ICE Section meeting
September 15th, 2010

Beam-Beam tune shift and long range interactions observations.

Emanuele Laface

Head-on tune shift measurements.

May 2nd and 3rd, 2010

https://lhc-commissioning.web.cern.ch/lhc-commissioning/meetings/20100504/ELaface.pdf

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

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:

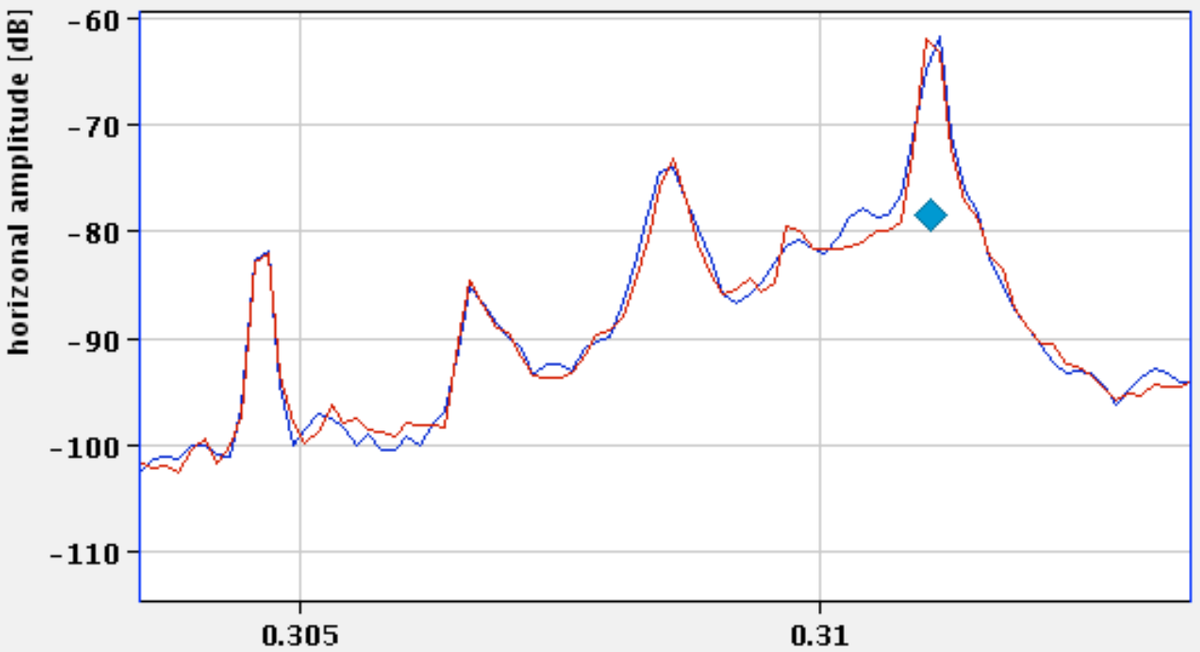
no comment

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



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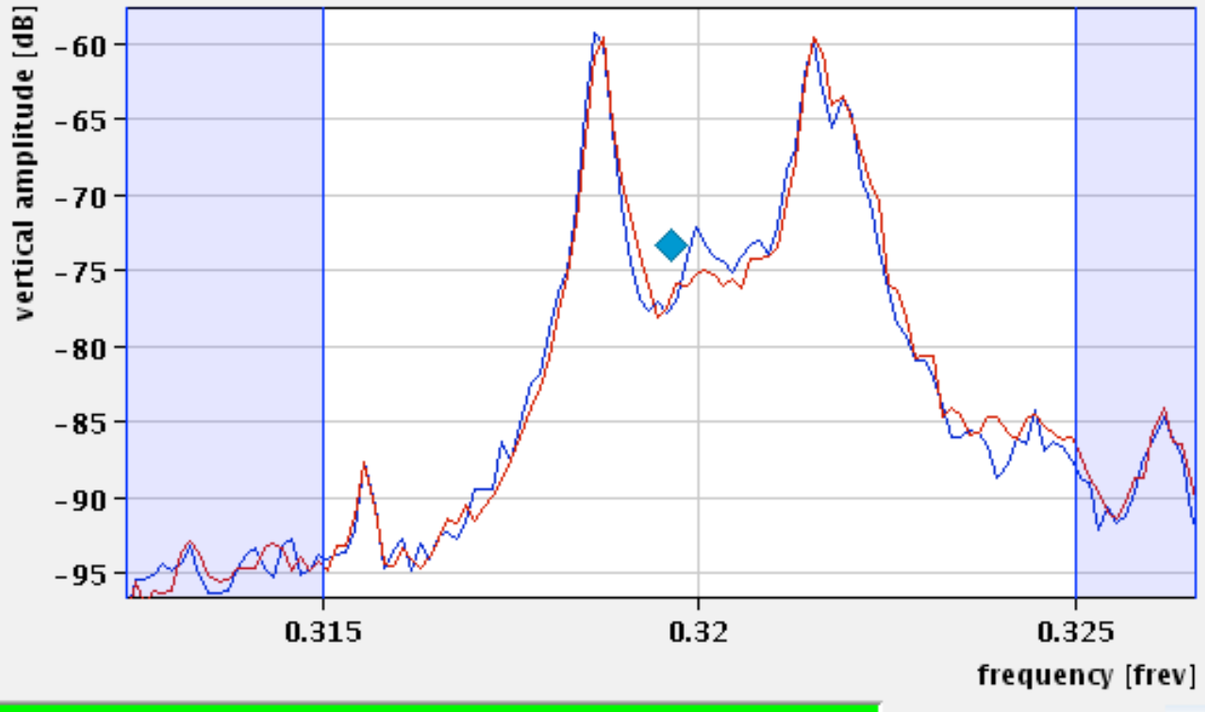

11:32:03 - <2> UIconf_FFT::UpdateSettings() - update read settings

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

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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

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Spawn TuneViewer Display

Comments:

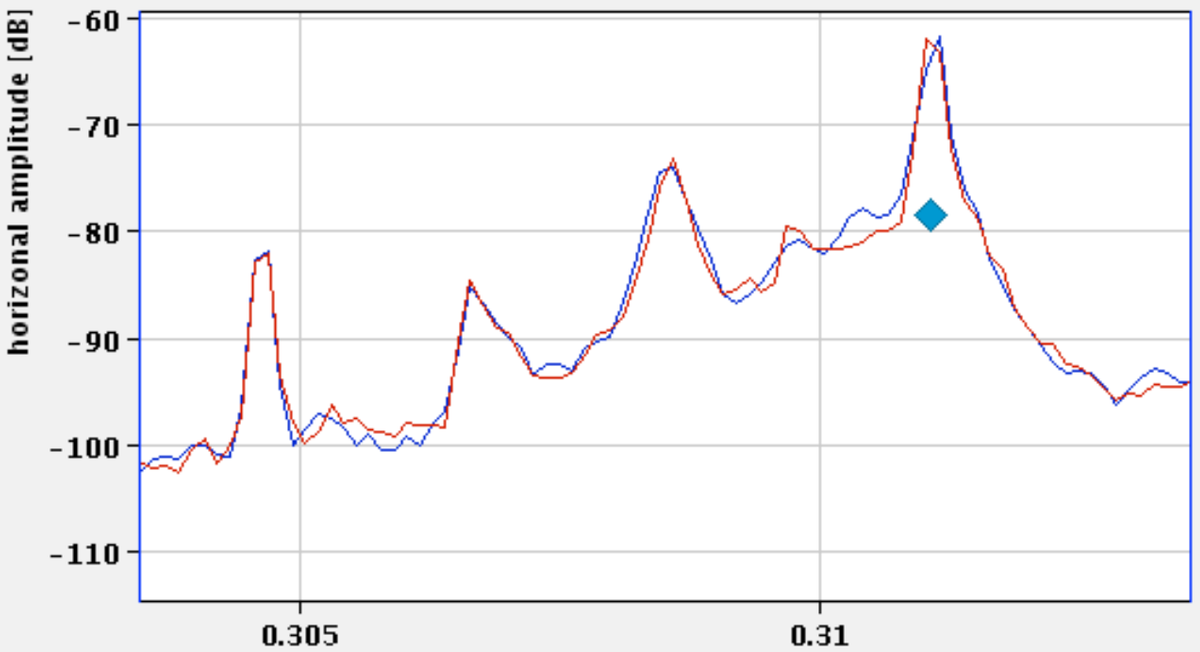
no comment

Q Q'

