LHC Beam Commissioning Working Group
May 4th, 2010

First Beam-Beam observations at high intensity collisions.

Measurements on May 2nd and 3rd, 2010

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John Jowett, Frank Schmidt
and all the OP people

Motivations

- Test scan behavior with high intensity hadron collisions.

- Test operations with separated beams (ALICE).

- Exploit available tune spread and tune spectra.

Conditions

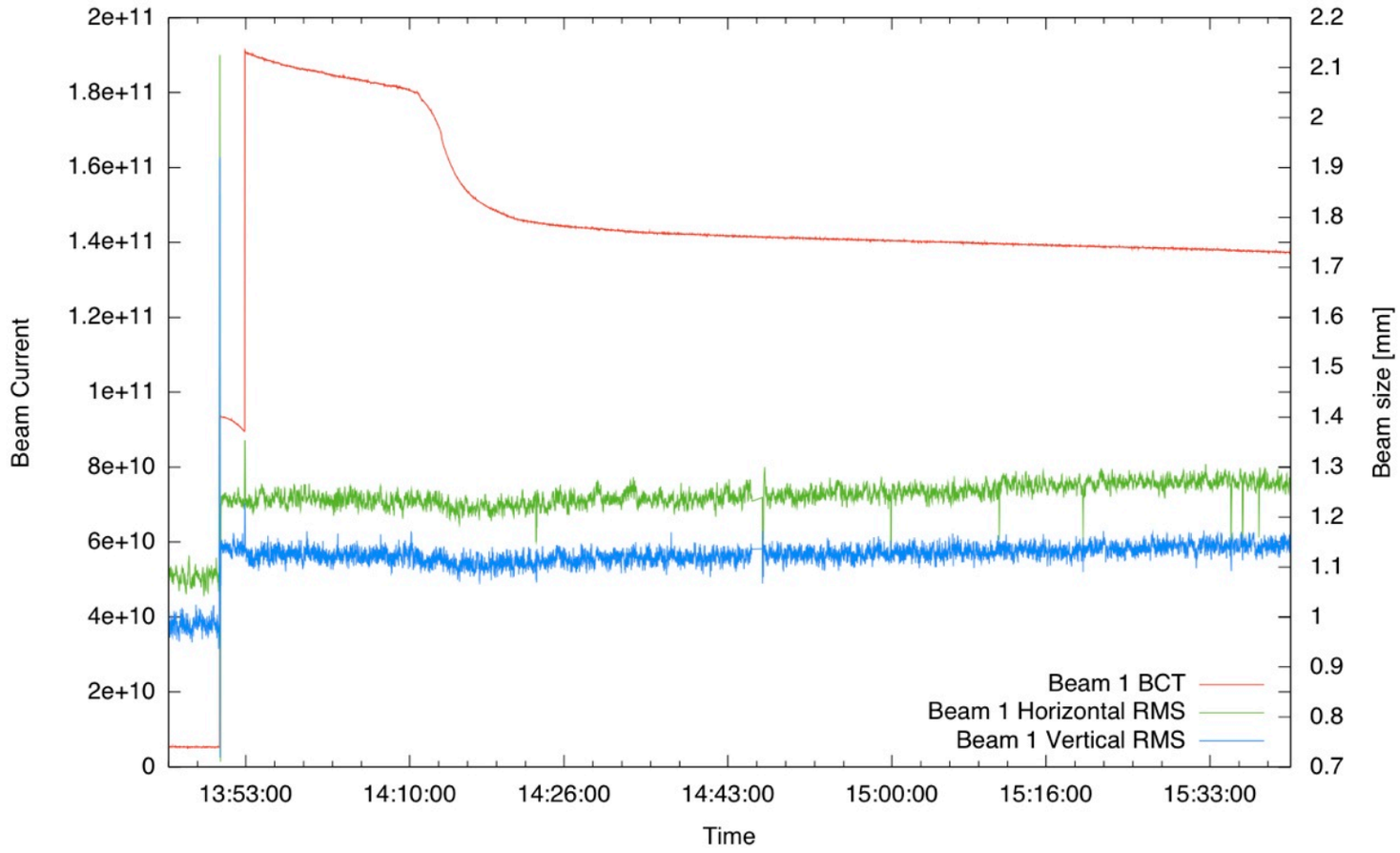
- 2 bunches per beam, one collision per IP.

- 10^{11} protons per bunch.

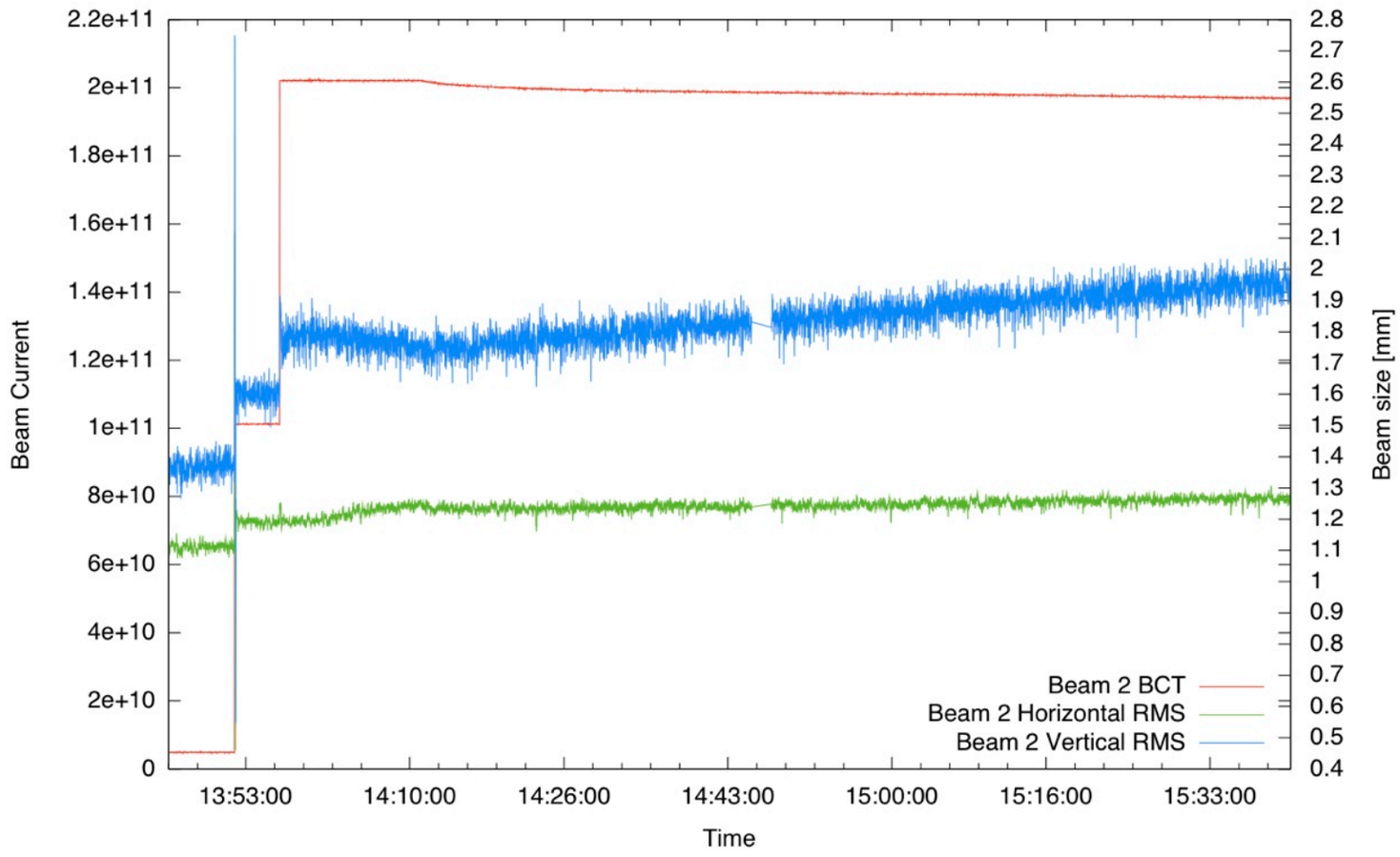
- End of fill measurements.

