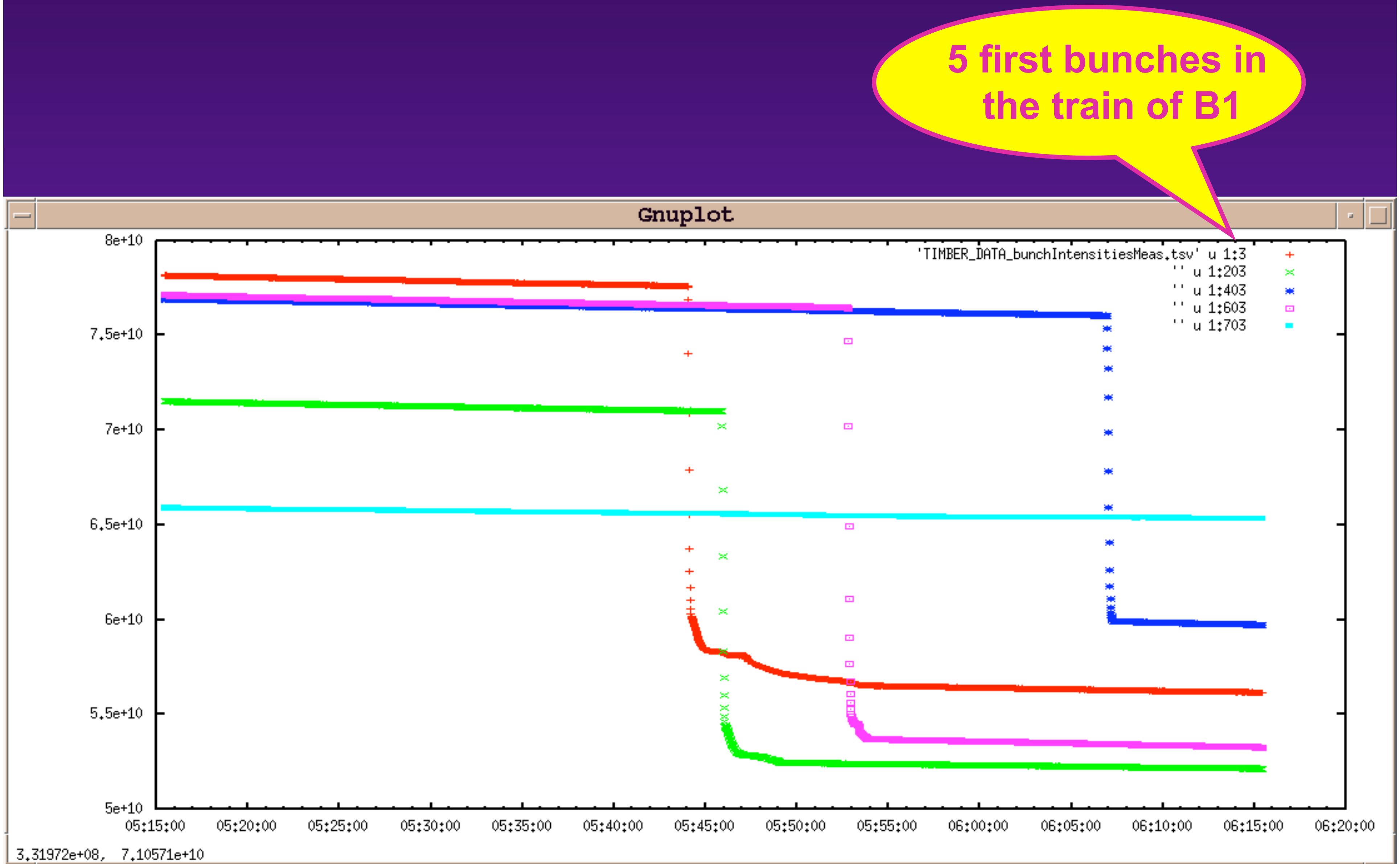
*) There are still some settings inconsistencies for the lumi-scan circuits.

*) The tune feedback for beam 2 has to correct quite a lot through the ramp. A feed forward could be useful there.