auto-save

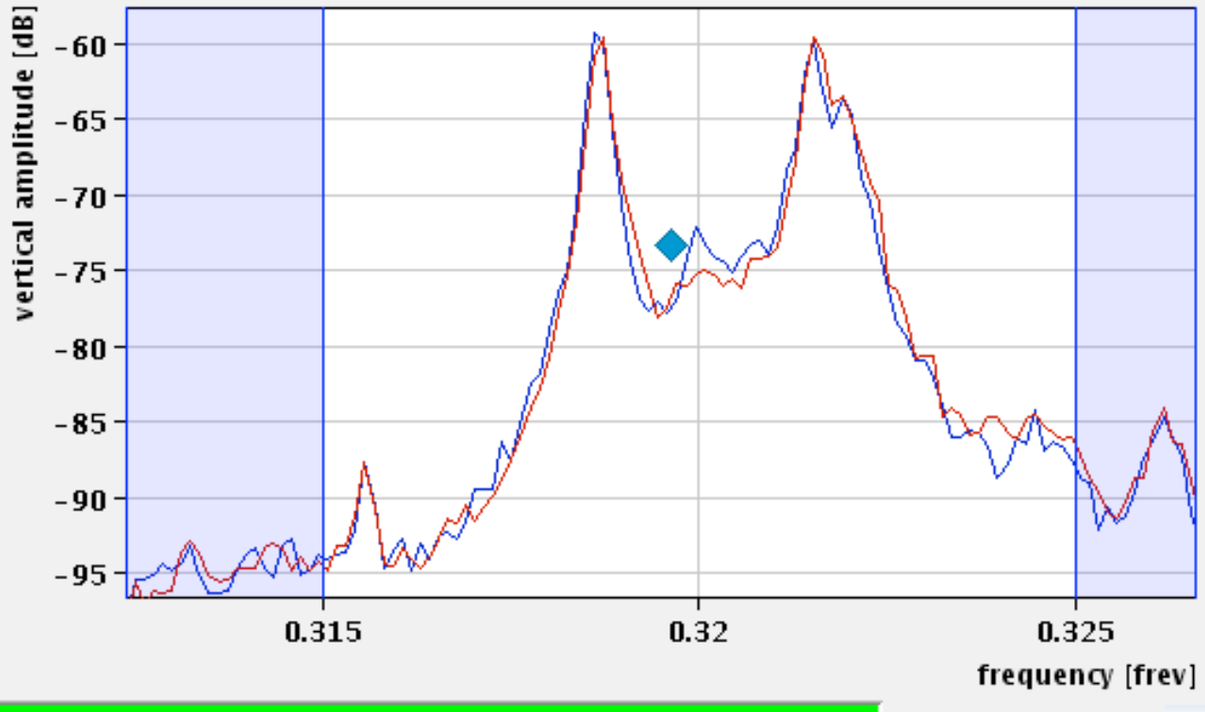
Graph Mag H ACQ# 0 Misc.

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

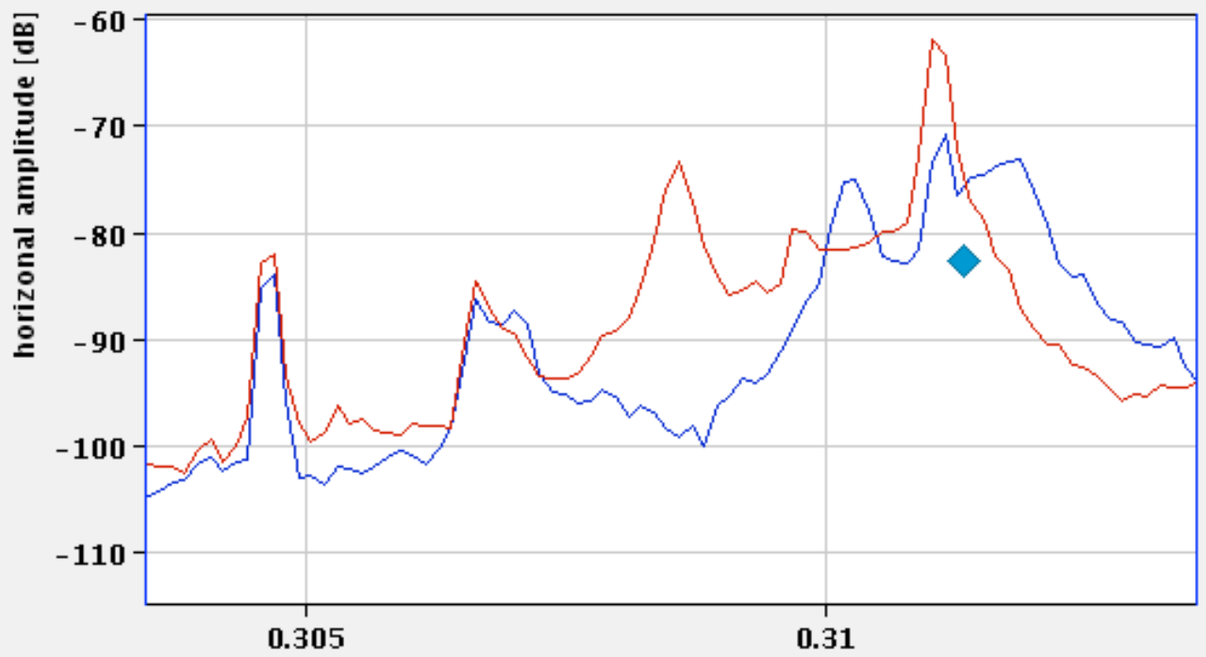
FFT1.B1) OFSU

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 =	???		

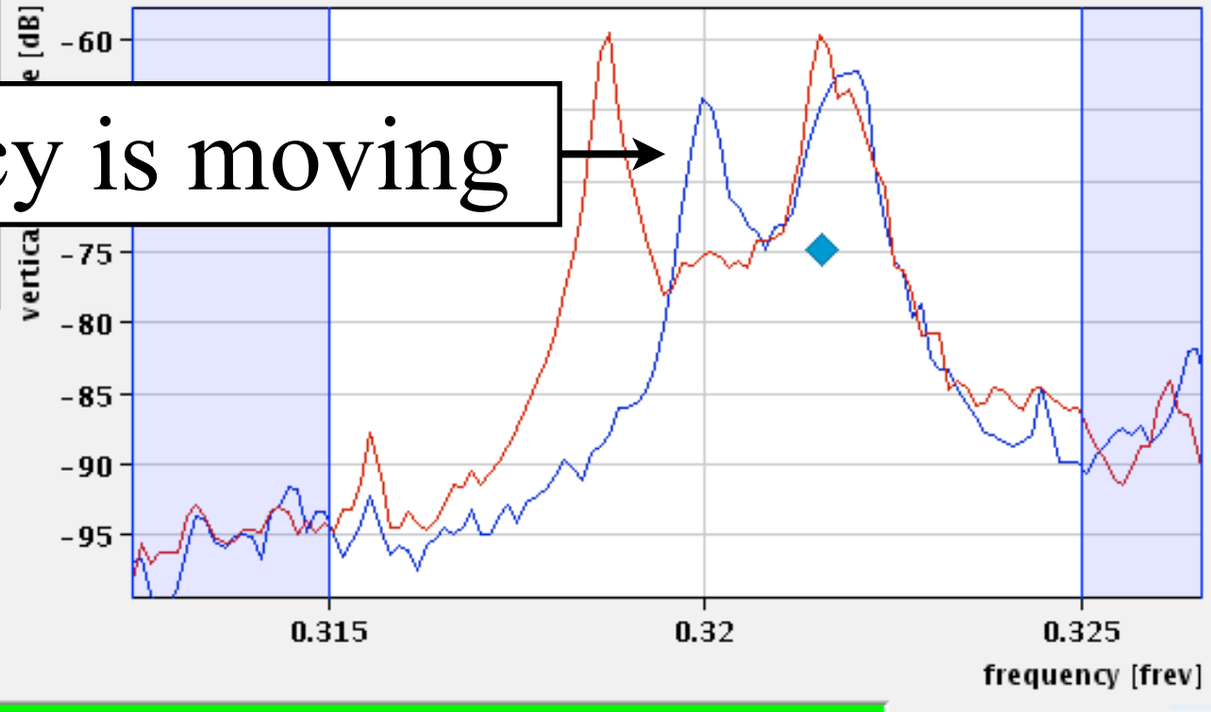
Graph Mag H ACQ# 0 Misc.

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)

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Q-FPGA

Tune Measurements

CERN

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Q'y =	???		

