Nov 2017

Rebecca, Doug

24/11/2017

Shift - Break Down

- The feedback results shown in this presentation were collected on the 10/11/2017 during a double shift.
    - High beta optics for 2-BPM feedback.
    - Nominal optics to perform 1-BPM feedback, stabilising at IPC.
- C-band BPFs were used throughout this double shift.

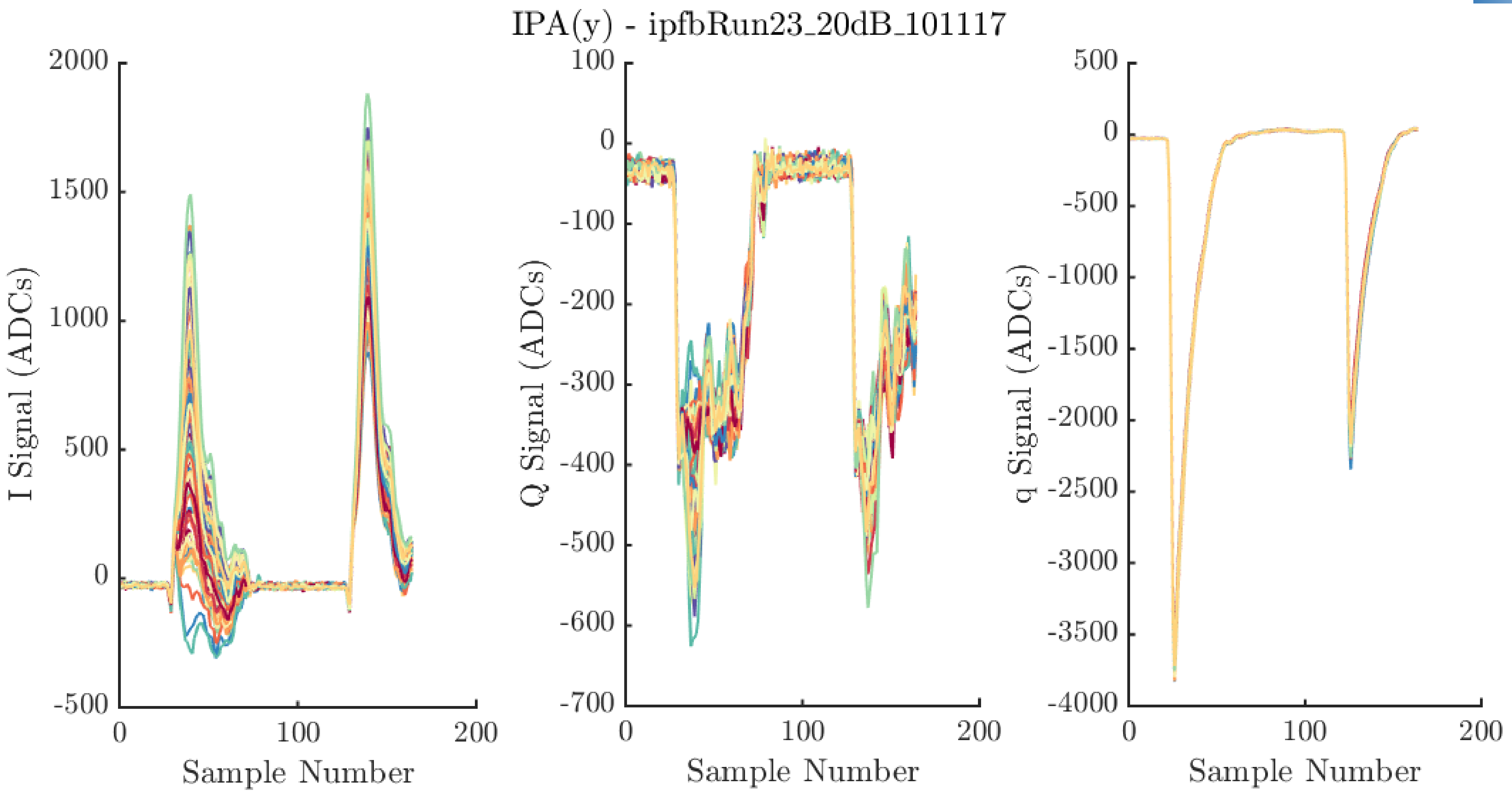
Sample Shifts

- Sample shifts dominated our data taking efforts – sometimes half sample jumps, must recalibrate etc.
- Happened typically a couple of times an hour, but periods where it happened every few seconds for multiple minutes. Tried power cycling etc. nothing helped.
- Part of what made this so inconvenient was a limitation of a function in Ben’s firmware, used to shift the waveform within the 164 sample data window. The shift capability only covers 120 samples. The bunch can jump into a zone from which you cannot recover it, because you require between 120-163 samples to shift it. Power cycling board did not help shift waveform.