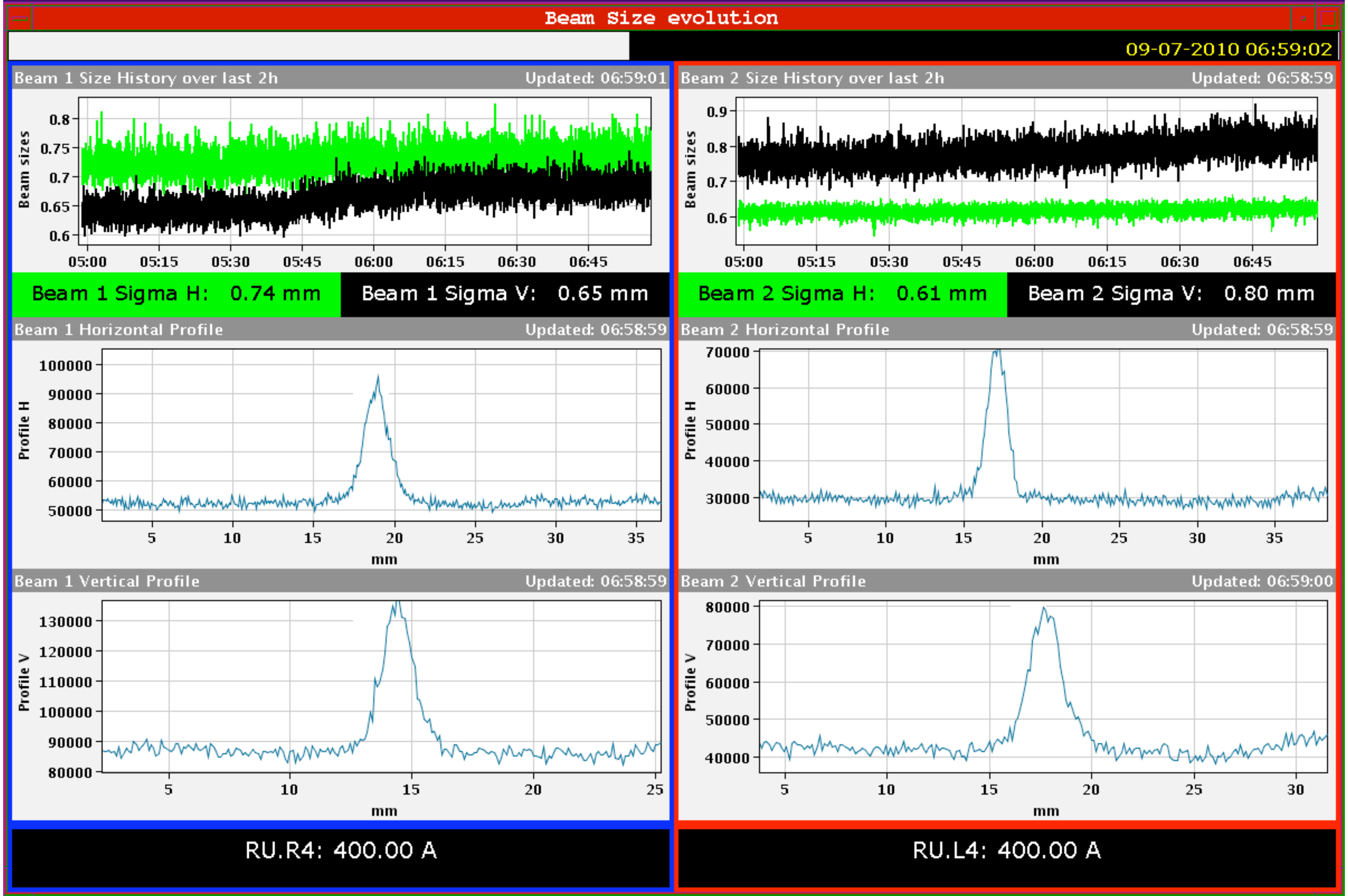
Measurements on FR 09/07/2010 (2/8)