Spawn TuneViewer Display

Comments:

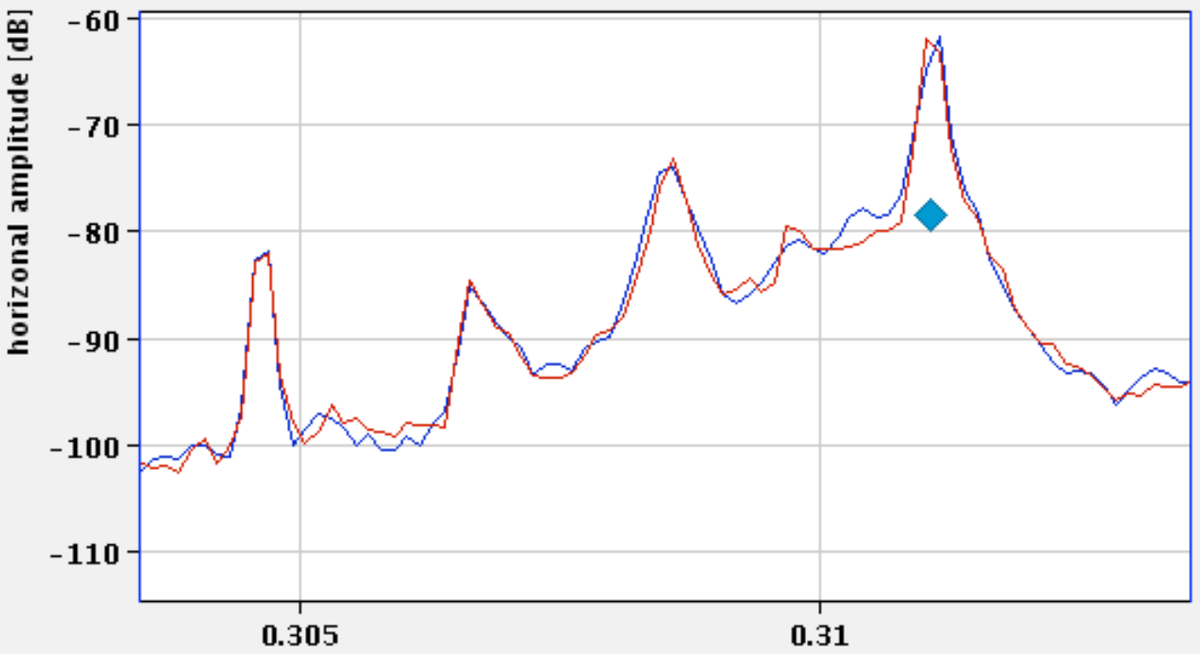
no comment

Q Q'

auto-save

Graph Mag H ACQ# 0 Misc.

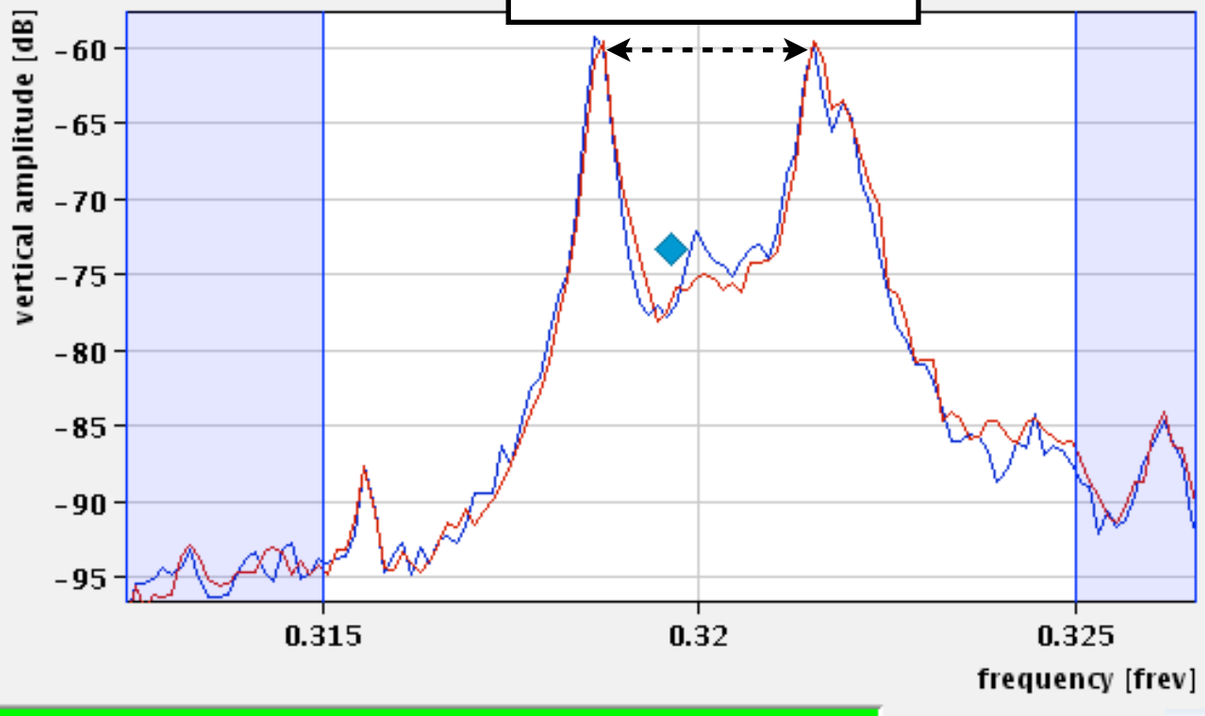
LHC - B1 - fill #0 - no comment - LHC_FFT1_B1 - 2010-05-03 11:32:05



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

Long range measurements.

September 10th, 2010

Conditions

- 28 bunches per beam, in 4 trains of 150 ns.

- 1 train of 4 bunches and 3 trains of 8 bunches.

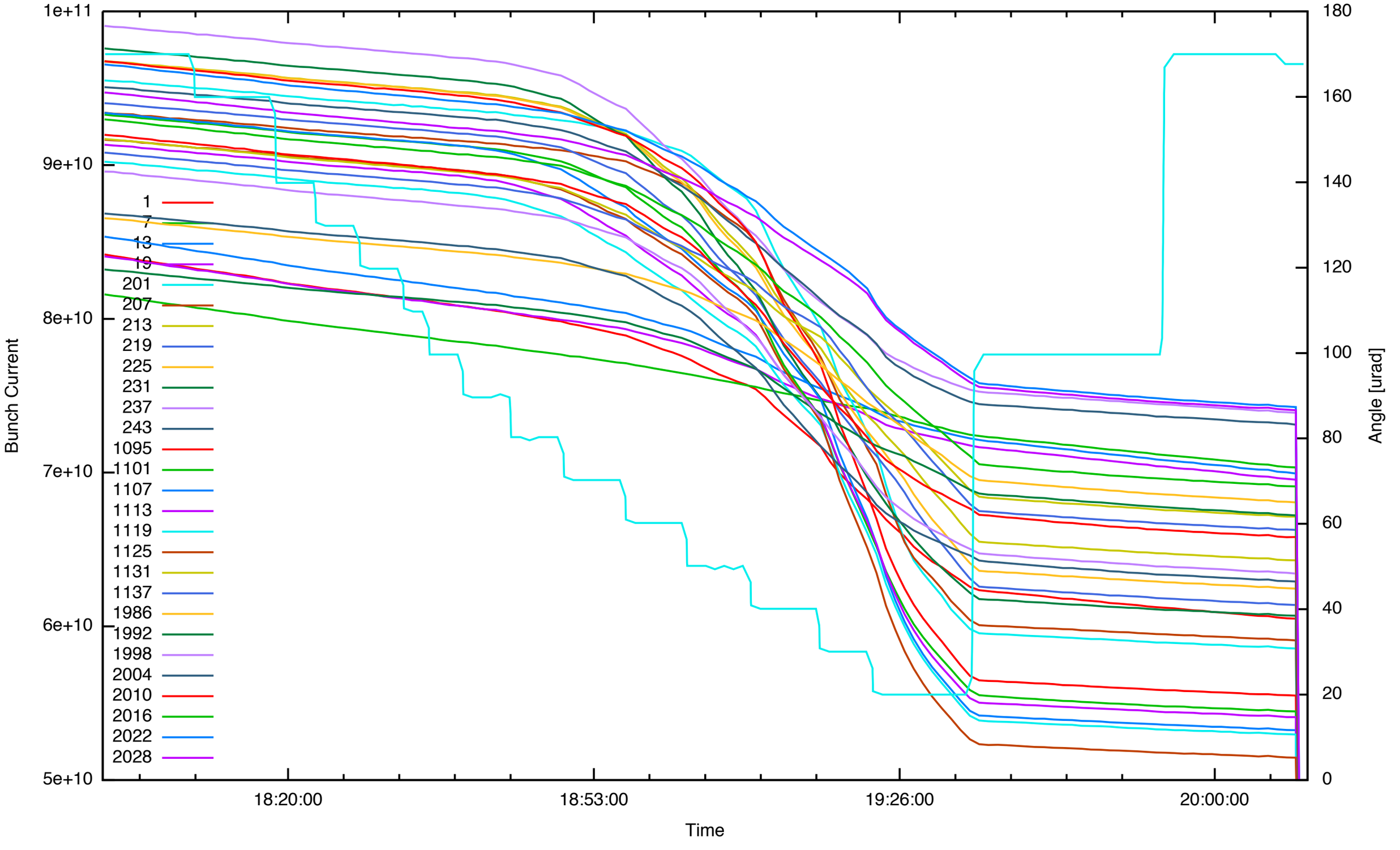
- 10^{11} protons per bunch at injection energy.

- 4 to 20 collisions per bunch.