	Beam 1		Beam 2	
	Bunch 1	Bunch 2	Bunch 1	Bunch2
Bucket	1	17851	1	8911
Number of collisions	3	1	2	2

Beam1:

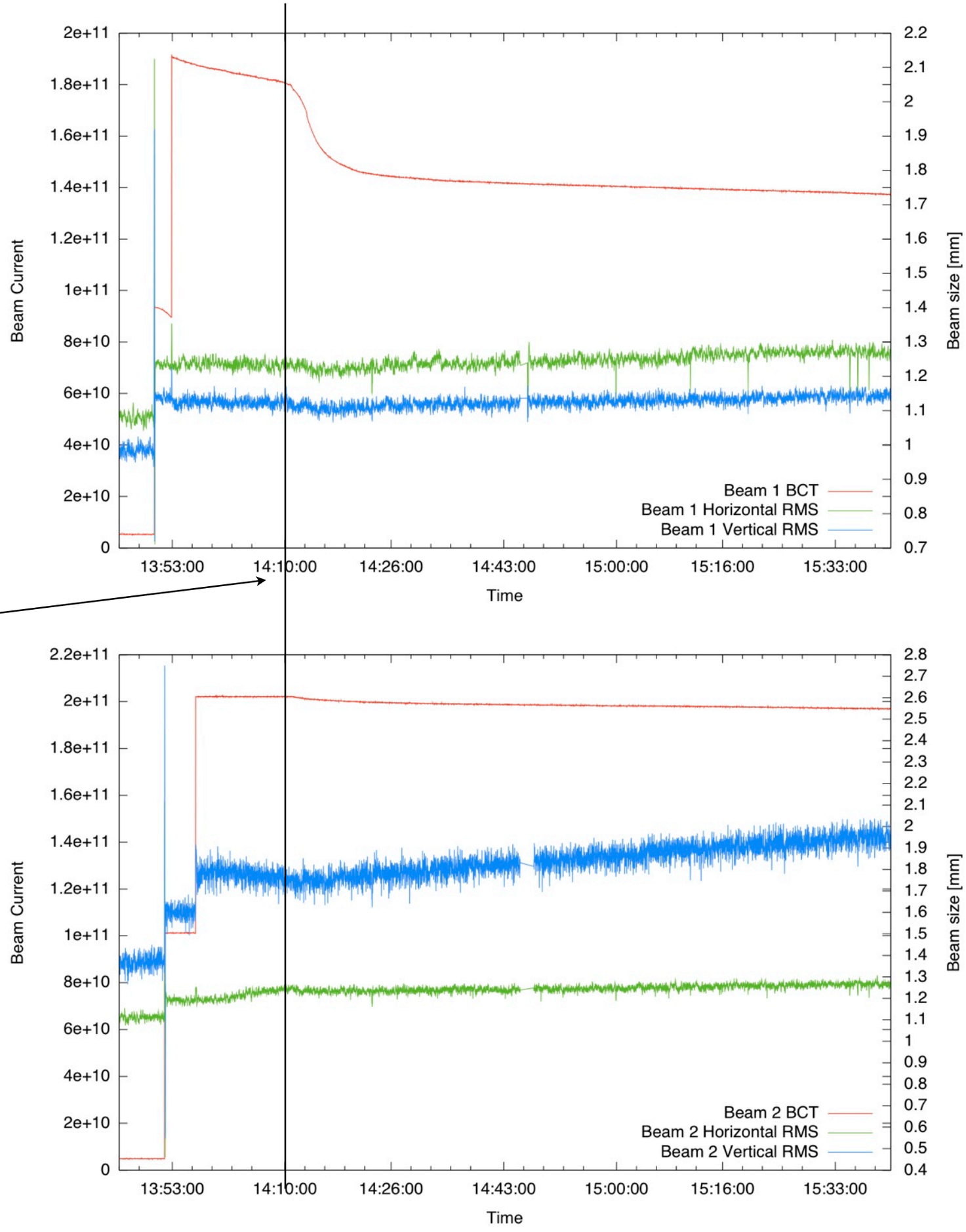

Beam Current
Beam size [mm]
Time
Beam 1 BCT
Beam 1 Horizontal RMS
Beam 1 Vertical RMS
2e+11
1.8e+11
1.6e+11
1.4e+11
1.2e+11
1e+11
8e+10
6e+10
4e+10
2e+10
0
2.2
2.1
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
13:53:00
14:10:00
14:26:00
14:43:00
15:00:00
15:16:00
15:33:00

Beam2:


Beam Current
Beam size [mm]
Time
Beam 2 BCT
Beam 2 Horizontal RMS
Beam 2 Vertical RMS
2.2e+11
2e+11
1.8e+11
1.6e+11
1.4e+11
1.2e+11
1e+11
8e+10
6e+10
4e+10
2e+10
0
2.8
2.7
2.6
2.5
2.4
2.3
2.2
2.1
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
13:53:00
14:10:00
14:26:00
14:43:00
15:00:00
15:16:00
15:33:00

Beam1:

Collapsing beams



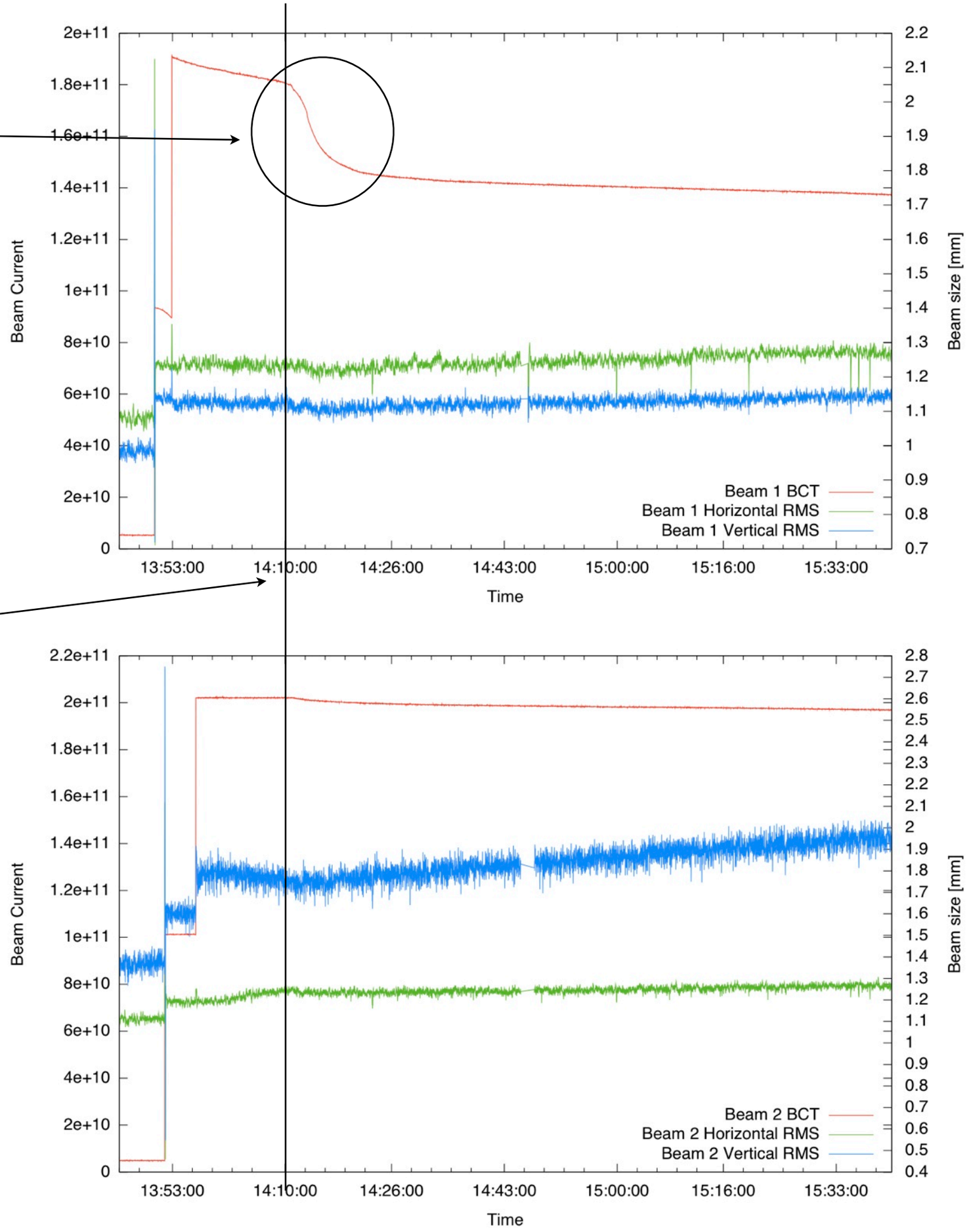
Beam2:

Before tune correction
(QH trimmed up by 0.005)

Beam1:

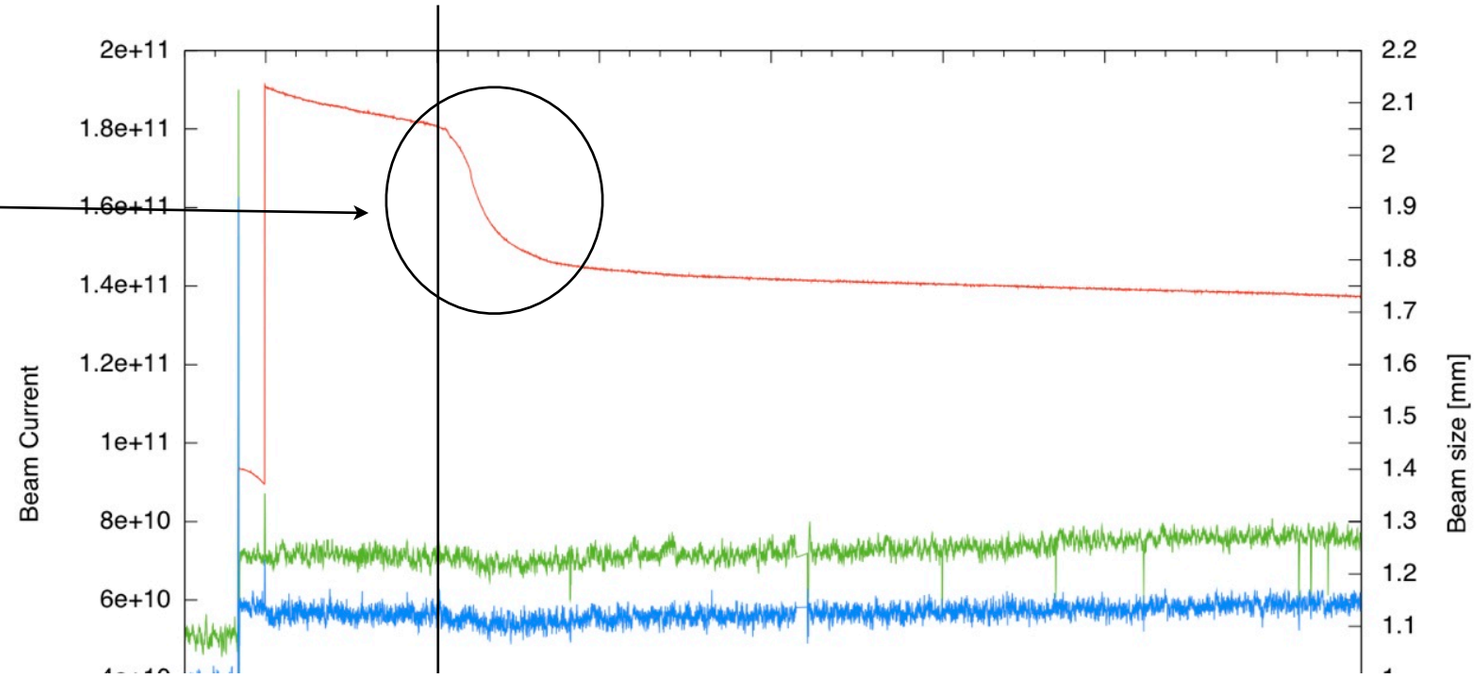
Collapsing beams

Beam2:



Before tune correction
(QH trimmed up by 0.005)

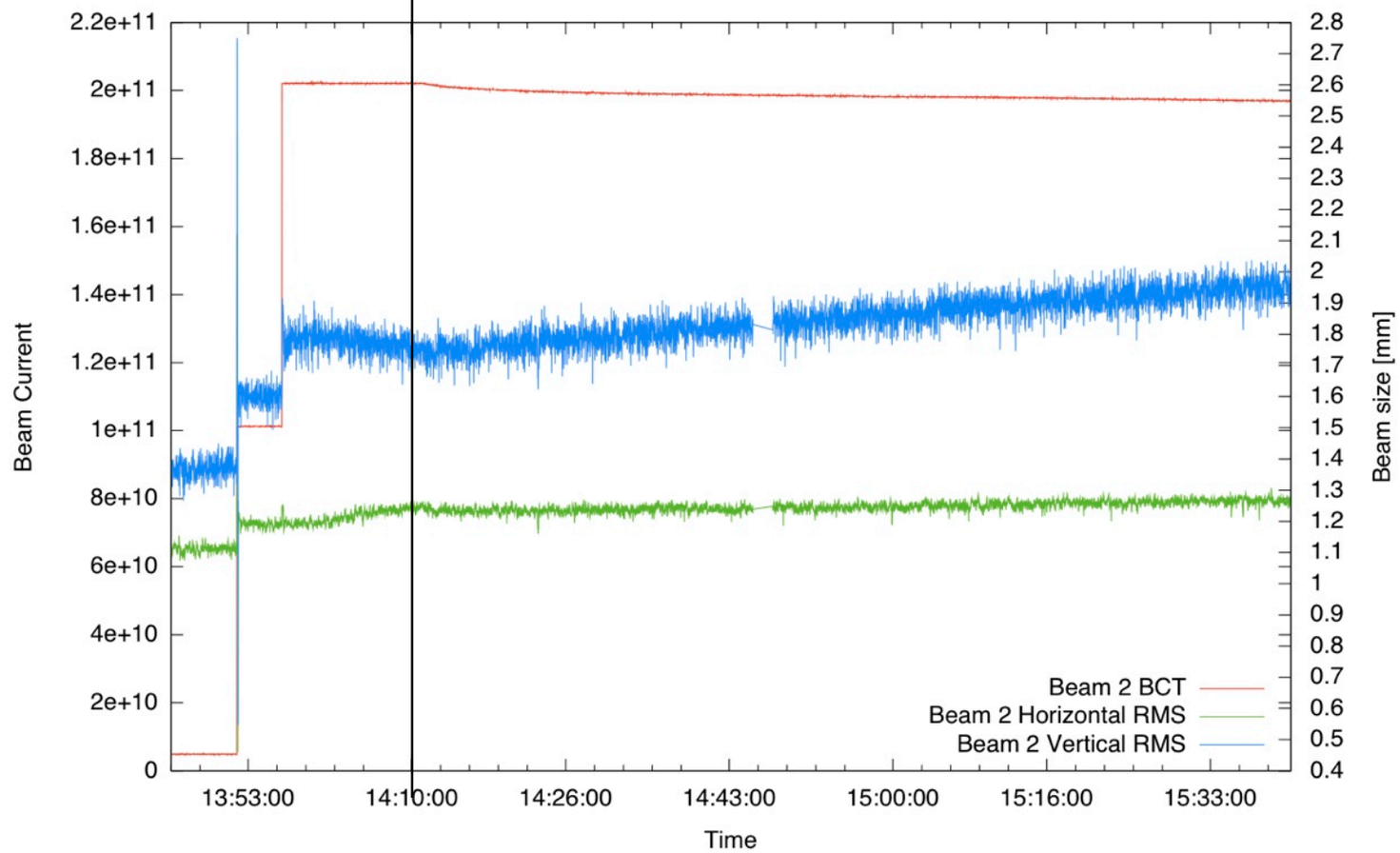
Beam1:



RMS here are only to see the trend; the absolute value must be calibrated with Wire Scanners

Collapsing beams

Beam2:

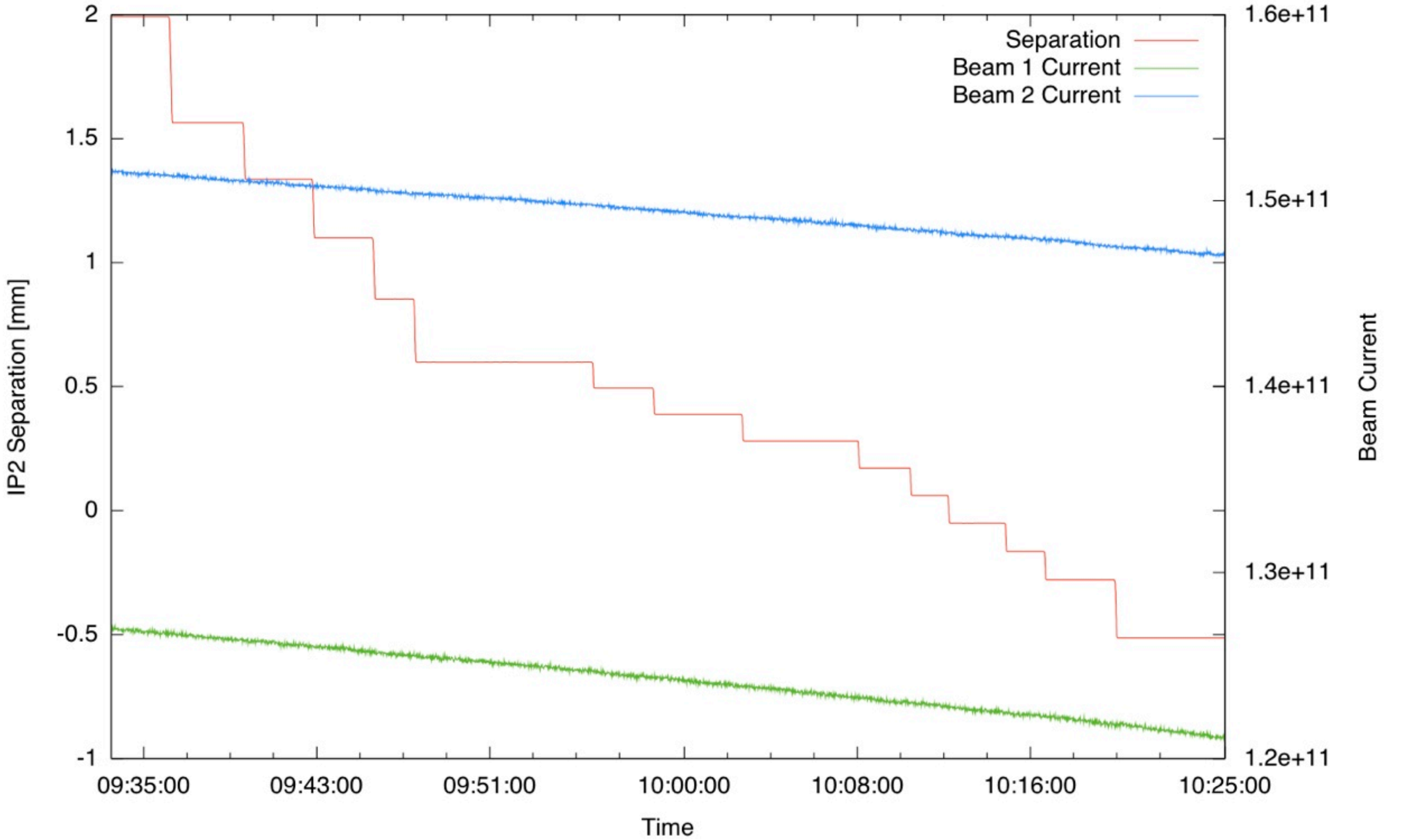


Test runs summary

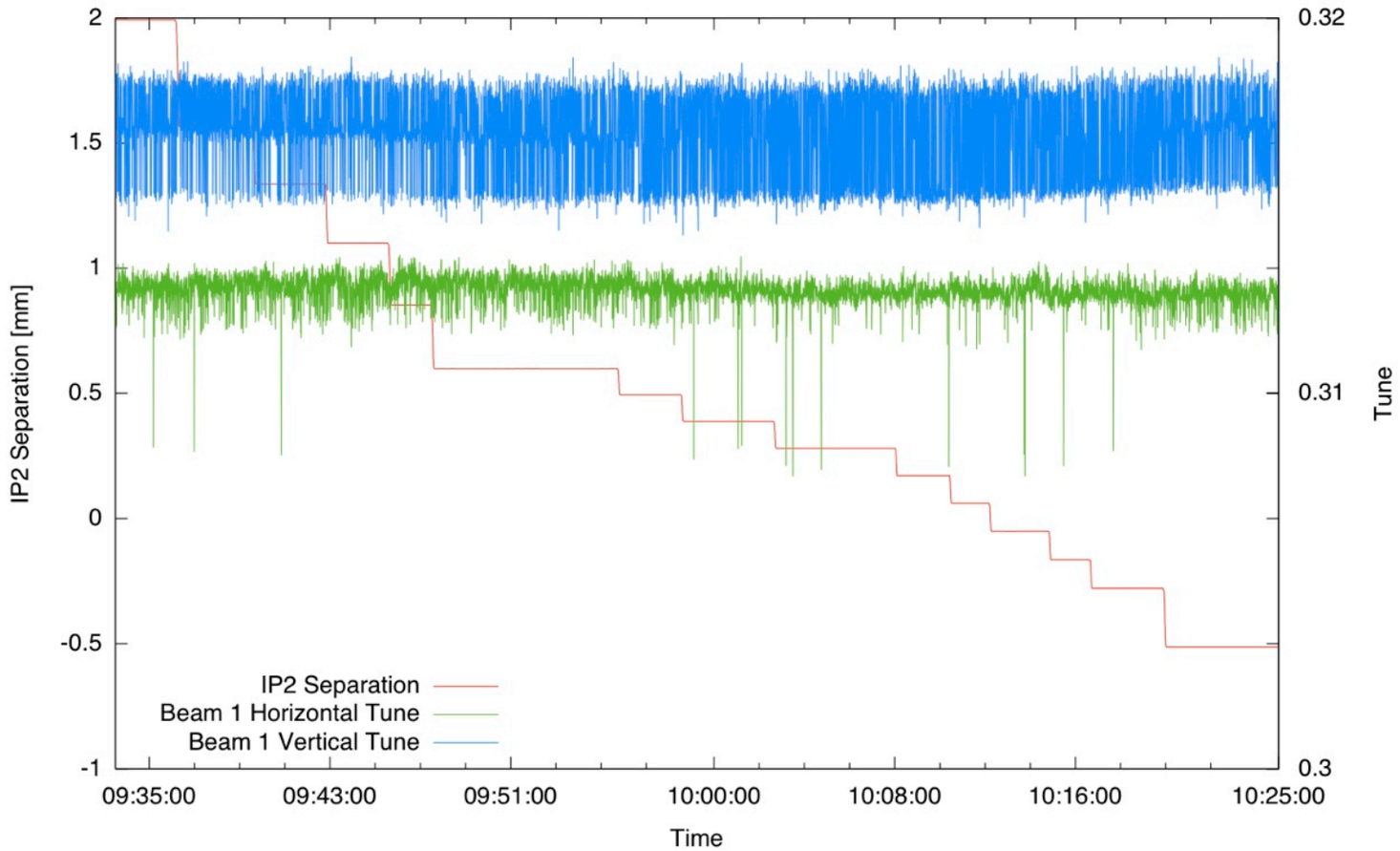
- Stability: we saw that for 10^{11} protons per bunch and full collisions and full beam-beam tune shift the lifetime was good for 10 h

- The lifetime of bunch 1 in beam 1 was worst than bunch 2, we believe because the number of collisions is different (3 vs. 1).