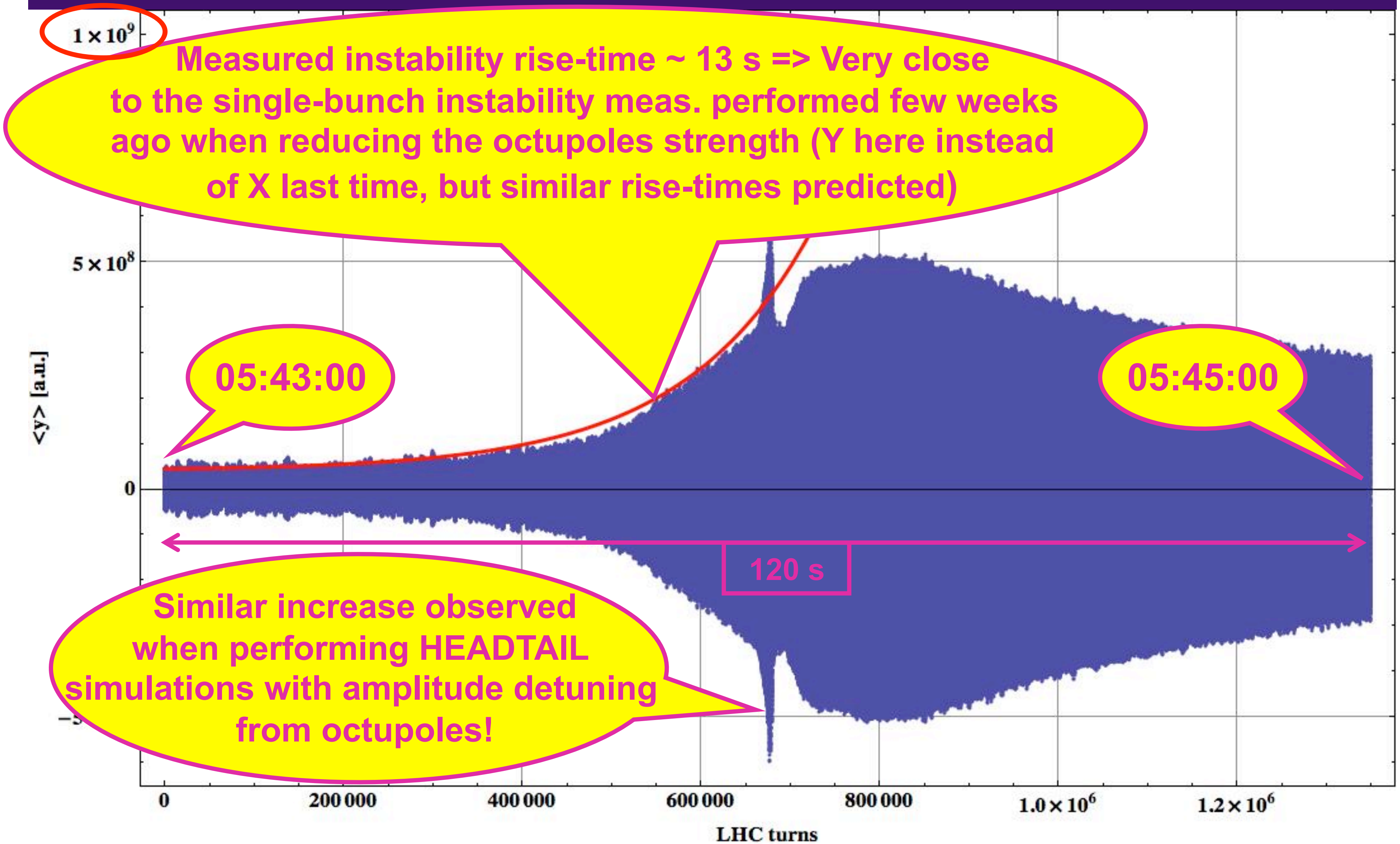
Measurements on FR 09/07/2010 (3/8)