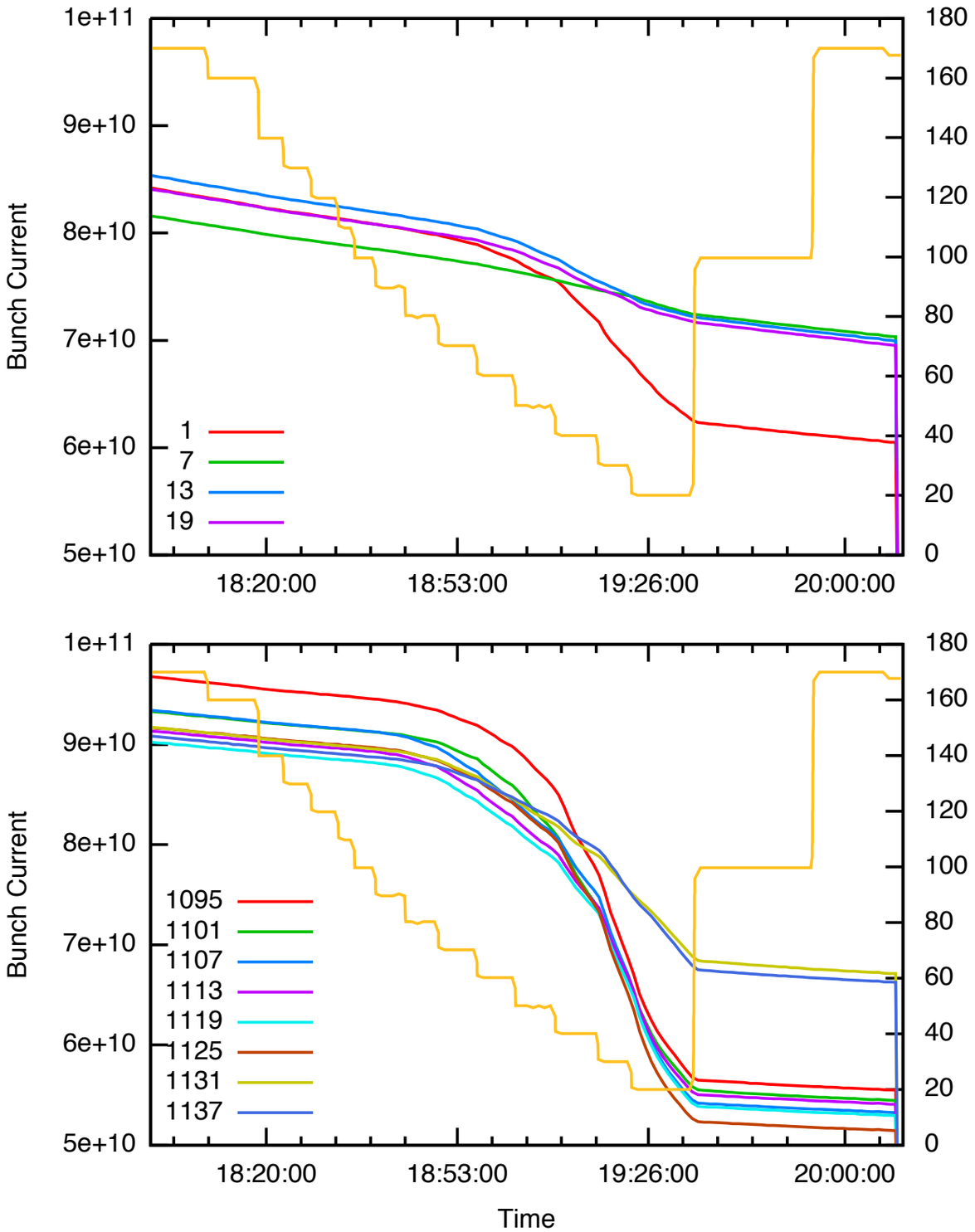
- Parallel separation > 3 σ (at nominal emittance).

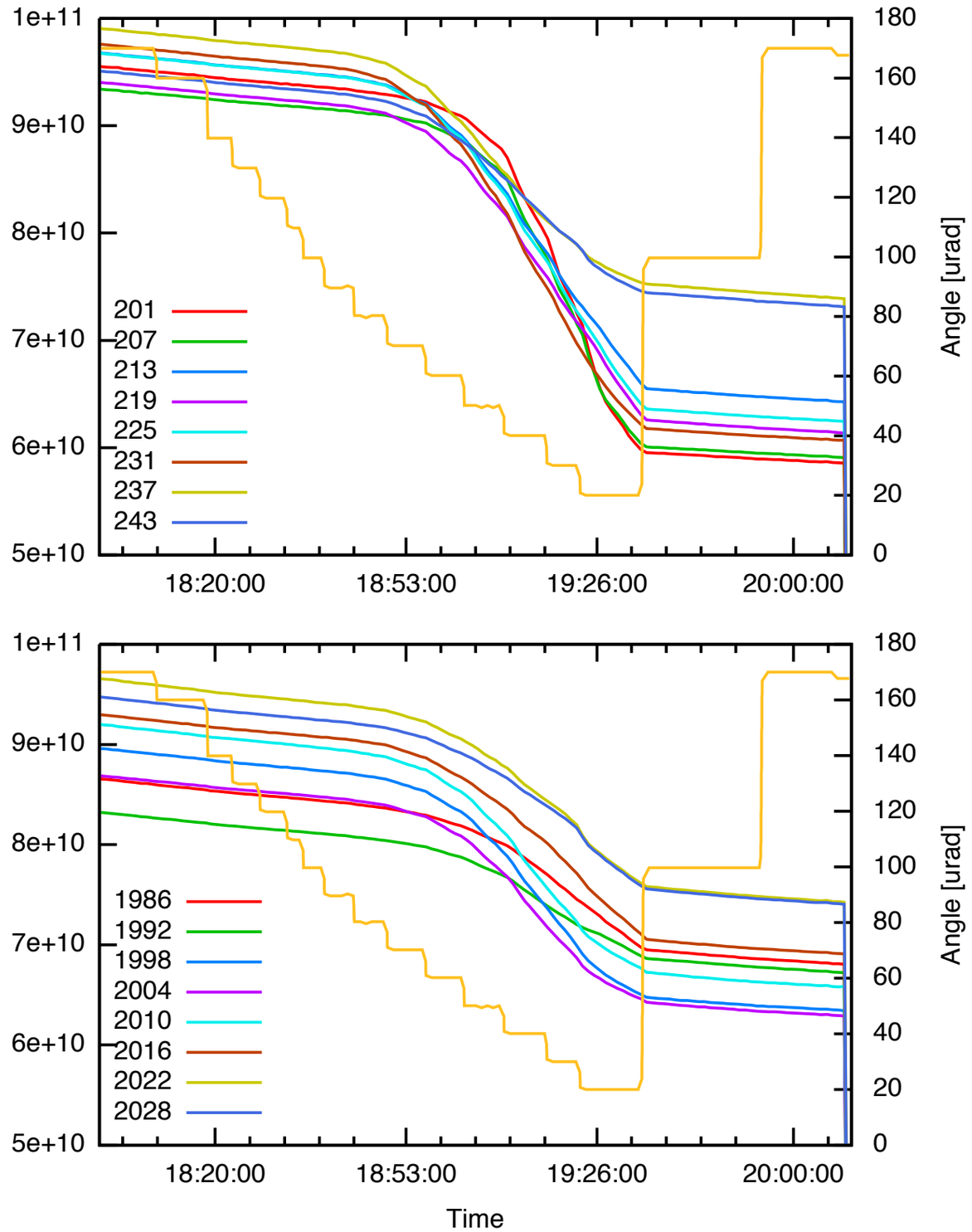
- Initial crossing angle of 170 μrad ($\sim$14 σ).

Beam 1


1e+11
9e+10
8e+10
7e+10
6e+10
5e+10
Bunch Current
180
160
140
120
100
80
60
40
20
0
Angle [urad]
18:20:00
18:53:00
19:26:00
20:00:00
Time
1
7
13
19
201
207
213
219
225
231
237
243
1095
1101
1107
1113
1119
1125
1131
1137
1986
1992
1998
2004
2010
2016
2022
2028