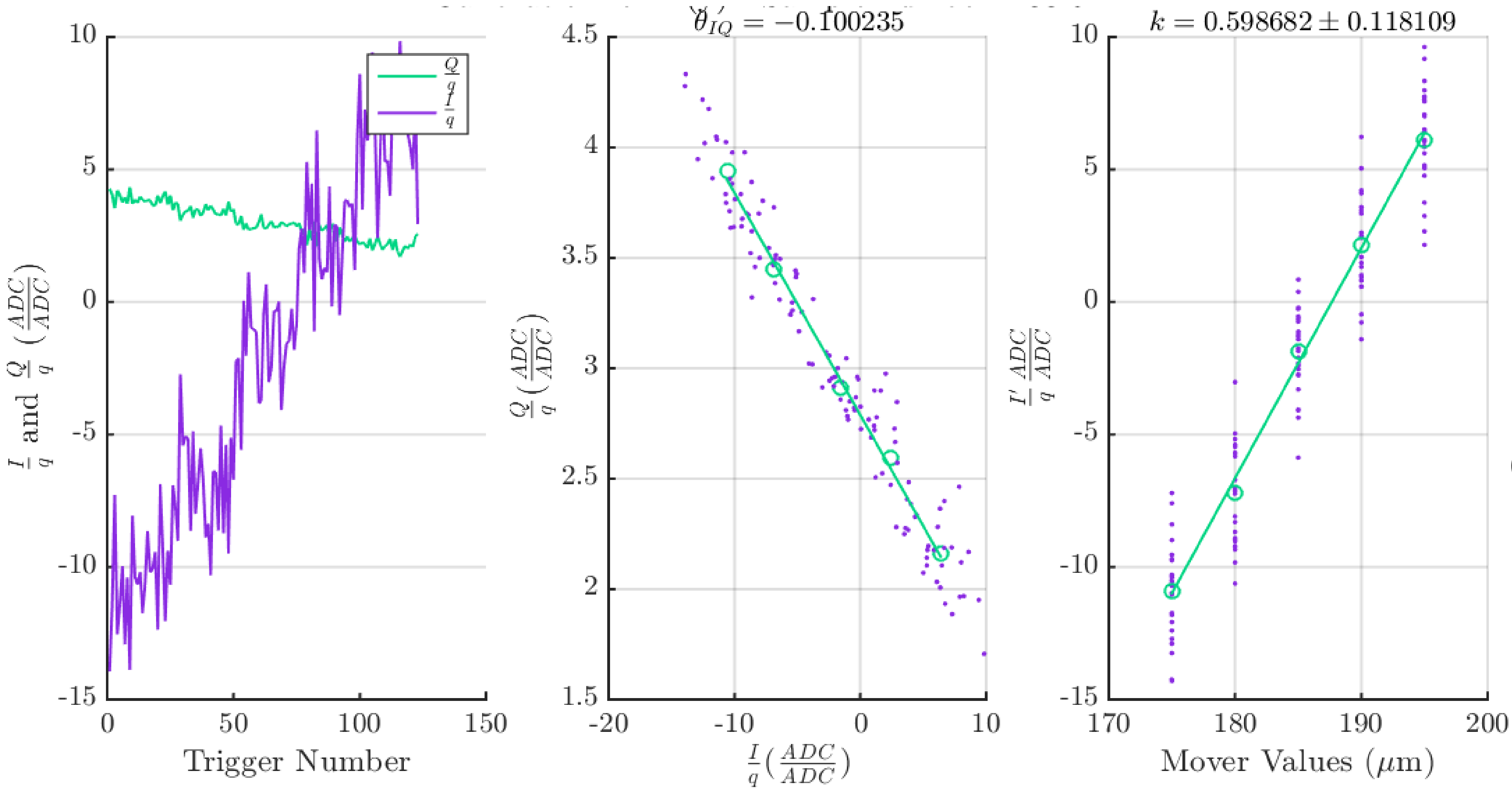
2-BPM Set Up

High Beta Optics
With C-band BPFs

IPA Waveforms – Feedback Off Triggers



2-BPM Calibration IP A

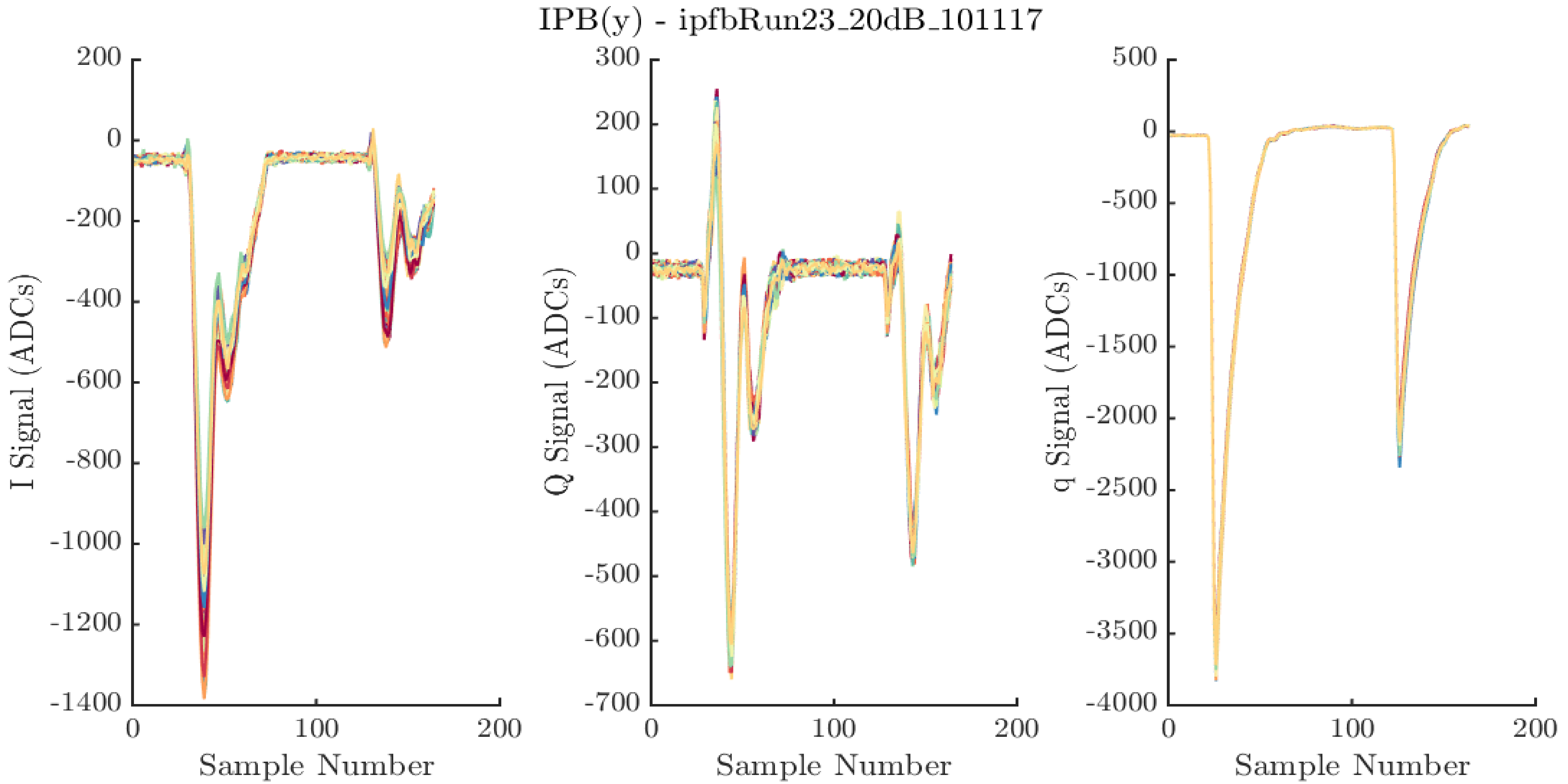


17 Sample integration 34:50

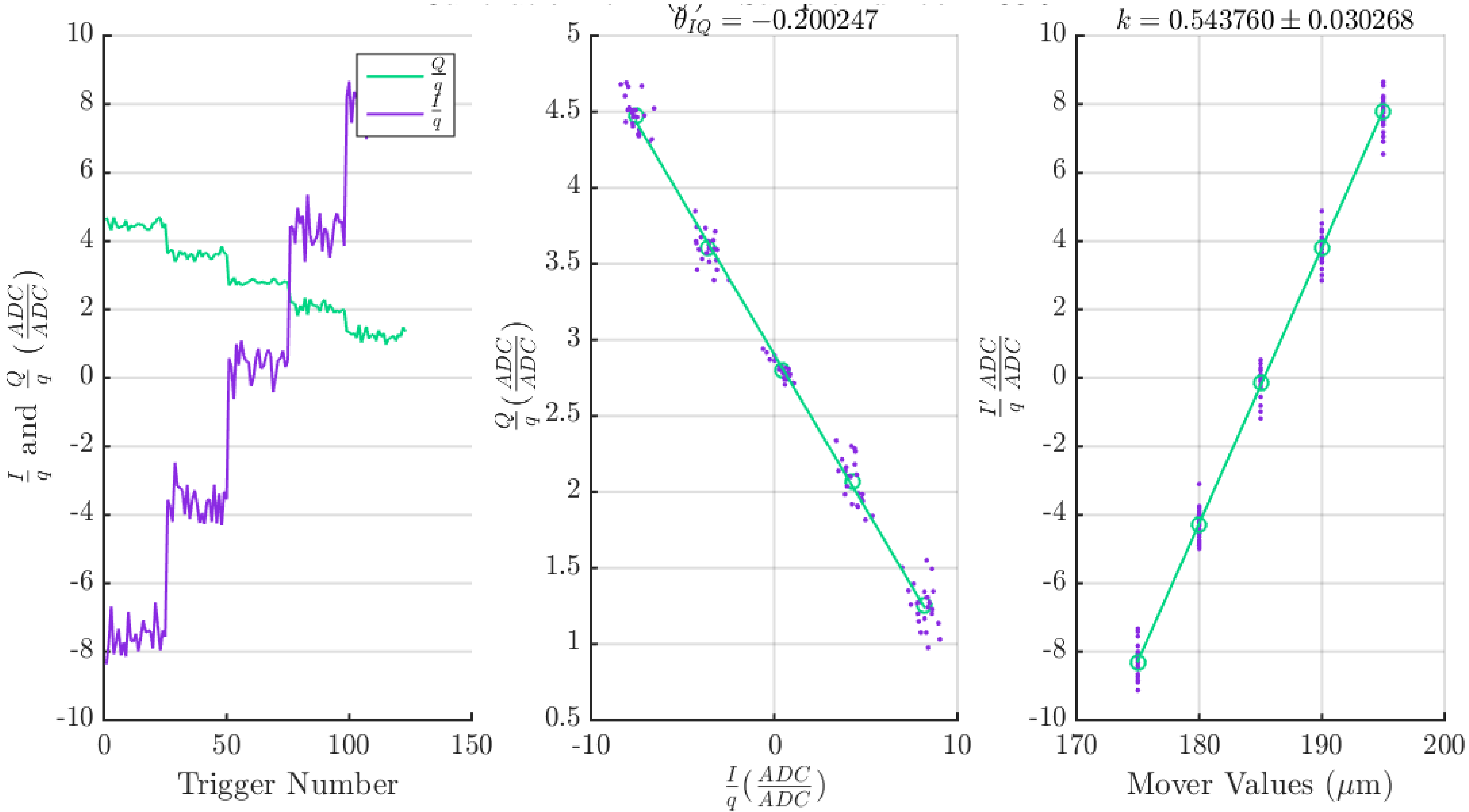
$\theta_{IQ} = -0.10$

$k =$
0.599 ∓ 0.118
(ADC/ADC)/um

IPB Waveforms – Feedback Off Triggers