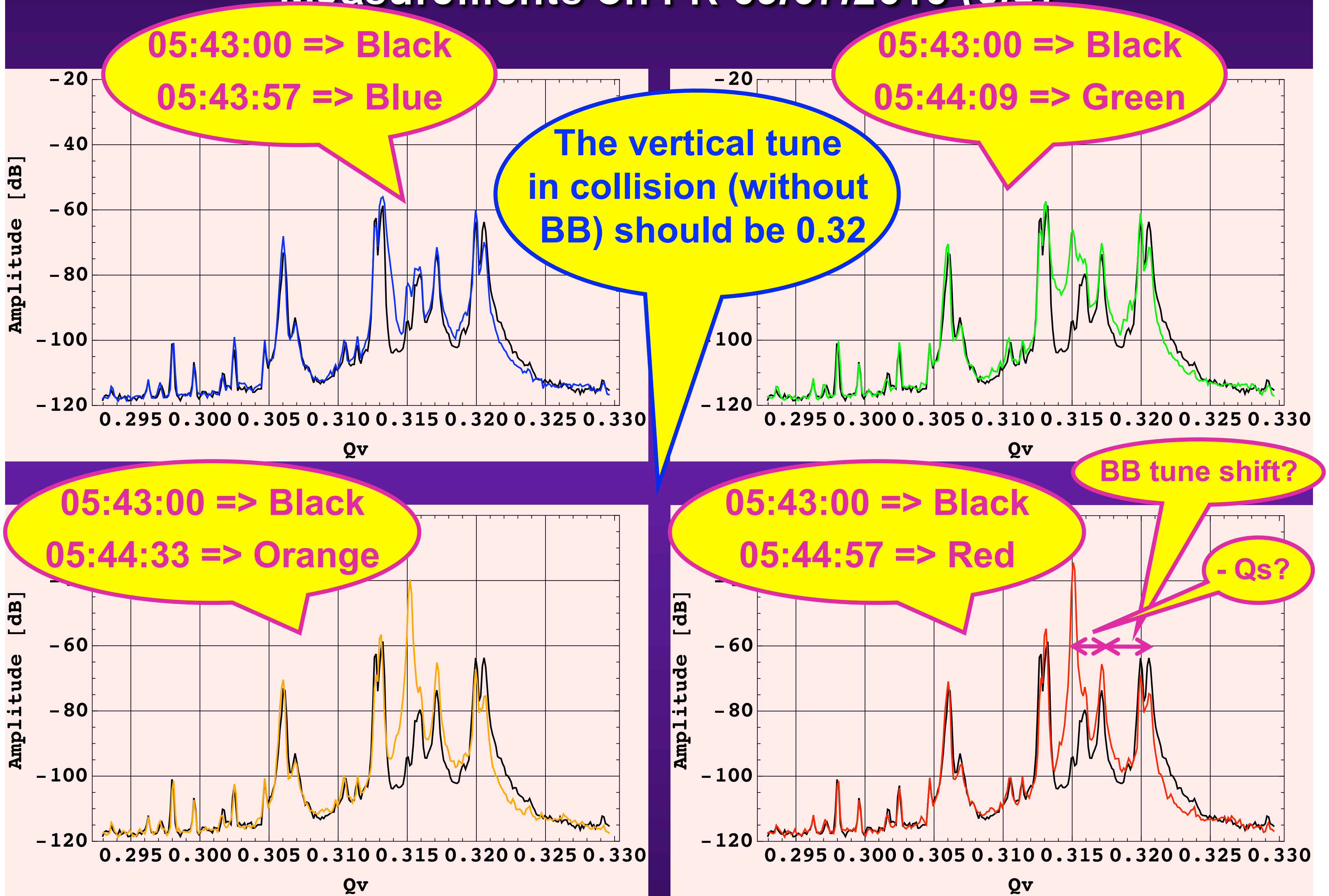
Measurements on FR 09/07/2010 (4/8)