Beam 1

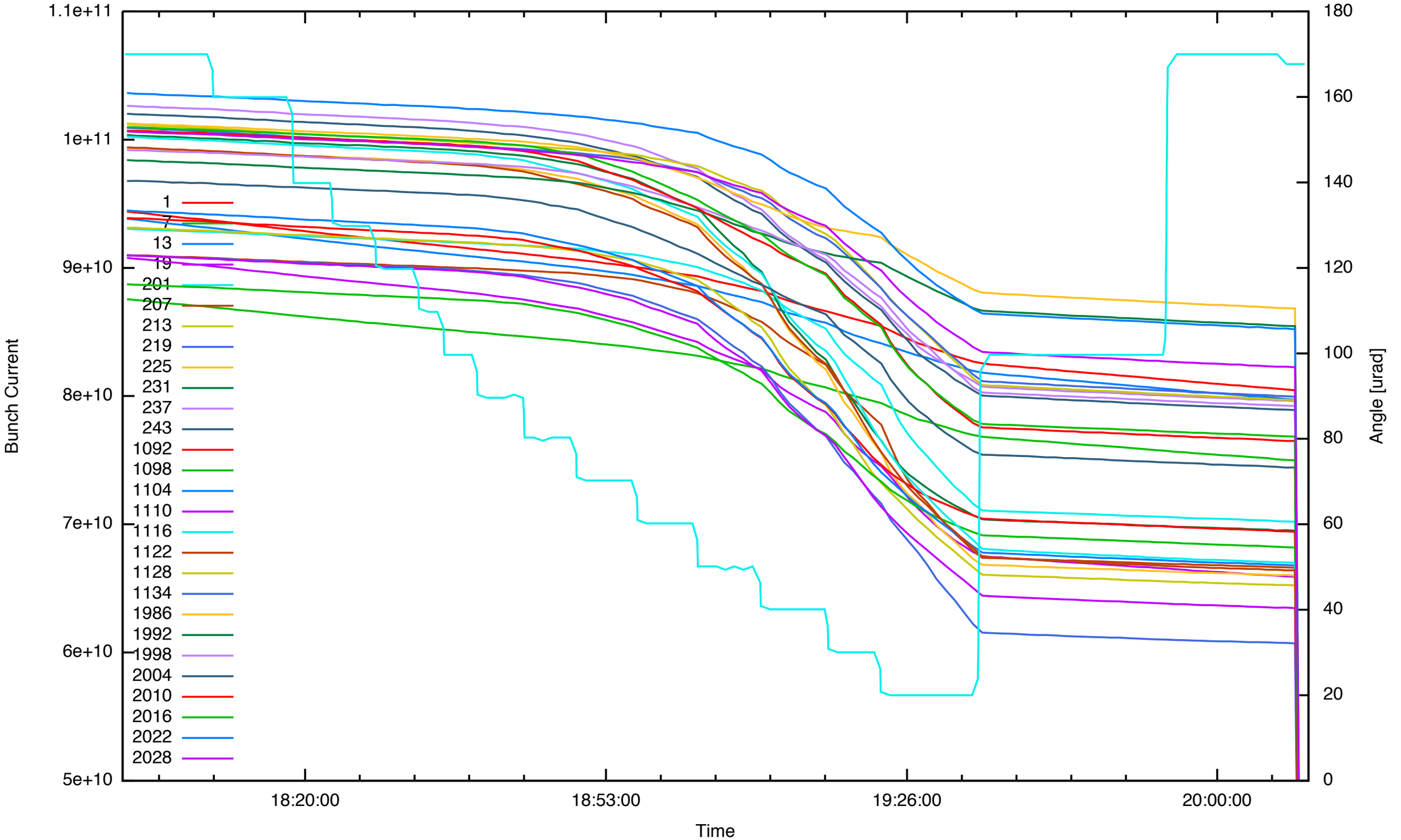

Bunch Current
1e+11
9e+10
8e+10
7e+10
6e+10
5e+10
180
160
140
120
100
80
60
40
20
0
1
7
13
19
18:20:00
18:53:00
19:26:00
20:00:00


1e+11
9e+10
8e+10
7e+10
6e+10
5e+10
180
160
140
120
100
80
60
40
20
0
Angle [urad]
201
207
213
219
225
231
237
243
18:20:00
18:53:00
19:26:00
20:00:00

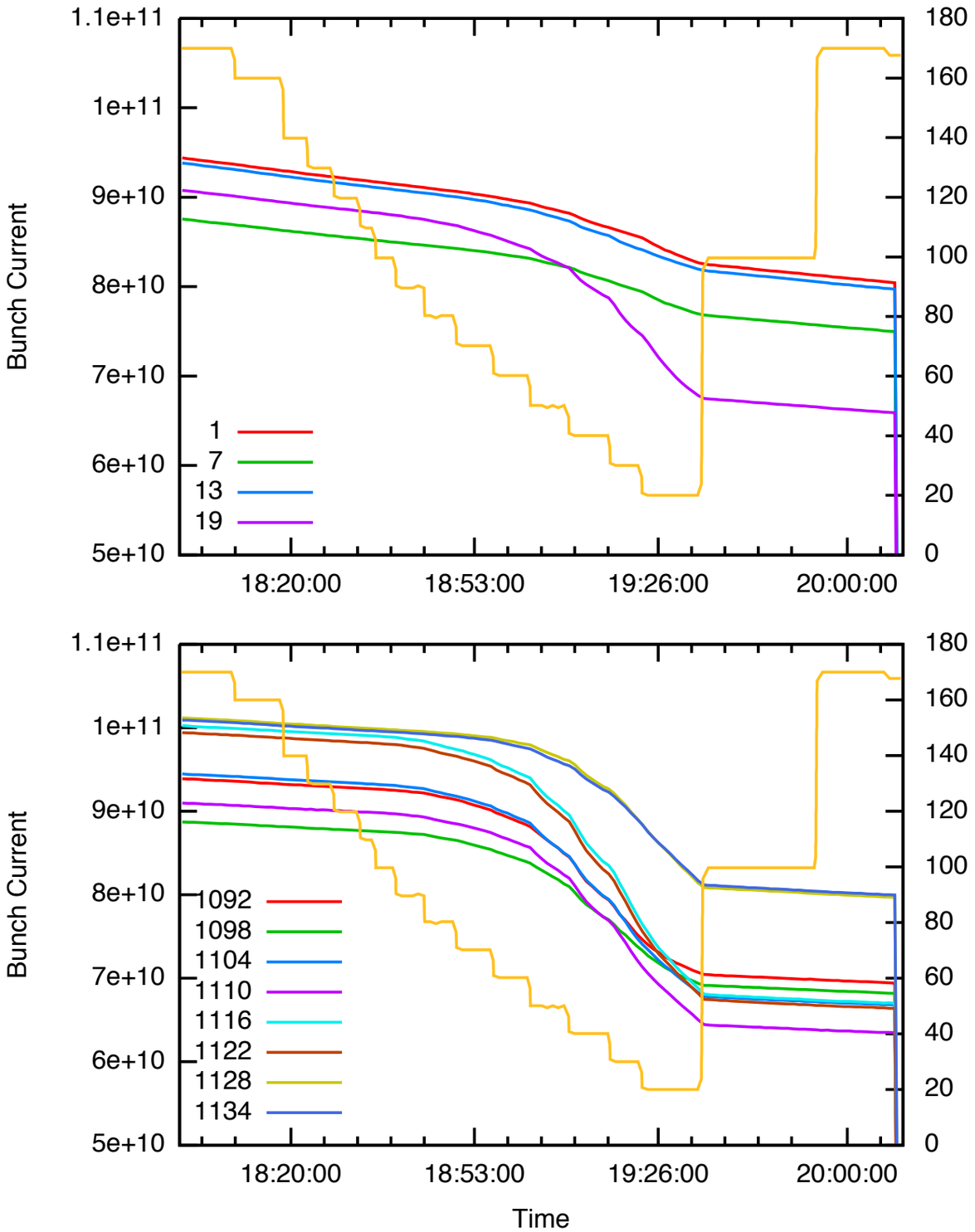
Bunch Current
1e+11
9e+10
8e+10
7e+10
6e+10
5e+10
180
160
140
120
100
80
60
40
20
0
1095
1101
1107
1113
1119
1125
1131
1137
18:20:00
18:53:00
19:26:00
20:00:00
Time

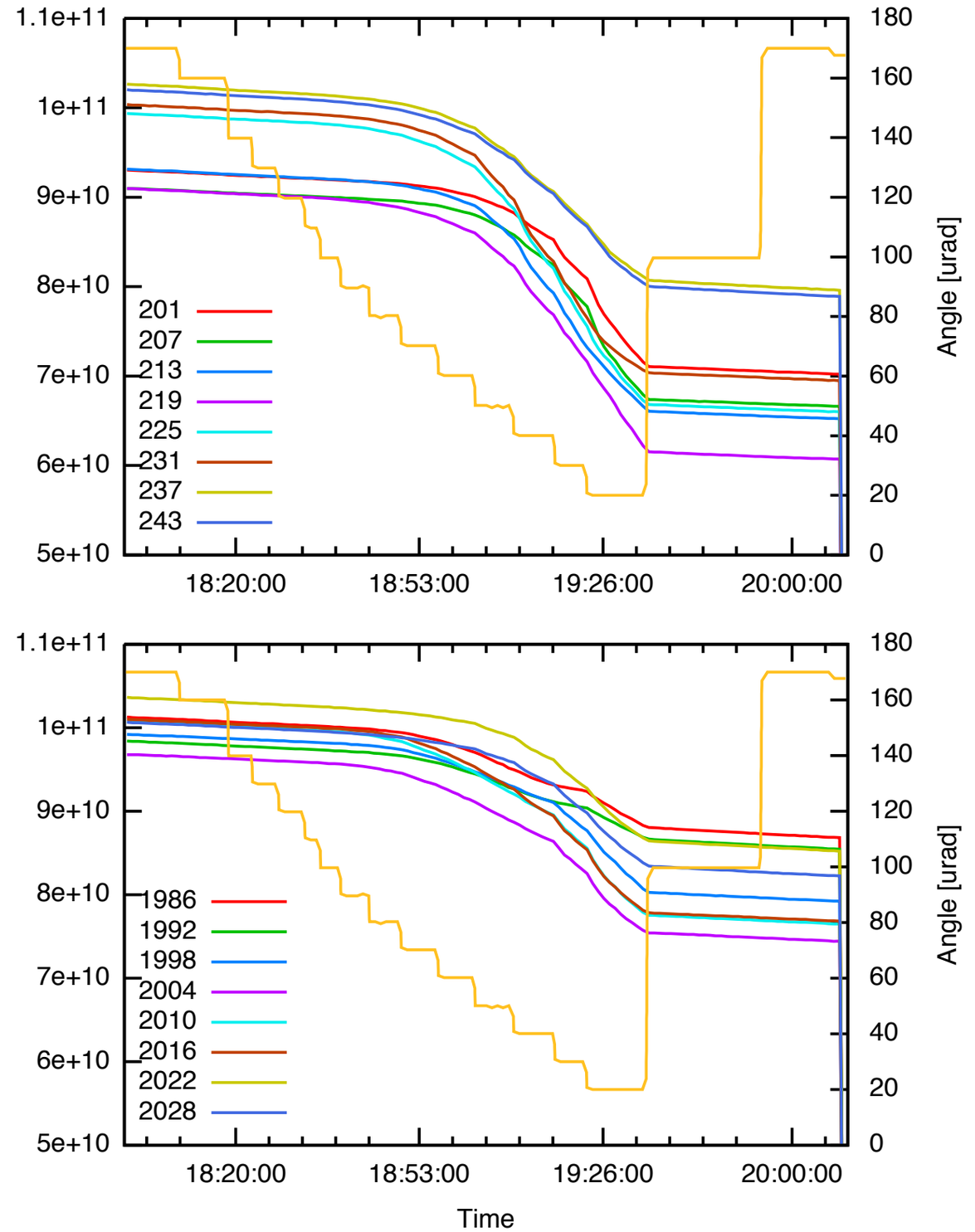
1e+11
9e+10
8e+10
7e+10
6e+10
5e+10
180
160
140
120
100
80
60
40
20
0
Angle [urad]
1986
1992
1998
2004
2010
2016
2022
2028
18:20:00
18:53:00
19:26:00
20:00:00
Time