2-BPM Calibration IP B

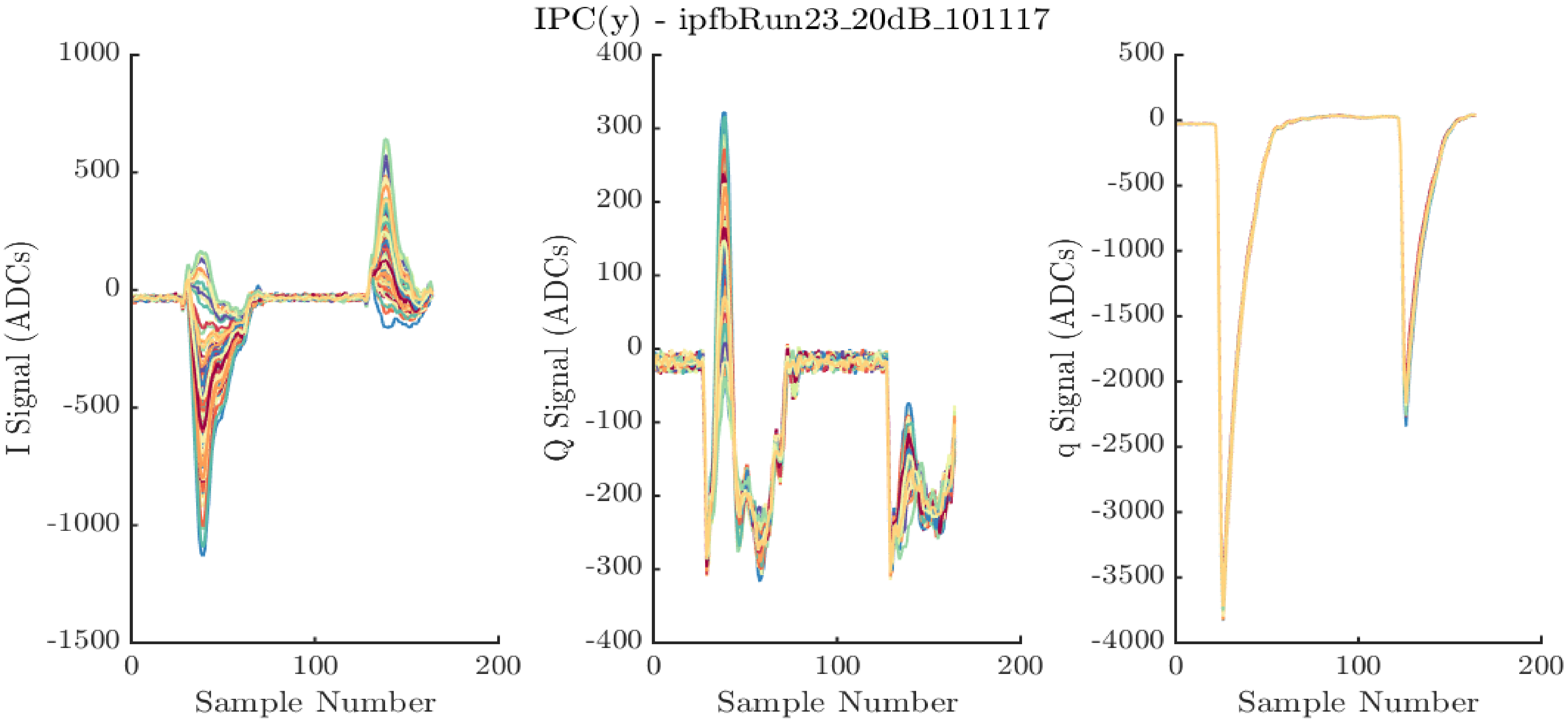


17 Sample integration 34:50

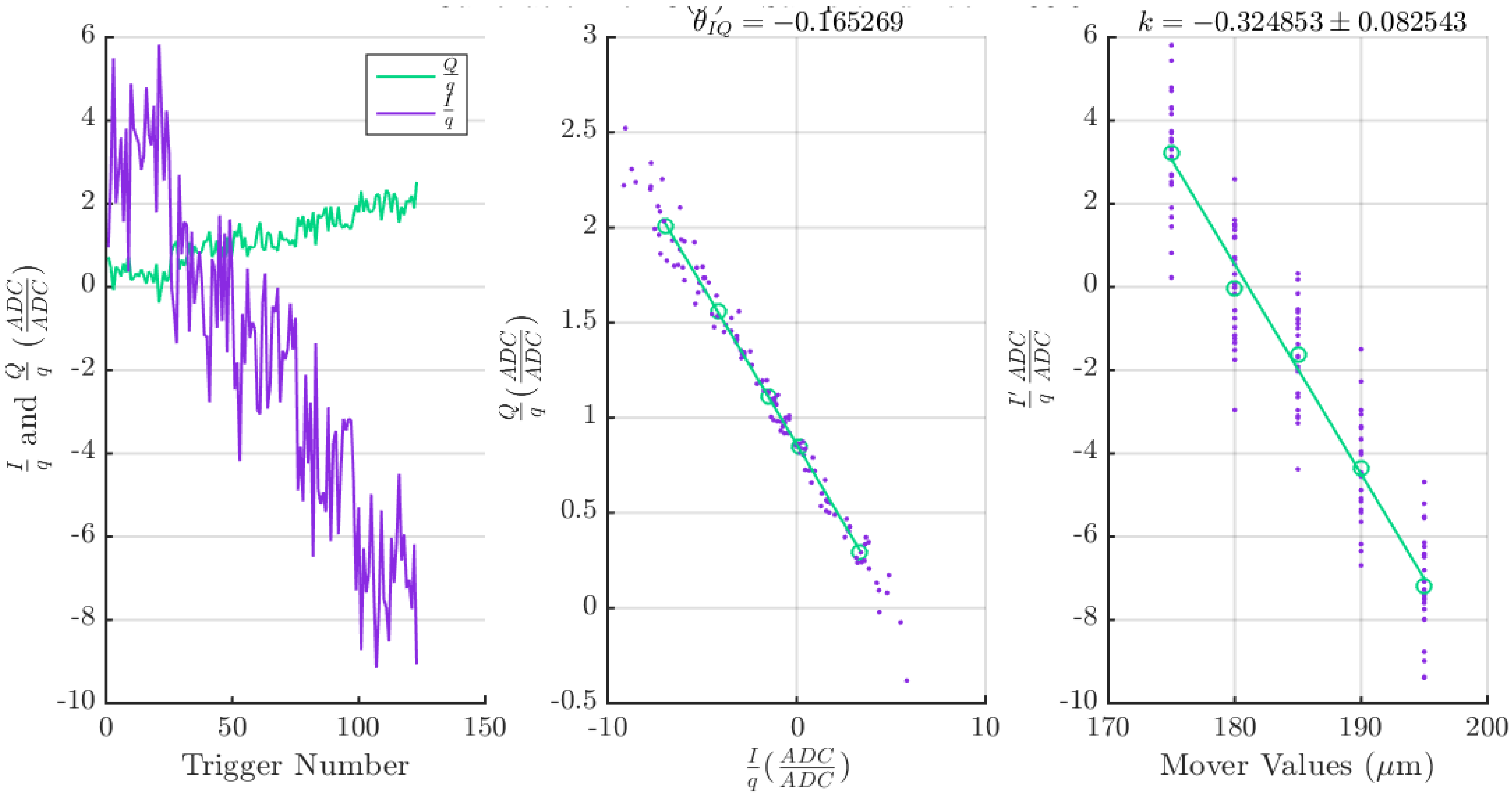
$\theta_{IQ} = -0.20$

$k = 0.544 \mp 0.030$ (ADC/ADC)/um

IPC Waveforms – Feedback Off Triggers



2-BPM Calibration IP C



17 Sample integration 34:50

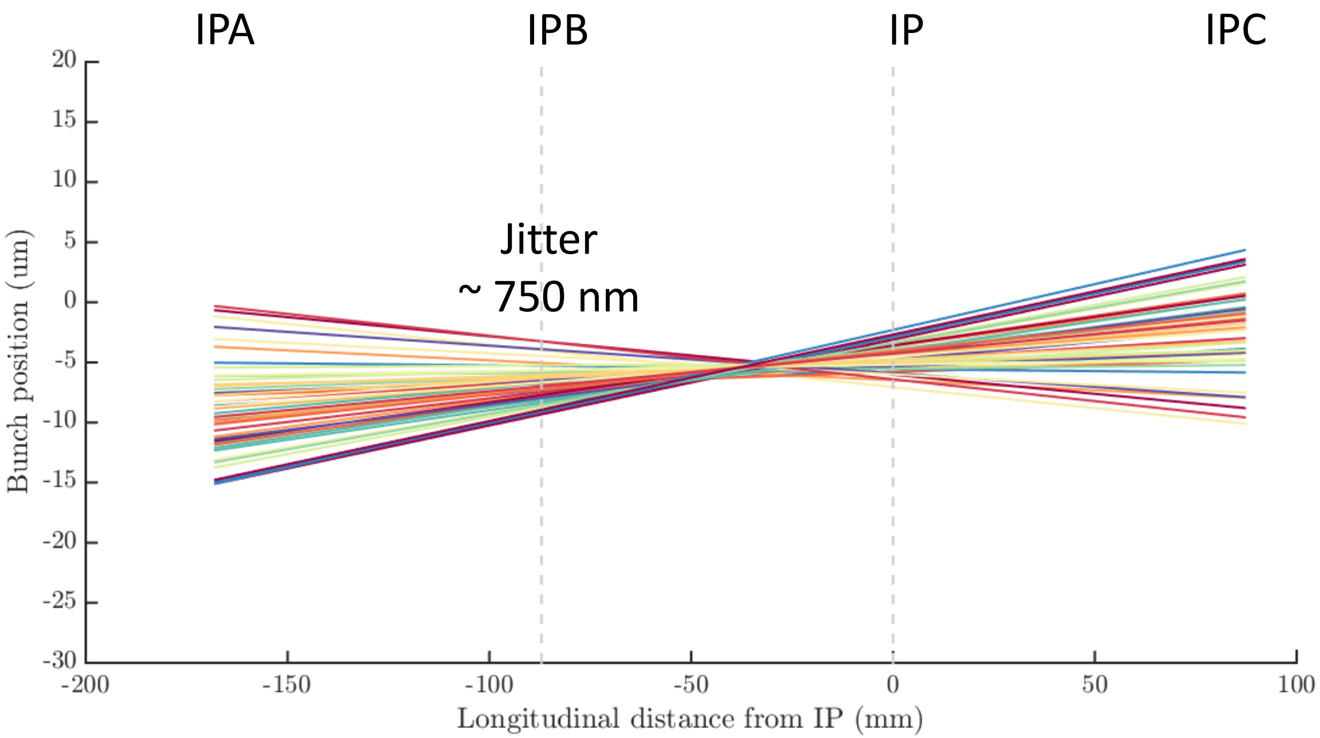
$\theta_{IQ} = -0.17$