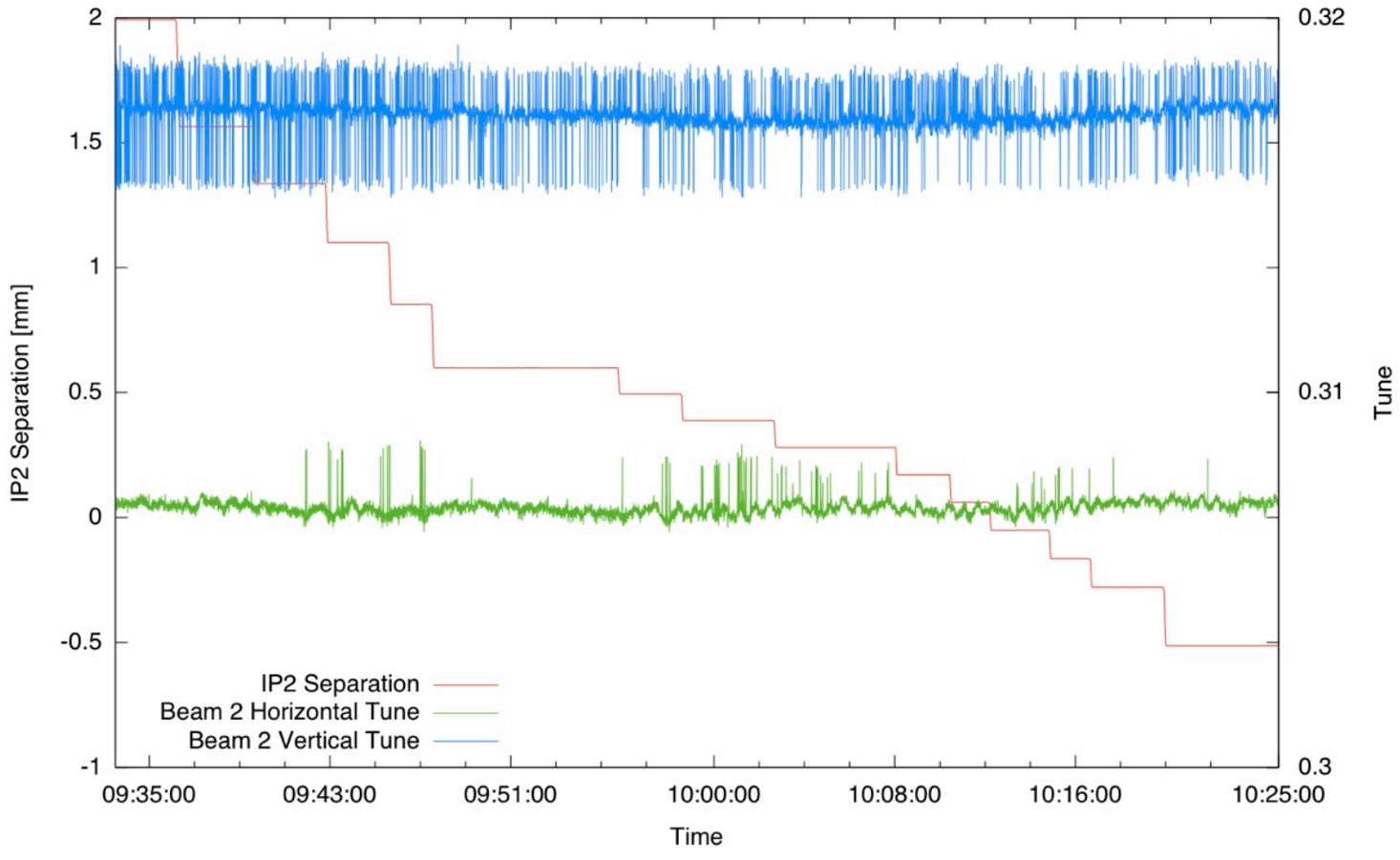
IP2 Separation scan (ALICE)



Beam1:


IP2 Separation [mm]
Tune
Time
IP2 Separation
Beam 1 Horizontal Tune
Beam 1 Vertical Tune
2
1.5
1
0.5
0
-0.5
-1
0.32
0.31
0.3
09:35:00
09:43:00
09:51:00
10:00:00
10:08:00
10:16:00
10:25:00

Beam2:


IP2 Separation [mm]
Tune
Time
IP2 Separation
Beam 2 Horizontal Tune
Beam 2 Vertical Tune
2
1.5
1
0.5
0
-0.5
-1
0.32
0.31
0.3
09:35:00
09:43:00
09:51:00
10:00:00
10:08:00
10:16:00
10:25:00

Separation scan summary

End-of-fill test separated collisions

- Test of separated collisions in ALICE
  - 09:00-10:30 3 May 2010, ADJUST, 450 GeV
  - 2 x 2 bunches, $N_b \sim 0.8 \times 10^{11}$
  - Emittance: Beam 1~nominal,
    Beam 2 ~ twice nominal
  - Beams colliding in IP1, IP5, IP8
  - Re-separated horizontally in IP2 to ±2 mm
  - Separation scanned from +2 to -0.5 mm, few minutes each point
  - No significant effects on emittance, lifetime or losses
- Encouraging for high energy operation with luminosity reduced in ALICE

Tune Viewer - LHC - Continuous B1 (FFT1.B1)

File Edit Run Timing Configure Load BI Defaults Help

RBA: Ihcop User: LHC ADJUST Continuous B1 (FFT1.B1) OFSU

Info FFT DataSets Q' FB/Trim Orbit

Q-FPGA

Tune Measurements

CERN

LHC - B1 - Fill#0.0

2010-05-03 11:32:05

RAW&FFT: 8192 turns@2.5Hz

no excitation

Q1 =	.311073	Qx =	.311577
Q2 =	.319616	Qy =	.319113
|C-| =	.004024	E =	450.1 GeV
Q'x =	???		
Q'y =	???		

Spawn TuneViewer Display

Comments:

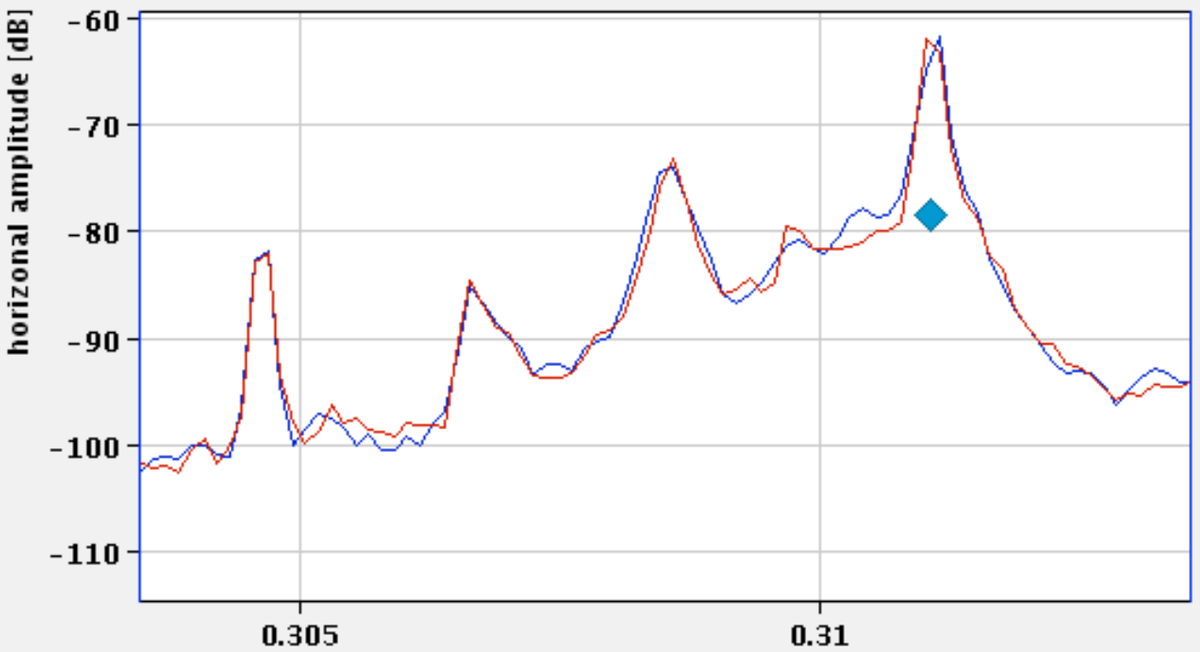
no comment

Q Q'