Beam 2

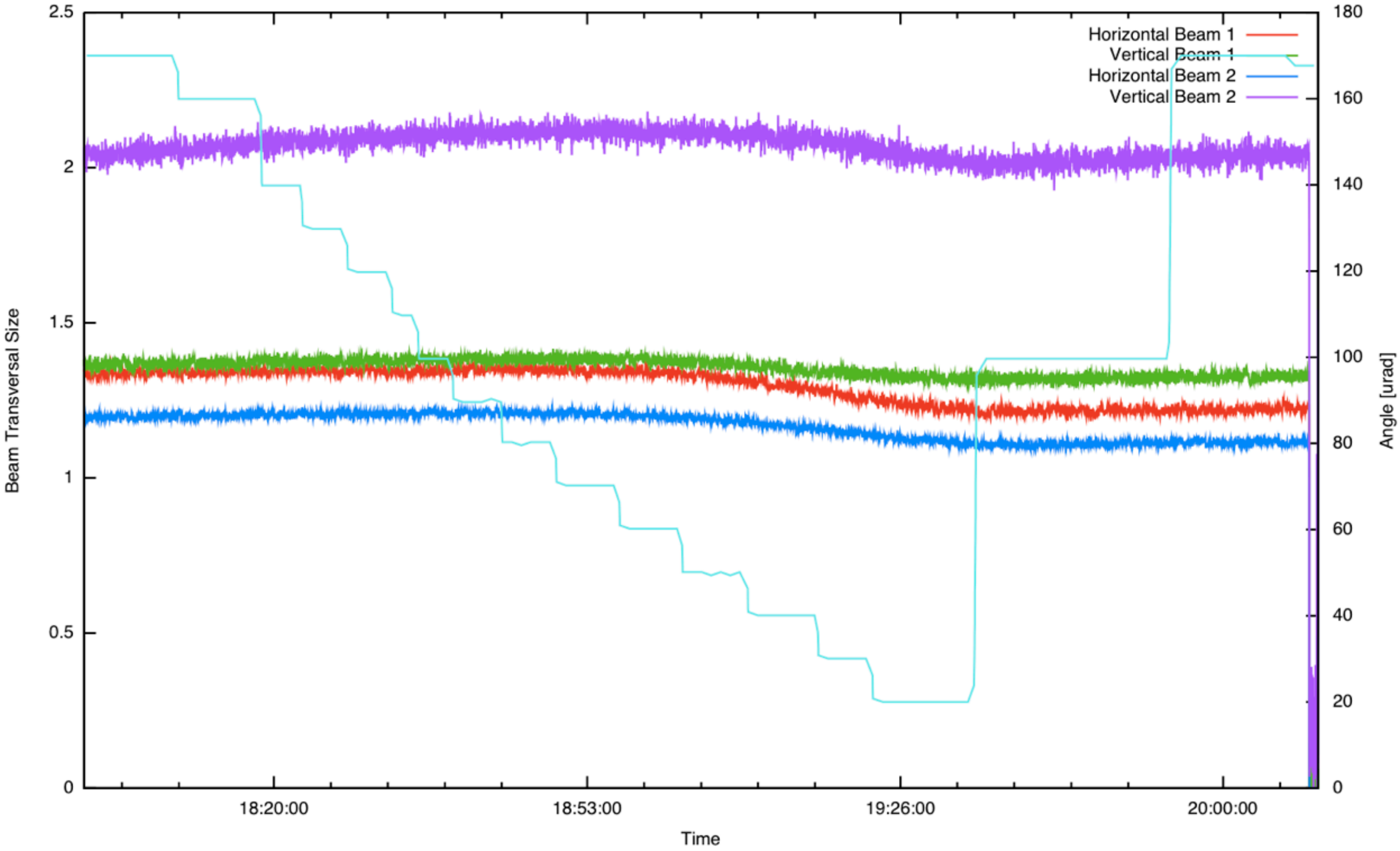

1.1e+11
1e+11
9e+10
8e+10
7e+10
6e+10
5e+10
Bunch Current
180
160
140
120
100
80
60
40
20
0
Angle [urad]
18:20:00
18:53:00
19:26:00
20:00:00
Time
1
7
13
19
201
207
213
219
225
231
237
243
1092
1098
1104
1110
1116
1122
1128
1134
1986
1992
1998
2004
2010
2016
2022
2028

Beam 2


Bunch Current
1.1e+11
1e+11
9e+10
8e+10
7e+10
6e+10
5e+10
180
160
140
120
100
80
60
40
20
0
1
7
13
19
1092
1098
1104
1110
1116
1122
1128
1134
18:20:00
18:53:00
19:26:00
20:00:00
Time


Angle [urad]
1.1e+11
1e+11
9e+10
8e+10
7e+10
6e+10
5e+10
180
160
140
120
100
80
60
40
20
0
201
207
213
219
225
231
237
243
1986
1992
1998
2004
2010
2016
2022
2028
18:20:00
18:53:00
19:26:00
20:00:00
Time

Transversal beam size



There is a clear evidence of the beam-beam effect in the LHC
(ok, not a big surprise).

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A quantitative analysis is going on: in particular it is interesting to find the correlation between the number of parasitic encounters and the lifetime.