$k = -0.325 \mp 0.083$ (ADC/ADC)/um

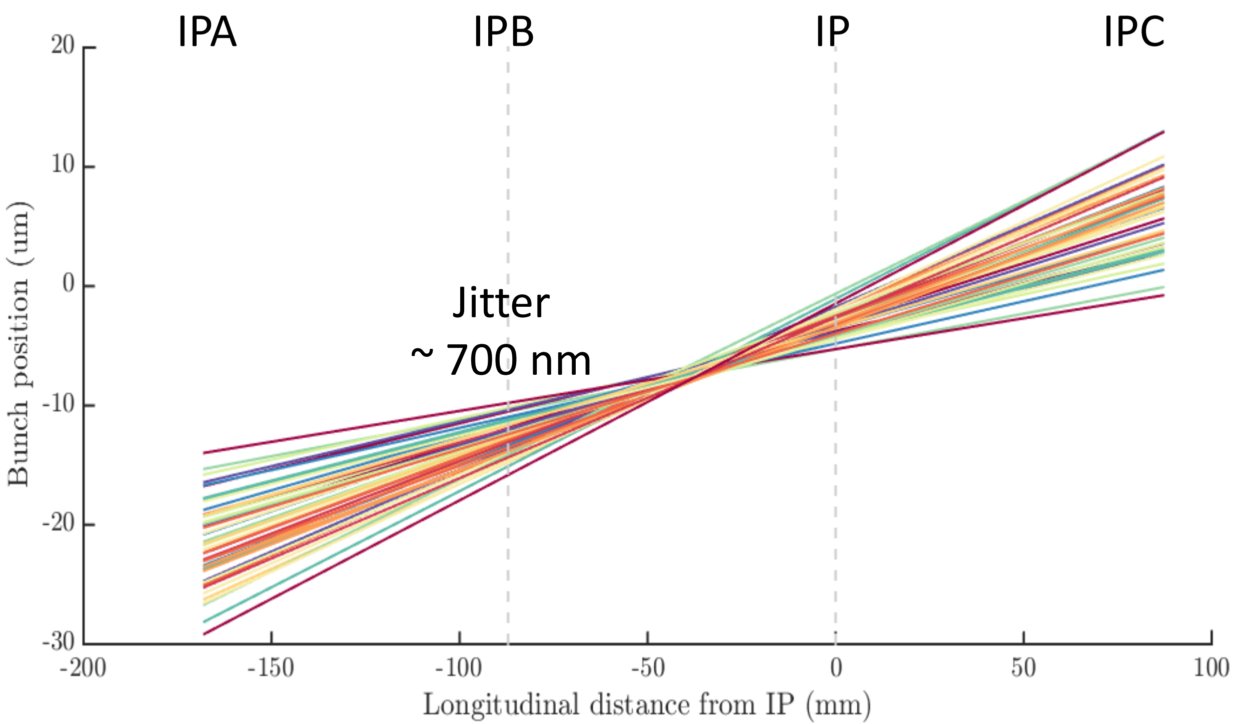
Feedback Off Trajectories

- High Beta Optics – Waist between IP and IPB, to make jitters at A and C comparable and to make aligning the beam at IPA easier.
- Considerable waist despite being in high beta optics.
- IPA, IPC interpolated beam trajectory, analysed at 17 sample integration, samples 34:50.