auto-save

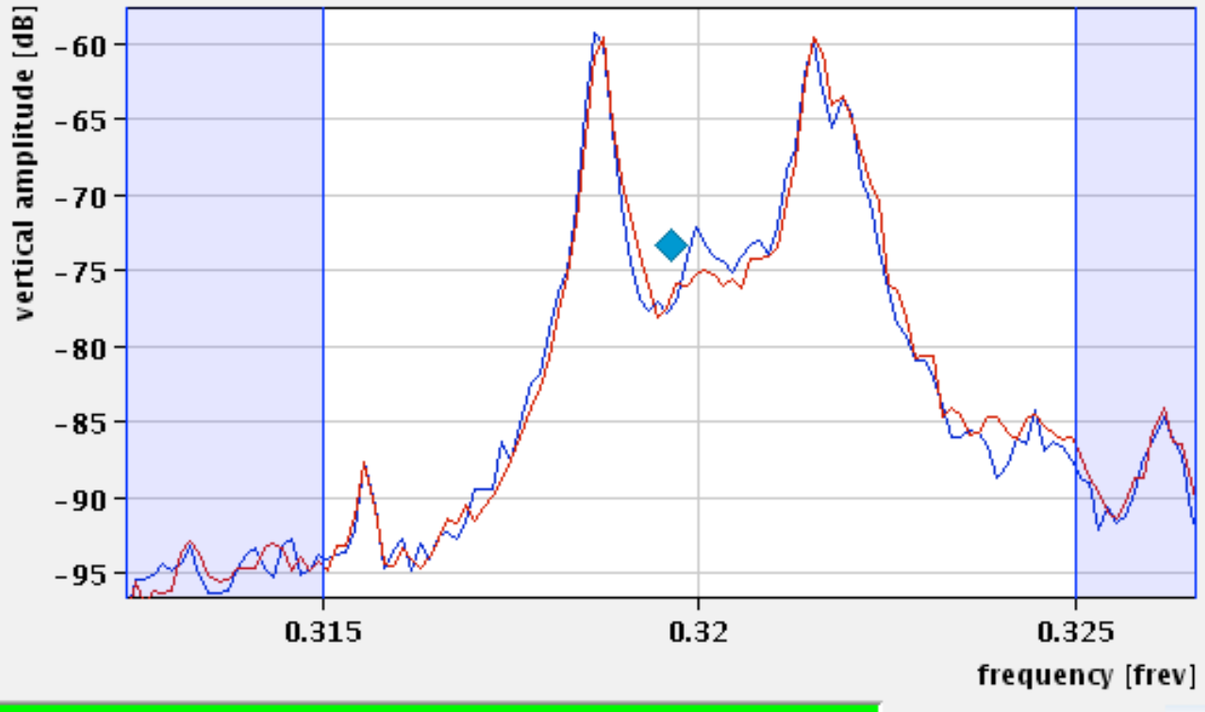
Graph Mag H ACQ# 0 Misc.

LHC - B1 - fill #0 - no comment - LHC_FFT1_B1 - 2010-05-03 11:32:05



Graph Mag V ACQ# 0 Misc.

LHC - B1 - fill #0 - no comment - LHC_FFT1_B1 - 2010-05-03 11:32:05



11:32:03 - <2> UIconf_FFT::UpdateSettings() - update read settings

Tune Viewer - LHC - Continuous B1 (FFT1.B1)

File Edit Run Timing Configure Load BI Defaults Help

RBA: Ihcop User: LHC ADJUST Continuous B1 (FFT1.B1) OFSU

Info FFT DataSets Q' FB/Trim Orbit

Q-FPGA Tune Measurements

LHC - B1 - Fill#0.0
2010-05-03 11:32:05
RAW&FFT: 8192 turns@2.5Hz
no excitation

Q'y = ???

Spawn TuneViewer Display

Comments:
no comment

Q Q' auto-save

Graph Mag H ACQ# 0 Misc.

LHC - B1 - fill #0 - no comment - LHC_FFT1_B1 - 2010-05-03 11:32:05

horizonal amplitude [dB]
-60 -70 -80 -90 -100

Two frequencies for B1, one bunch is making 3 collisions and the other 1, different BB tune shift?

LHC - B1 - fill #0 - no comment - LHC_FFT1_B1 - 2010-05-03 11:32:05

vertical amplitude [dB]
-60 -65 -70 -75 -80 -85 -90 -95

0.315 0.32 0.325
frequency [frev]

11:32:03 - <2> UIconf_FFT::UpdateSettings() - update read settings

Tune Viewer - LHC - Continuous B1 (FFT1.B1)

File Edit Run Timing Configure Load BI Defaults Help

RBA: Ihcop User: LHC ADJUST Continuous B1 (FFT1.B1) OFSU

Info FFT DataSets Q' FB/Trim Orbit

Q-FPGA

Tune Measurements

CERN

LHC - B1 - Fill#0.0

2010-05-03 11:32:05

RAW&FFT: 8192 turns@2.5Hz

no excitation

Q1 =	.311073	Qx =	.311577
Q2 =	.319616	Qy =	.319113
|C-| =	.004024	E =	450.1 GeV
Q'x =	???		
Q'y =	???		

Spawn TuneViewer Display

Comments:

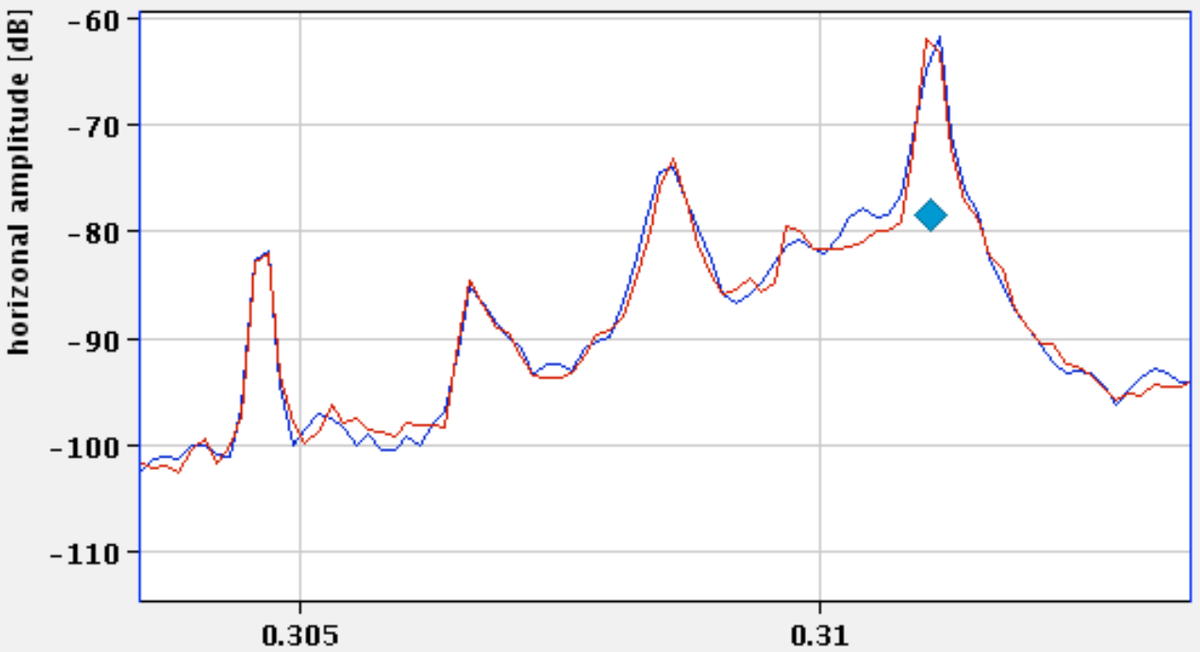
no comment

Q Q'

auto-save

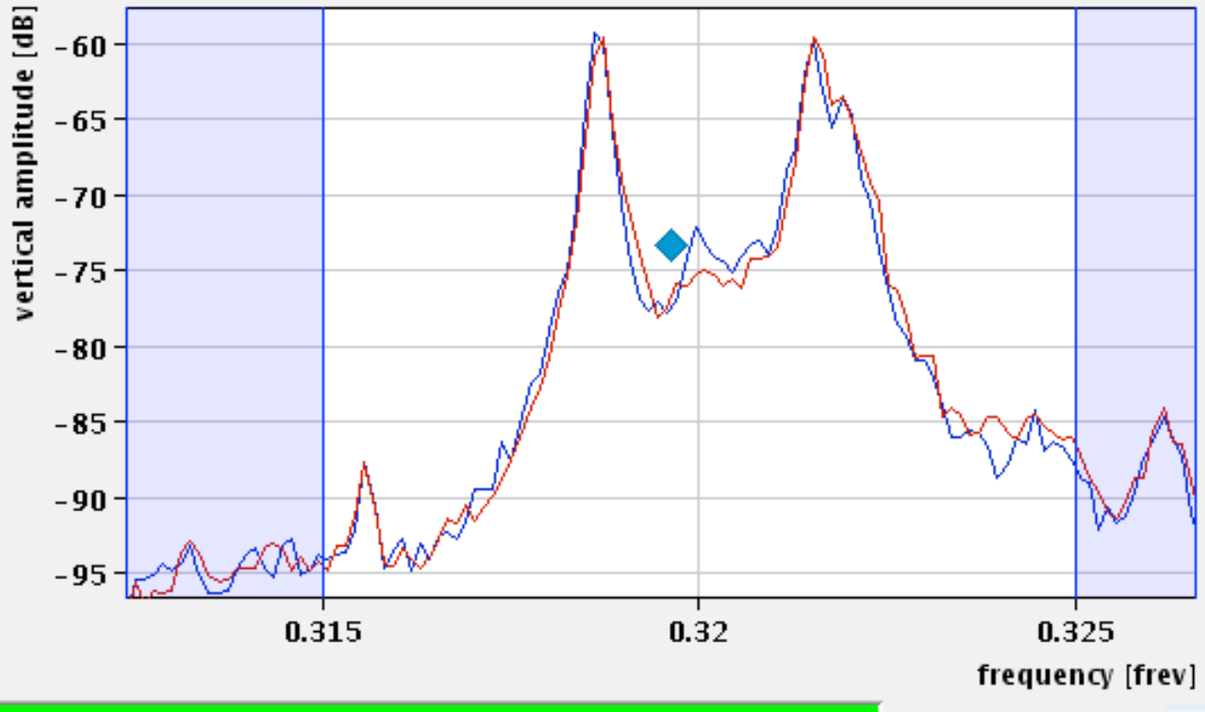
Graph Mag H ACQ# 0 Misc.