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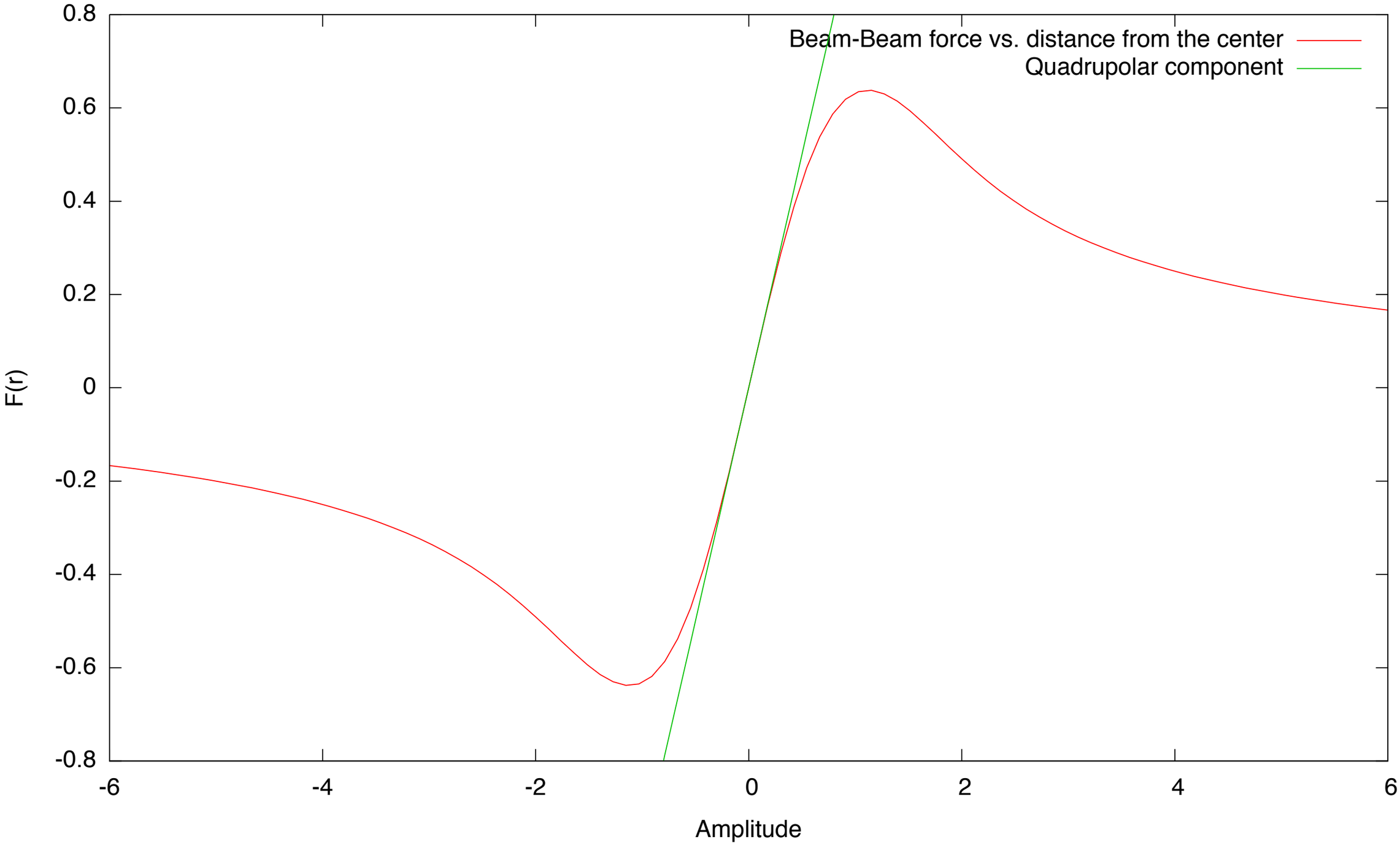
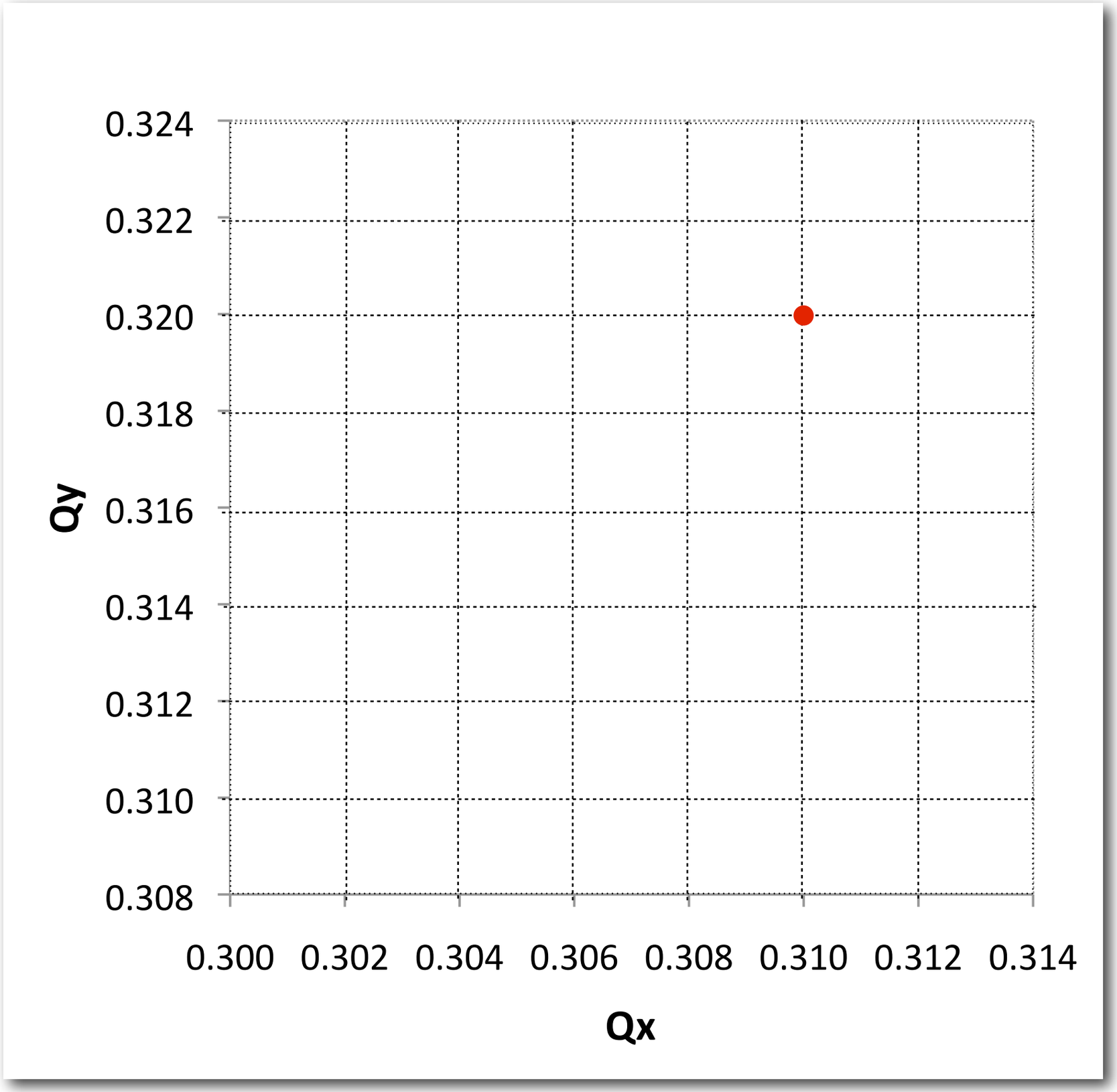
(ok, not a big surprise).

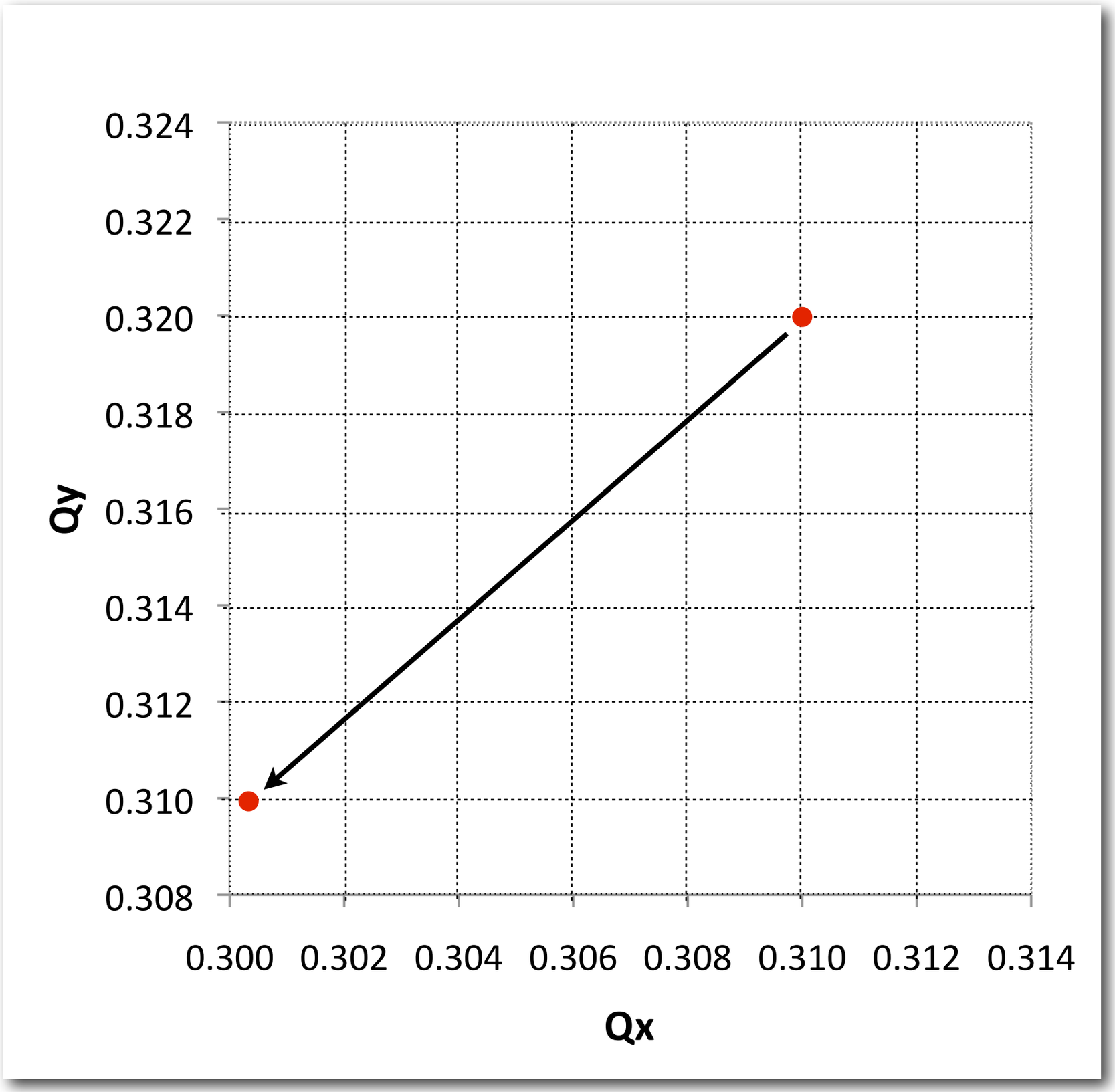
A quantitative analysis is going on: in particular it is interesting to find the correlation between the number of parasitic encounters and the lifetime.