Bunch 1



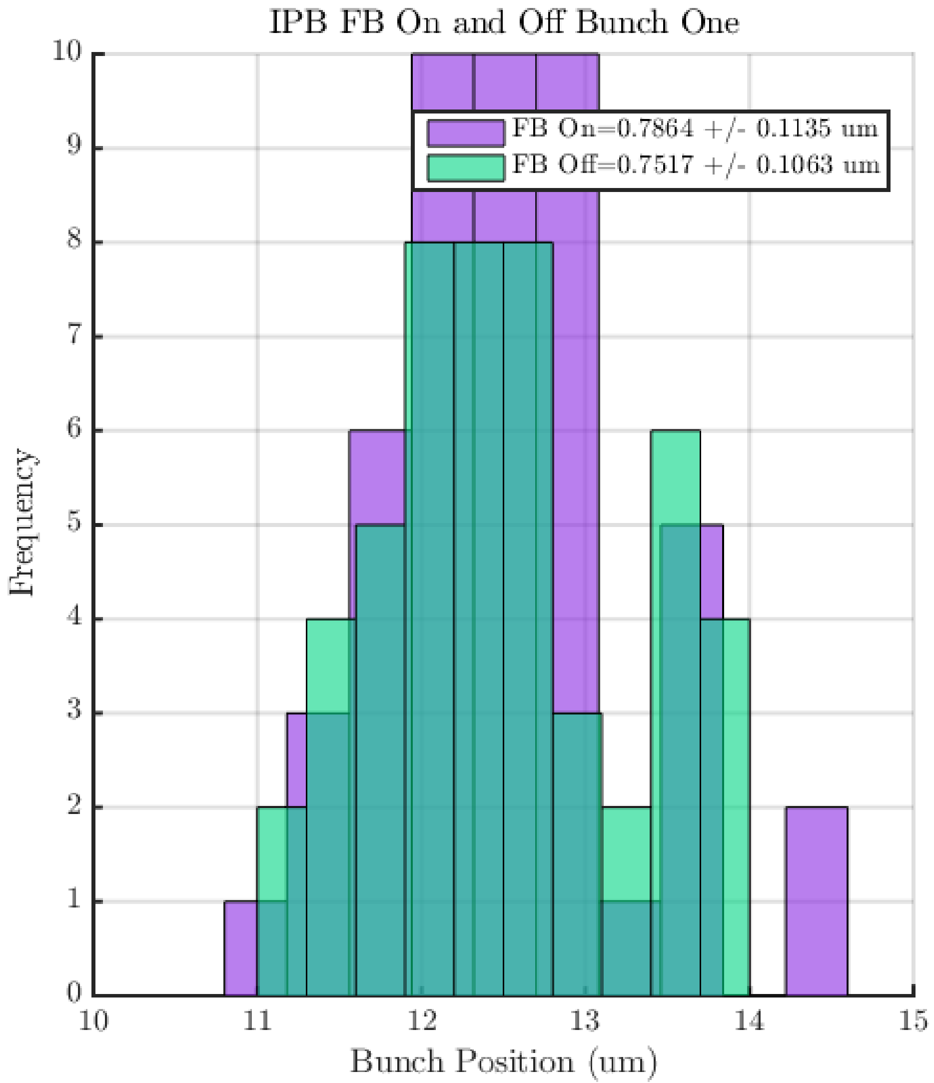
Bunch 2

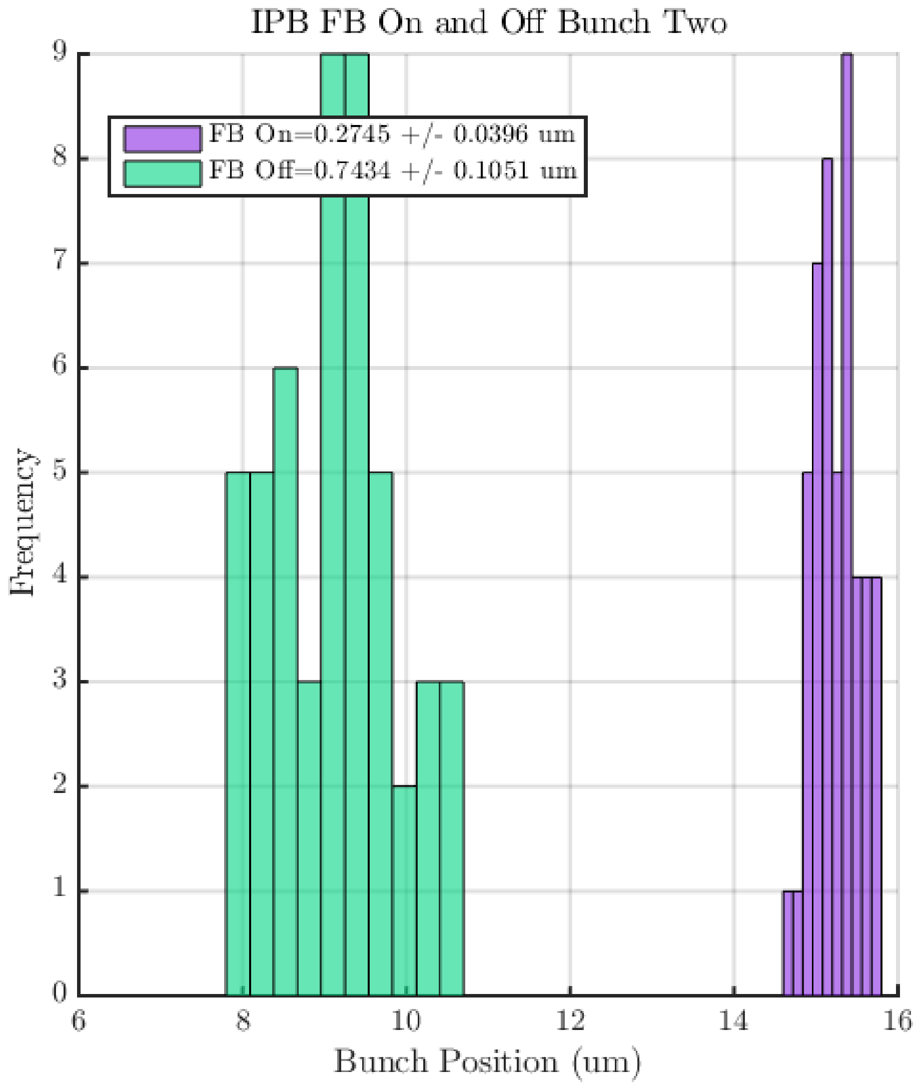


2-BPM Feedback

High Beta Optics
With C-band BPFs

Single Sample 2-BPM Feedback





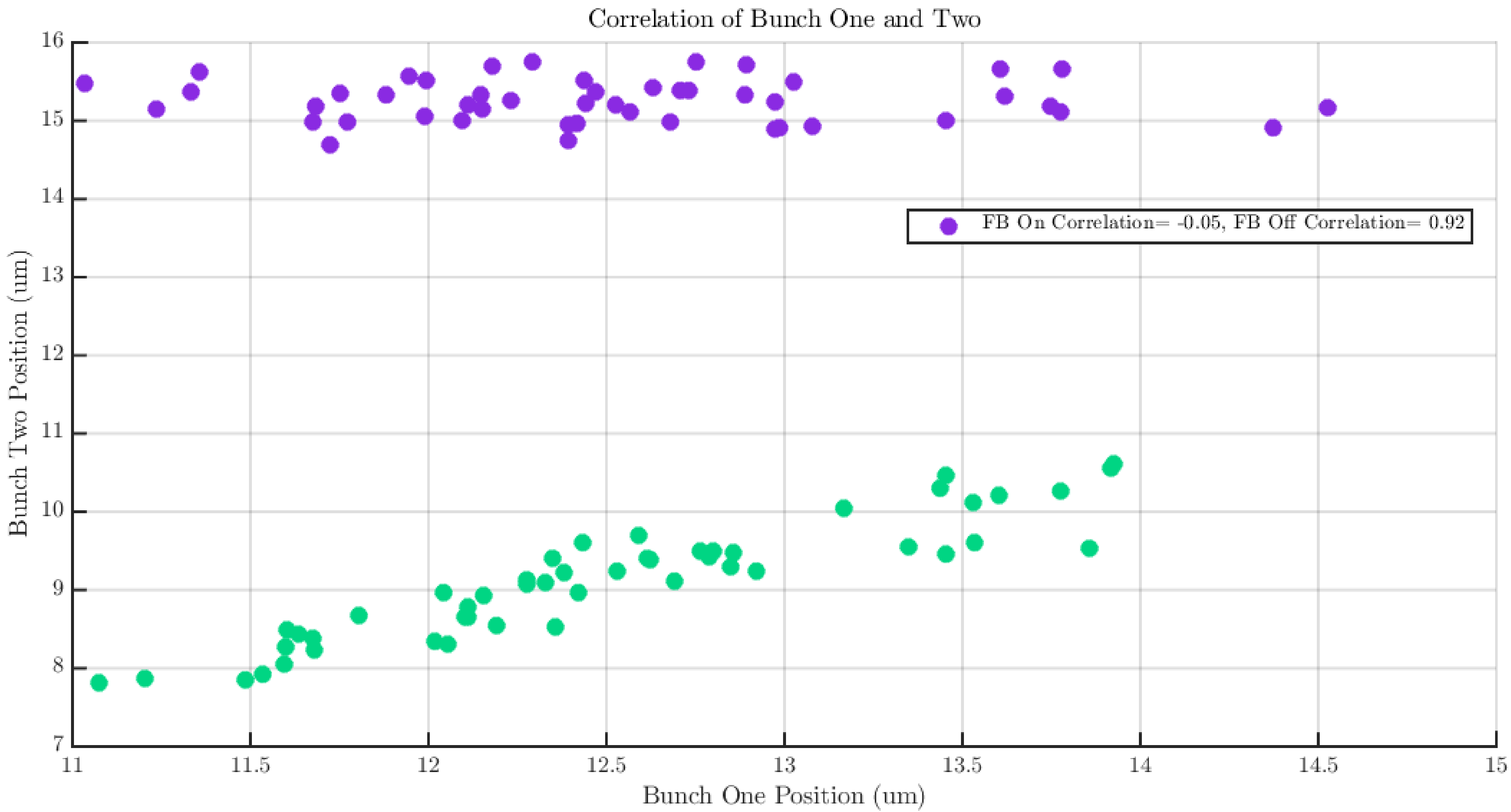
Bunch 2:
FB Off jitter:
743 +/- 105 nm

FB On Jitter:
275 +/- 40 nm

FB Off Correlation: 92%.
Single sample resolution: 170nm.

Samples analysed: 34:50.