LHC - B1 - fill #0 - no comment - LHC_FFT1_B1 - 2010-05-03 11:32:05



Graph Mag V ACQ# 0 Misc.

LHC - B1 - fill #0 - no comment - LHC_FFT1_B1 - 2010-05-03 11:32:05



11:32:03 - <2> UIconf_FFT::UpdateSettings() - update read settings

Tune Viewer - LHC - Continuous B1 (FFT1.B1)

Help

IP2 Separation

IP8 Separation

IP5 Separation

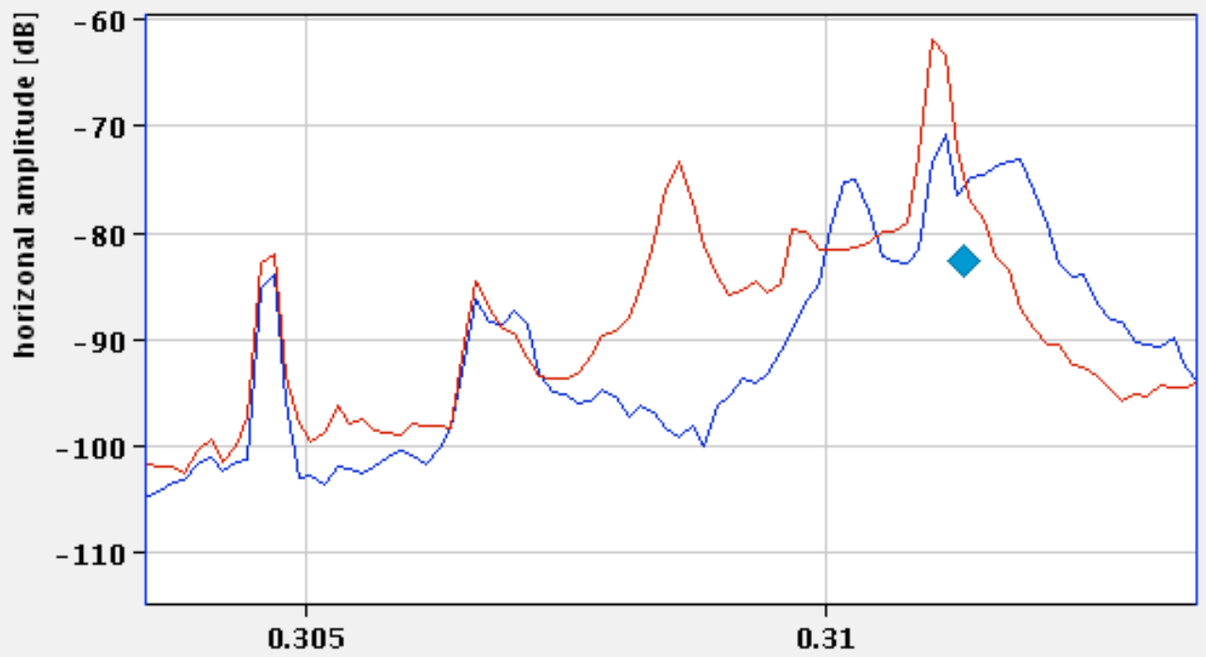
FFT1.B1) OFSU

LHC - B1 - Fill#0.0
2010-05-03 11:42:35
RAW&FFT: 8192 turns@2.5Hz
no excitation

Q1 =	.311339	Qx =	.311946
Q2 =	.321558	Qy =	.320950
|C-| =	.004833	E =	450.1 GeV
Q'x =	???		
Q'y =	???		

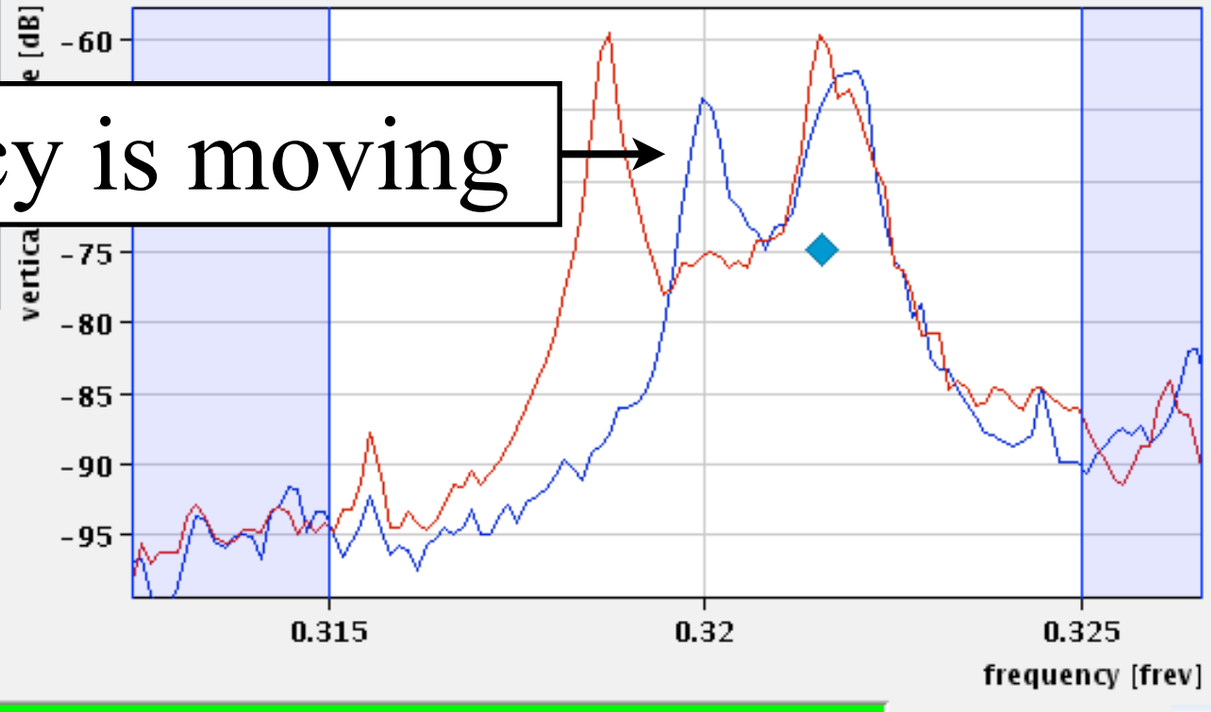
Graph Mag H ACQ# 0 Misc.

LHC - B1 - fill #0 - no comment - LHC_FFT1_B1 - 2010-05-03 11:42:35



Graph Mag V ACQ# 0 Misc.

LHC - B1 - fill #0 - no comment - LHC_FFT1_B1 - 2010-05-03 11:42:35



Second frequency is moving →

Spawn TuneViewer Display

Comments:
no comment

Q Q' auto-save

11:42:30 - <2> getActiveBeamProcess() - refresh LSA cache

Tune Viewer - LHC - Continuous B1 (FFT1.B1)

Help

No collisions

FFT1.B1) OFSU

Info | FFT | DataSets | Q' | FB/Trim | Orbit

Q-FPGA
Tune Measurements

LHC - B1 - Fill#0.0
2010-05-03 11:45:51
RAW&FFT: 8192 turns@2.5Hz
no excitation

Q1 =	.311780	Qx =	.312395
Q2 =	.321862	Qy =	.321246
|C-| =	.004829	E =	450.2 GeV
Q'x =	???		
Q'y =	???		

Graph | Mag | H | ACQ# 0 | Misc.