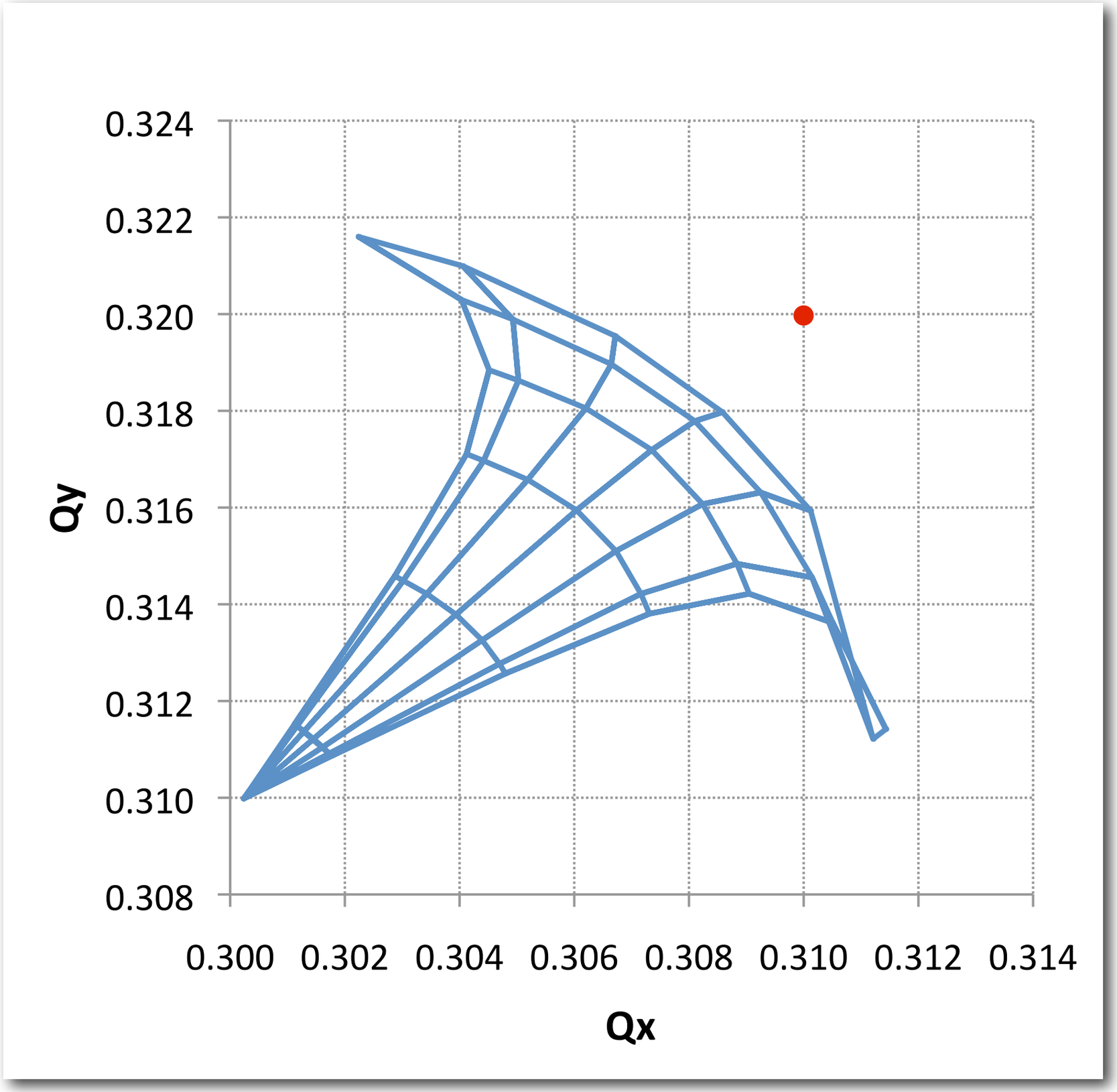
If we want to give numbers, it is of capital importance to have the single bunch instrumentation (for the tune, the beam size etc.).

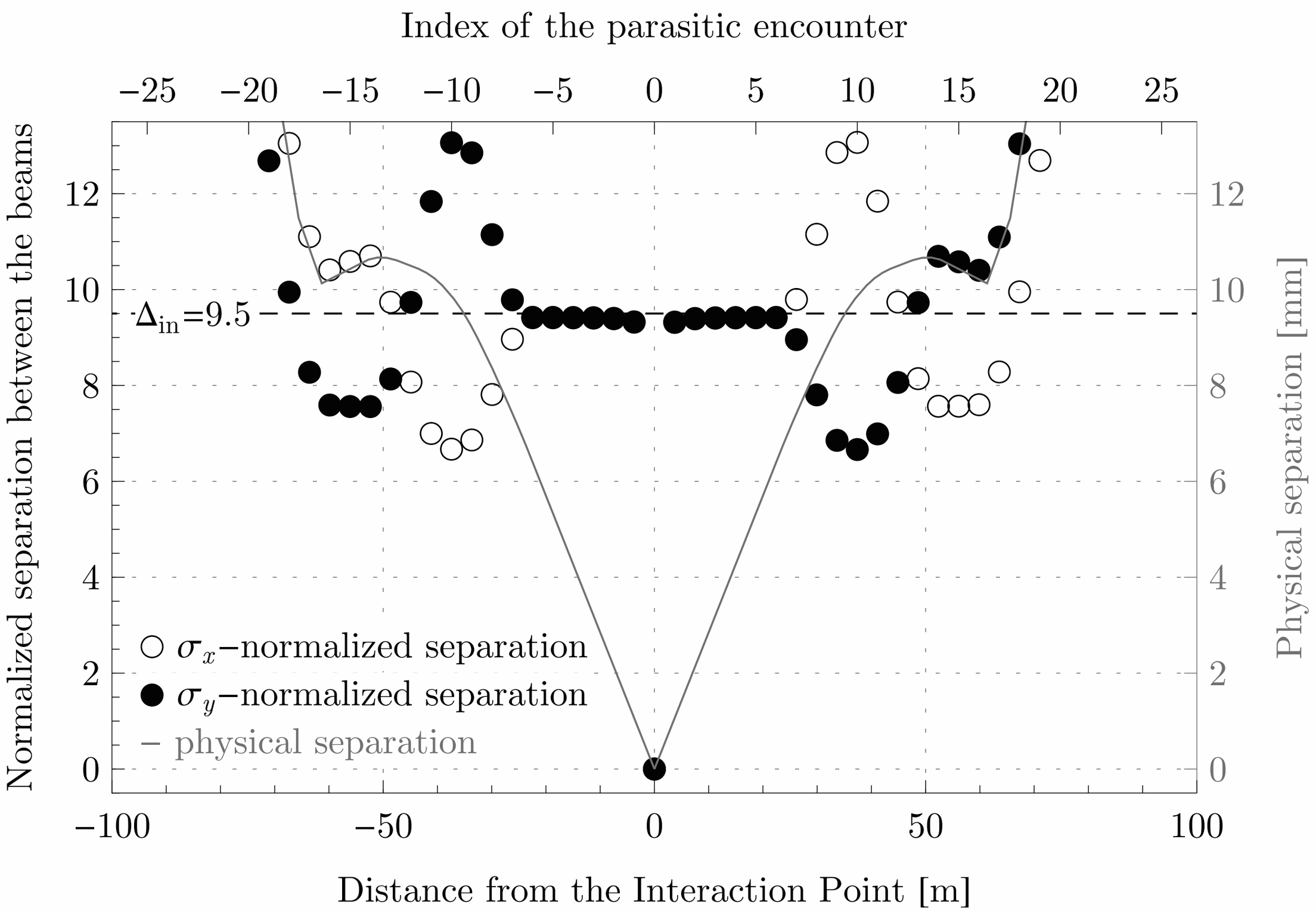
A consideration


Beam-Beam force vs. distance from the center
Quadrupolar component
F(r)
Amplitude
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-6
-4
-2
0
2
4
6


0.324
0.322
0.320
0.318
0.316
0.314
0.312
0.310
0.308
Qy
0.300
0.302
0.304
0.306
0.308
0.310
0.312
0.314
Qx


0.324
0.322
0.320
0.318
0.316
0.314
0.312
0.310
0.308
Qy
0.300
0.302
0.304
0.306
0.308
0.310
0.312
0.314
Qx


0.324
0.322
0.320
0.318
0.316
0.314
0.312
0.310
0.308
Qy
0.300
0.302
0.304
0.306
0.308
0.310
0.312
0.314
Qx


Index of the parasitic encounter
−25
−20
−15
−10
−5
0
5
10
15
20
25
Normalized separation between the beams
Physical separation [mm]
12
10
8
6
4
2
0
Δ_{in}=9.5
○ σ_x−normalized separation
● σ_y−normalized separation
– physical separation
−100
−50
0
50
100
Distance from the Interaction Point [m]