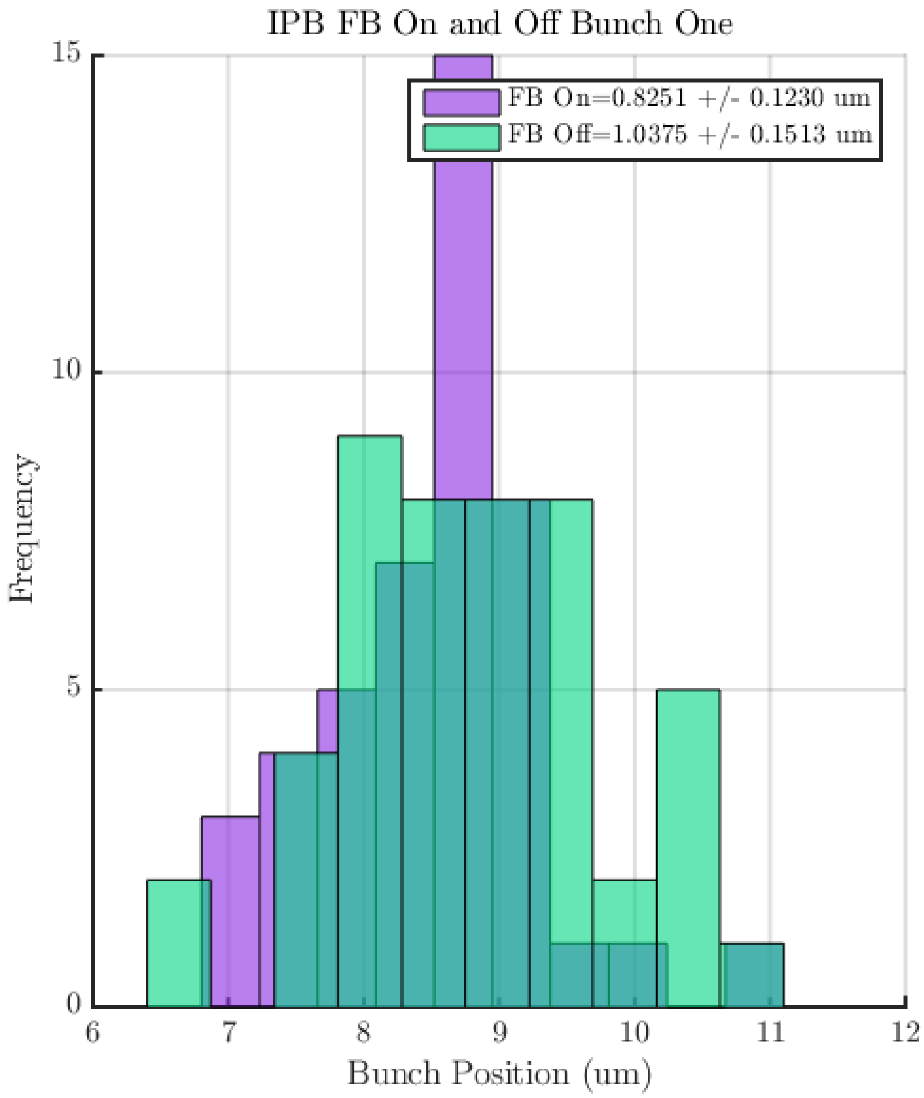
Single Sample 2-BPM Feedback

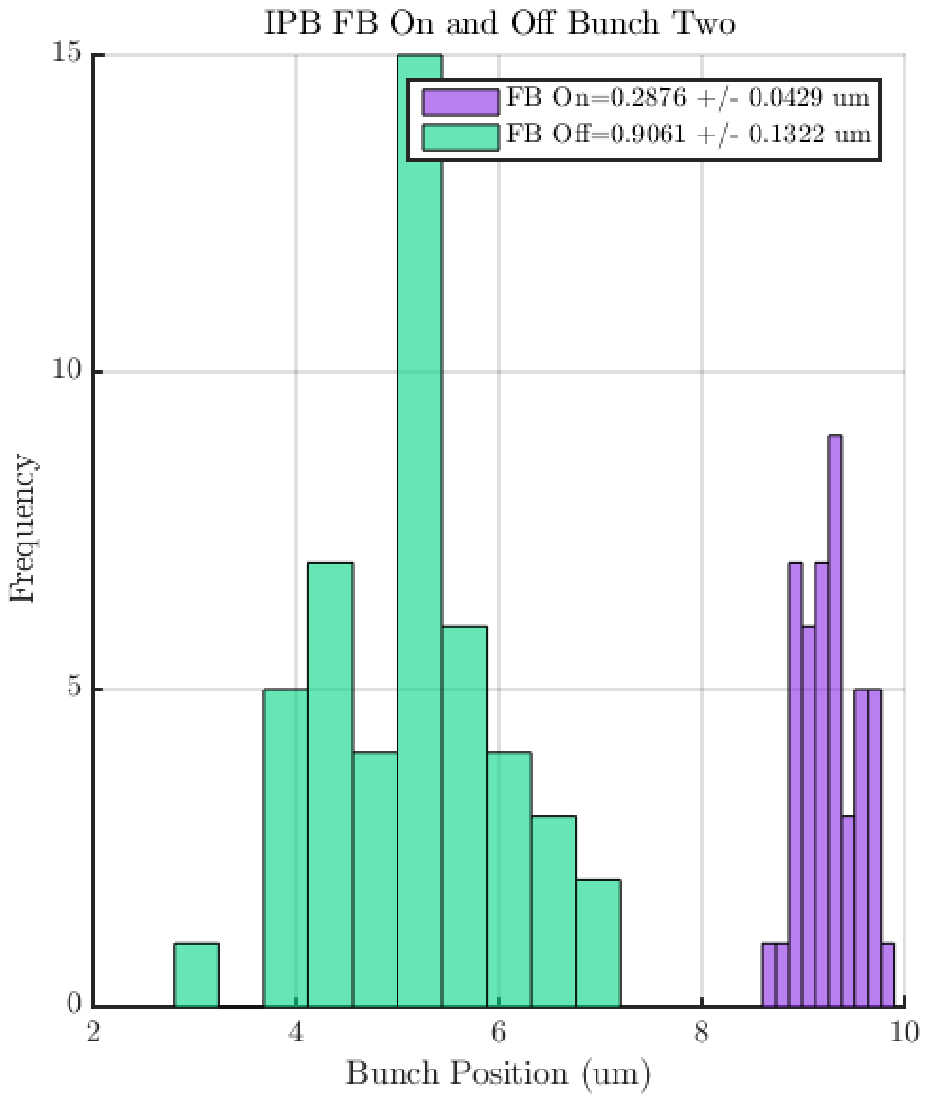


Correlation: 92% corrected to -5%

Samples analysed: 34:50.