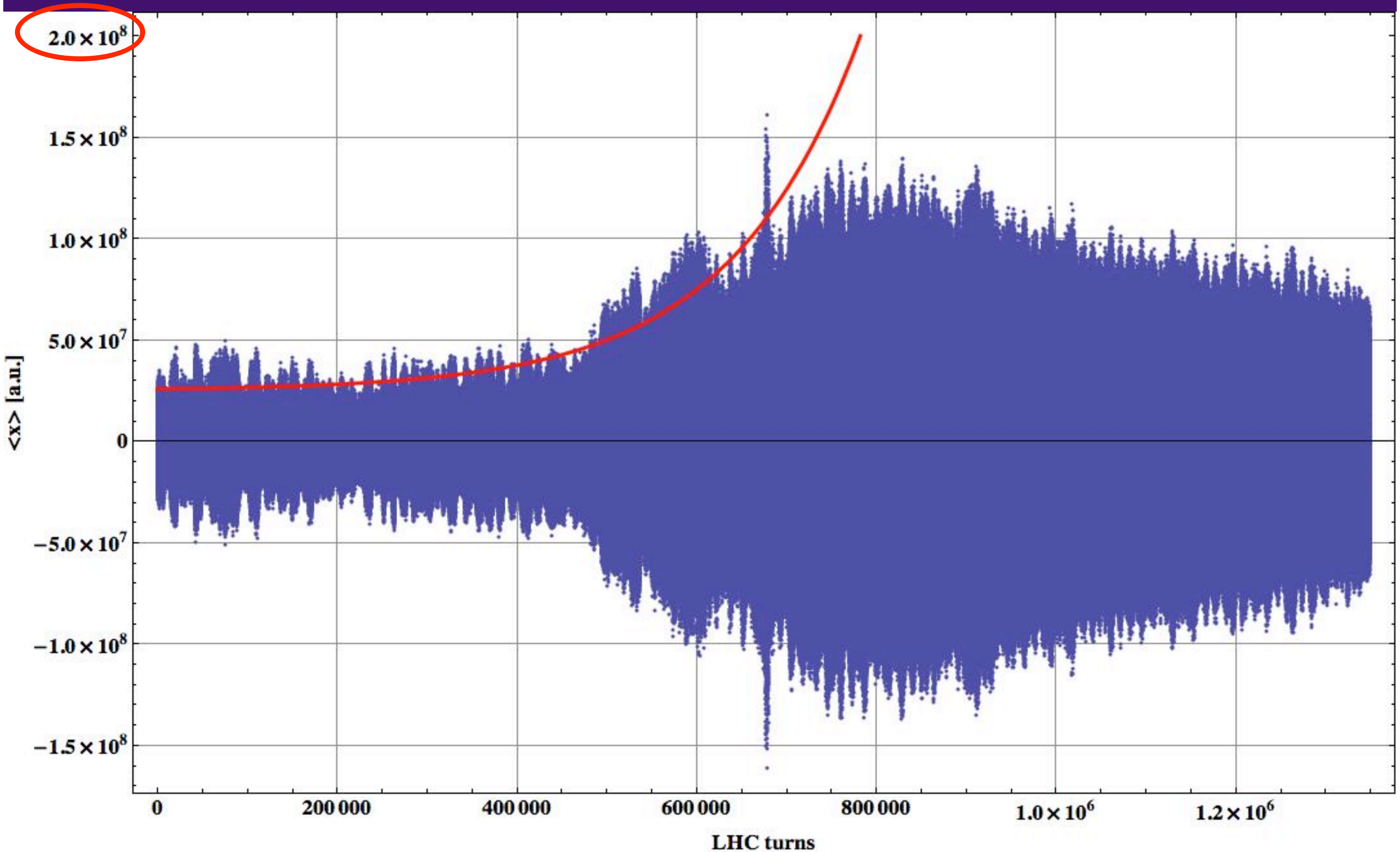
Measurements on FR 09/07/2010 (5/8)



Measurements on FR 09/07/2010 (6/8)



Measurements on FR 09/07/2010 (7/8)



Measurements on FR 09/07/2010 (8/8)

Preliminary conclusions and next steps

- When the beam (bunch) becomes unstable the instability rise-time (on the 2 cases analyzed!) seems very close to the one measured during a dedicated MD (and predicted from theory and simulations) with a single-bunch only (no beam-beam), reducing the octupoles' strength => ~ 10 s of instability rise time
  - Is this rise-time similar in the other cases of beam losses?
  - What are the predicted rise-times from the coherent beam-beam modes?
  - We could imagine that something happens which leads to a loss of Landau damping: When Landau damping is lost, the single-bunch instability (due the machine impedance) could develop
  - We could for instance use the HEADTAL monitor to superimpose several consecutive traces and try and indentify the m = - 1 instability (as already proposed for the previous study). We could also look at the evolution of the spectrum to see the m = - 1 developing or not (as done in the previous MD) => To disentangle between coherent beam-beam modes and head-tail instability from the machine impedance
- Many propositions by WH… More observations required… To be followed up