LHC - B1 - fill #0 - no comment - LHC_FFT1_B1 - 2010-05-03 11:45:51

horizonal amplitude [dB]: -60, -70, -80, -90, -100, -110

0.305, 0.31

frequency [frev]

Graph | Mag | V | ACQ# 0 | Misc.

LHC - B1 - fill #0 - no comment - LHC_FFT1_B1 - 2010-05-03 11:45:51

vertical amplitude [dB]: -60, -75, -80, -85, -90, -95, -100

0.315, 0.32, 0.325

frequency [frev]

Only one frequency

Spawn TuneViewer Display

Comments:
no comment

Q | Q' | auto-save

11:45:50 - <2> UIconf_FFT::UpdateSettings() - update read settings

Estimate of tune-shift

$$\Delta Q = \frac{1}{4\pi} r_p \frac{N_p}{\epsilon_n}$$

In this fill, the emittance and charge per bunch (**for B1** that acts on B2) are:

$$\epsilon_n \approx 3 \cdot 10^{-6}, \;\; N \approx 0.7 \cdot 10^{11}$$

$$\Delta Q \approx -2.8 \cdot 10^{-3}$$

and **for B2** that acts on B1are:

$$\epsilon_n \approx 7 \cdot 10^{-6}, \;\; N \approx 0.7 \cdot 10^{11}$$

$$\Delta Q \approx -1.22 \cdot 10^{-3}$$

for B1 one bunch see 3 encounters and the other bunch 1, so the difference in tune is:

$$\boxed{2\Delta Q \approx -2.44 \cdot 10^{-3}}$$

Tune Viewer - LHC - Continuous B1 (FFT1.B1)

File Edit Run Timing Configure Load BI Defaults Help

RBA: Ihcop User: LHC ADJUST Continuous B1 (FFT1.B1) OFSU

Info FFT DataSets Q' FB/Trim Orbit

Q-FPGA

Tune Measurements

CERN

LHC - B1 - Fill#0.0

2010-05-03 11:32:05

RAW&FFT: 8192 turns@2.5Hz

no excitation

Q1 =	.311073	Qx =	.311577
Q2 =	.319616	Qy =	.319113
|C-| =	.004024	E =	450.1 GeV
Q'x =	???		
Q'y =	???		

Spawn TuneViewer Display

Comments:

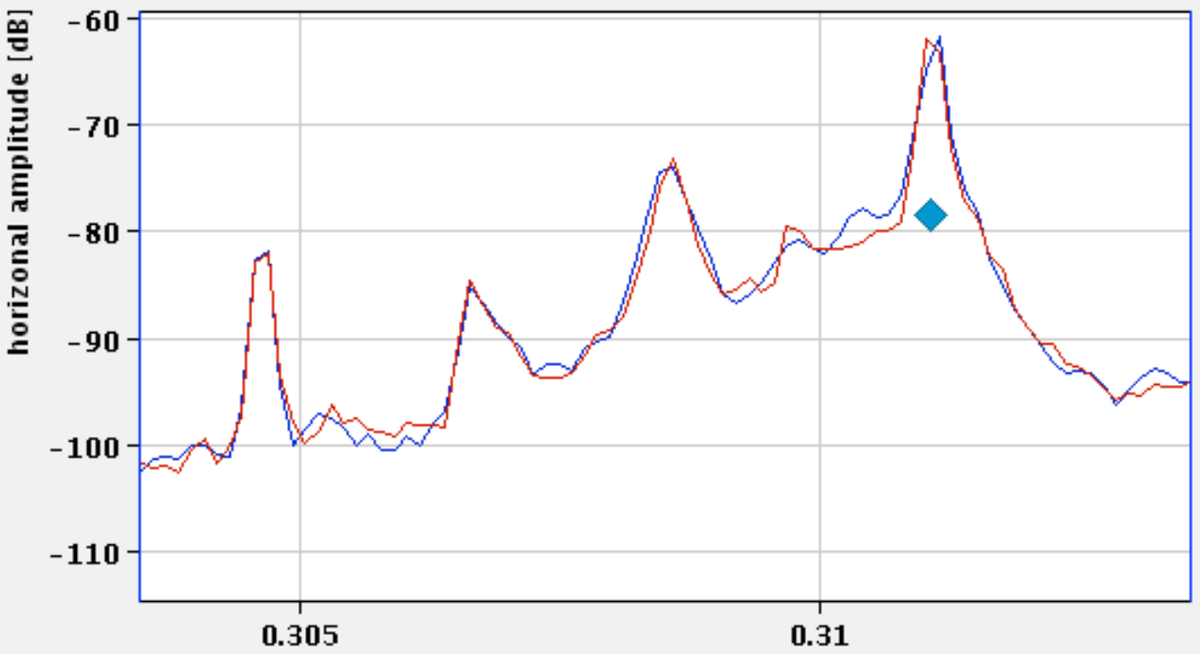
no comment

Q Q'

auto-save

Graph Mag H ACQ# 0 Misc.

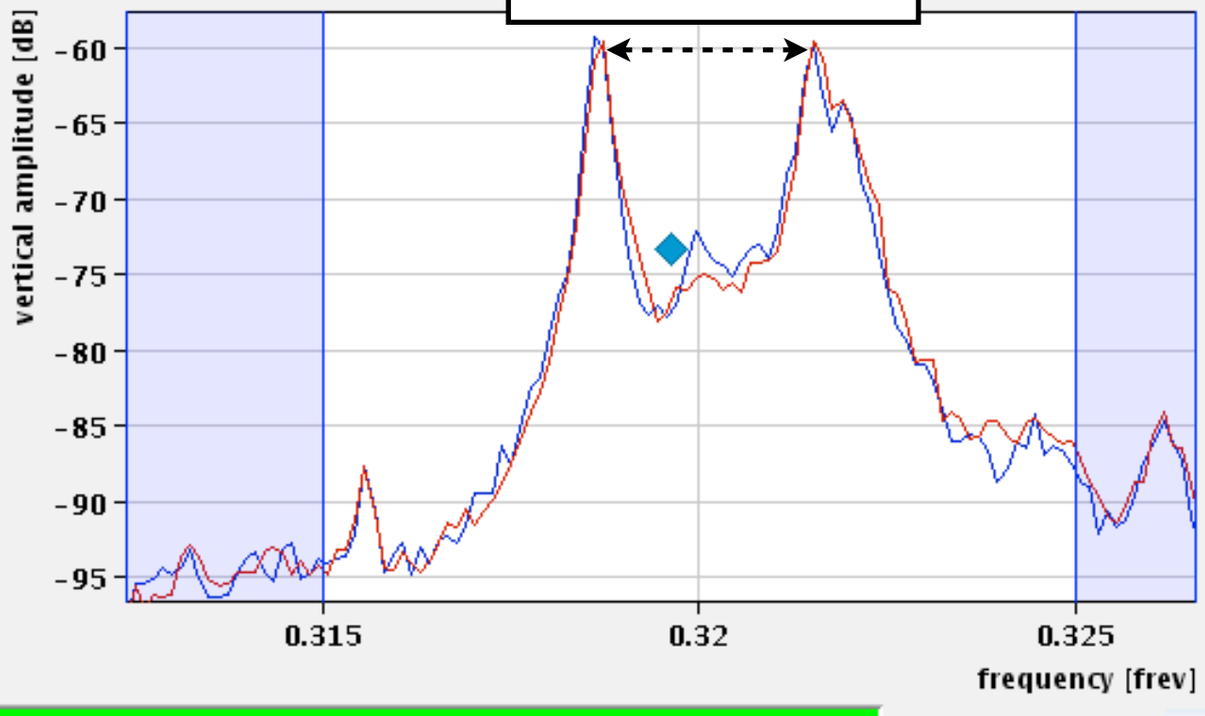
LHC - B1 - fill #0 - no comment - LHC_FFT1_B1 - 2010-05-03 11:32:05



Graph Mag V Misc.

LHC - B1 - fill #0 - no comment - LH 32:05

~2.8e-3



11:32:03 - <2> UIconf_FFT::UpdateSettings() - update read settings

Summary

- Successfully collided bunches with (about) nominal intensity and tune shift at 450 GeV, asymmetric collision scheme (PACMAN effects observed as expected) collision data taken by experiments.

- Good beam lifetime, no deterioration due to beam-beam effects.

- No lifetime problems when beams still separated.

- Separation scan done in ALICE: no detrimental effect on beam, stability of collision point to be checked.

- Done or partially done: tune scan and beam-beam deflection scan (to be analyzed).

- Highly desirable: bunch-by-bunch diagnostics.