Ten Sample 2-BPM Feedback





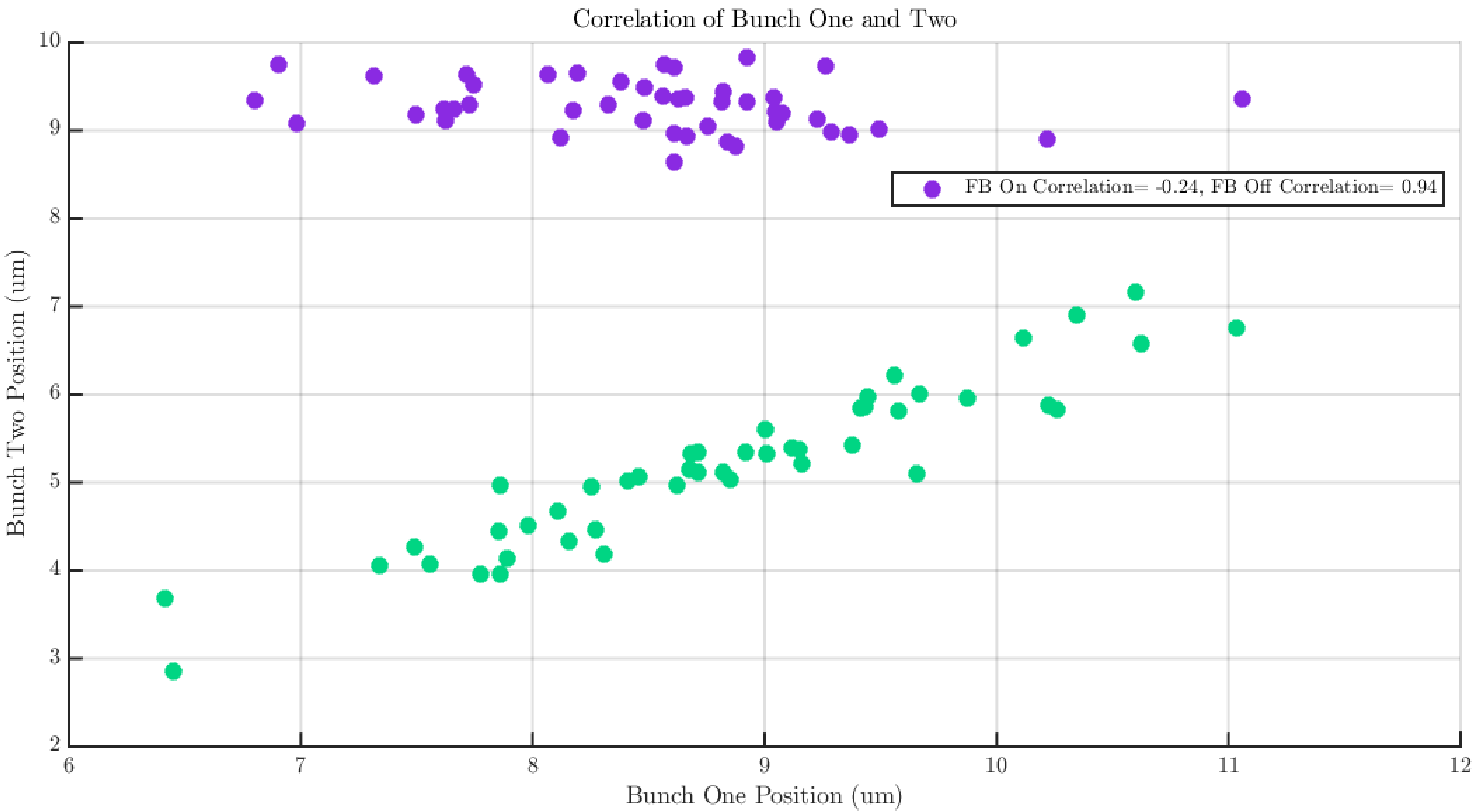
Bunch 2:
FB Off jitter:
906 +/- 132 nm

FB On Jitter:
288 +/- 43 nm

FB Off Correlation:
94%.
Ten sample resolution
110 nm.

Samples analysed:
34:50.

Ten Sample 2-BPM Feedback



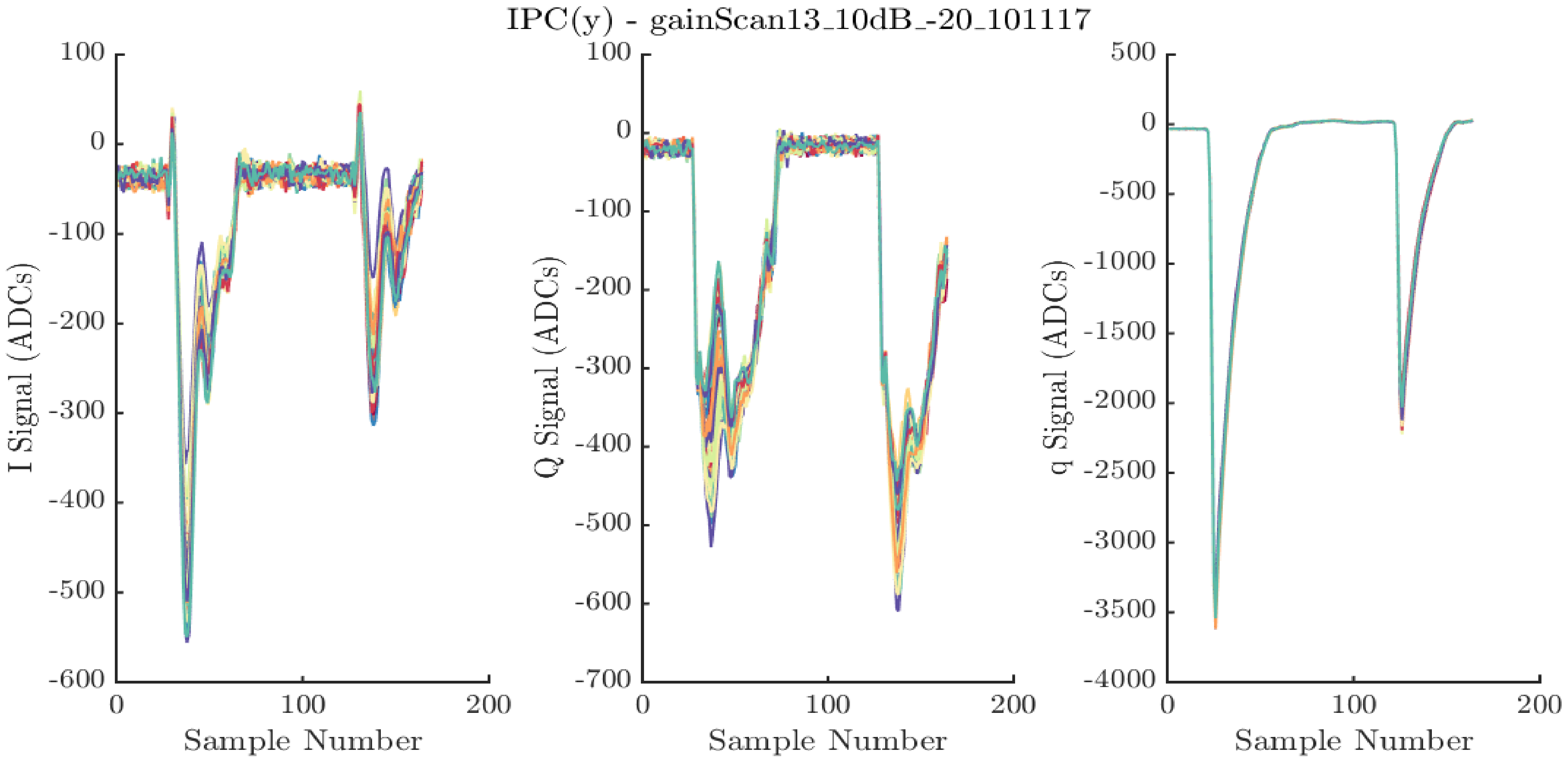
Correlation: 94% corrected to -24%

Samples analysed: 34:50

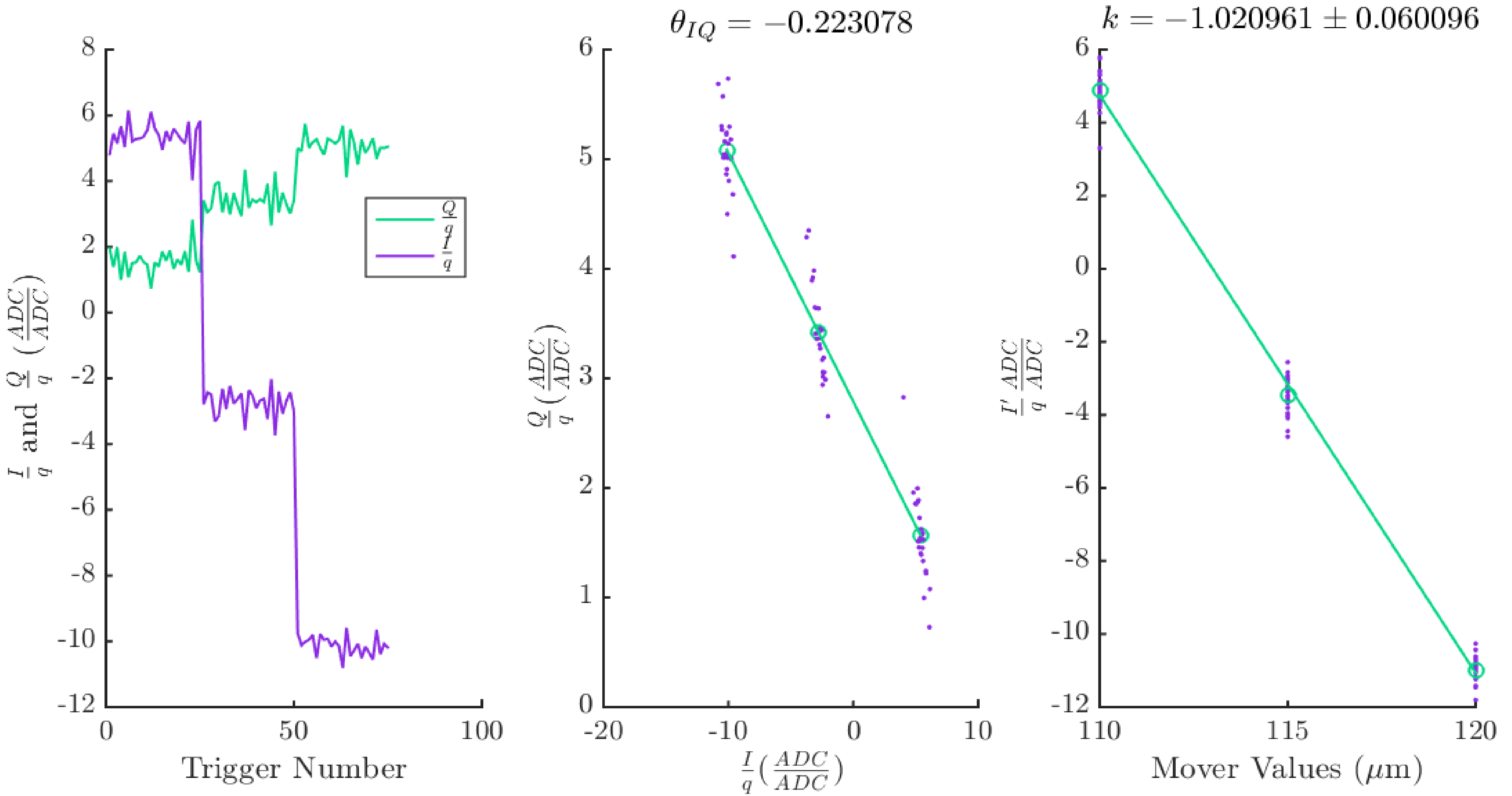
1-BPM Set Up

Nominal Optics
With C-band BPFs

IPC Waveforms - Feedback Off Triggers



1-BPM Calibration – Bunch 1



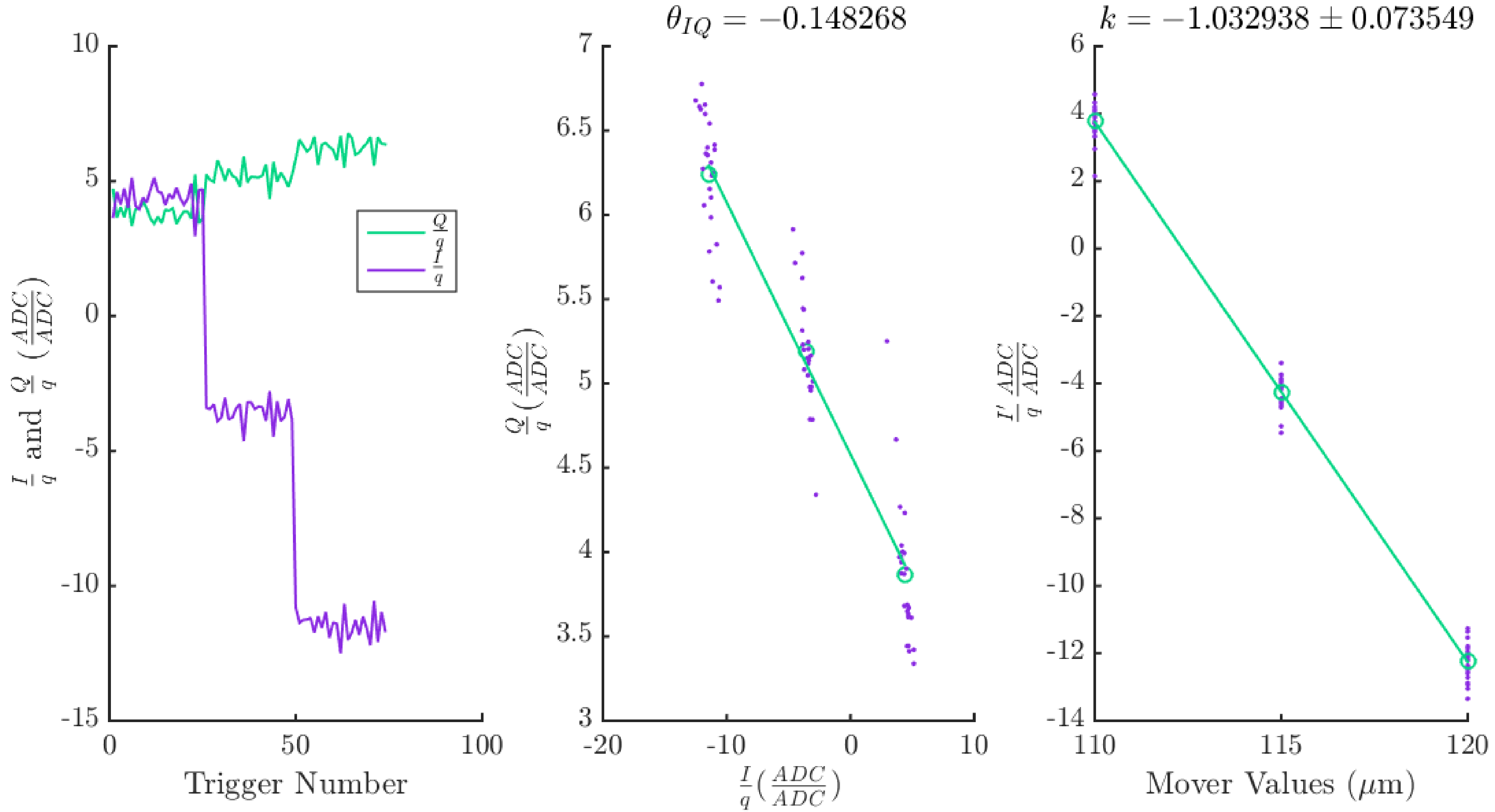
17 Sample integration 34:50

$\theta_{IQ} = -0.22$

$k = -1.021 \mp 0.060$ (ADC/ADC)/um

Saturated settings not used for analysis – plot in appendix

1-BPM Calibration – Bunch 2



17 Sample integration 34:50

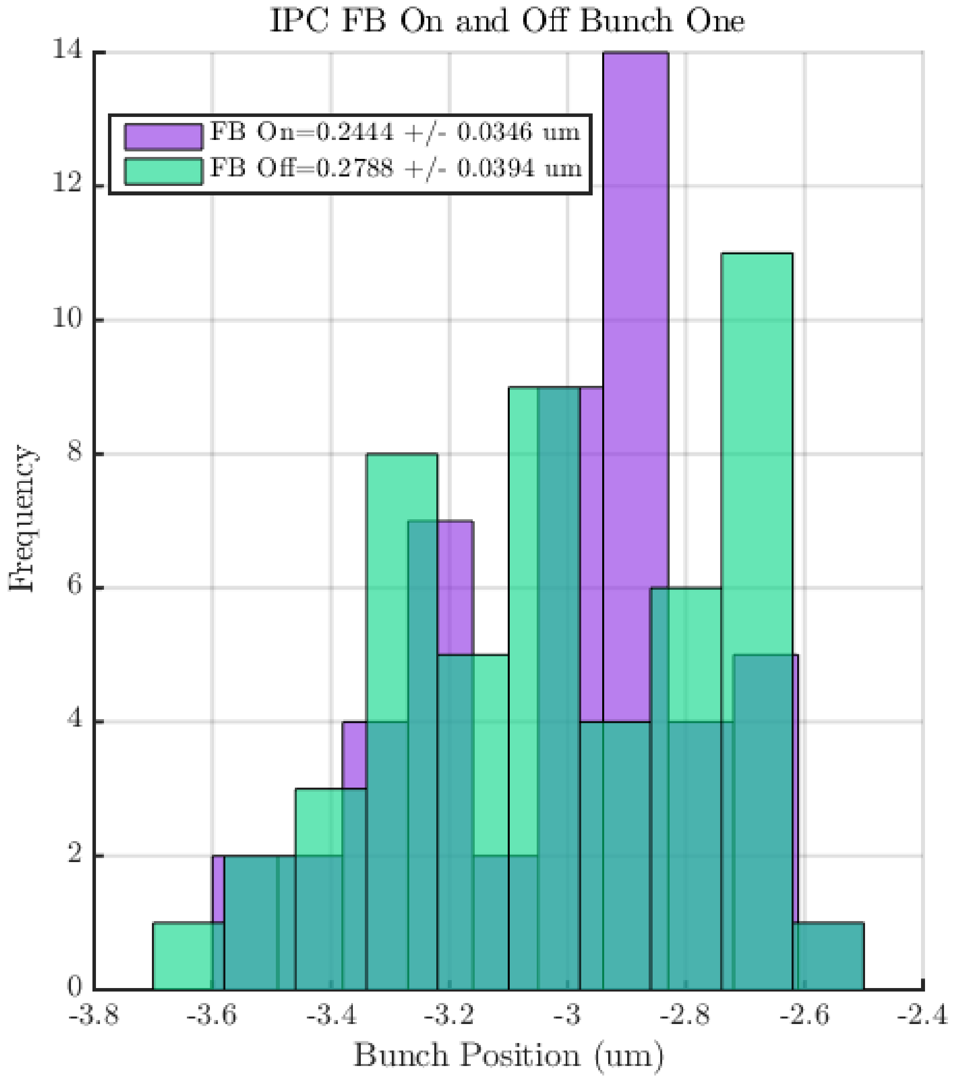
$\theta_{IQ} = -0.148$
k = -1.033 ∓ 0.074 (ADC/ADC)/um

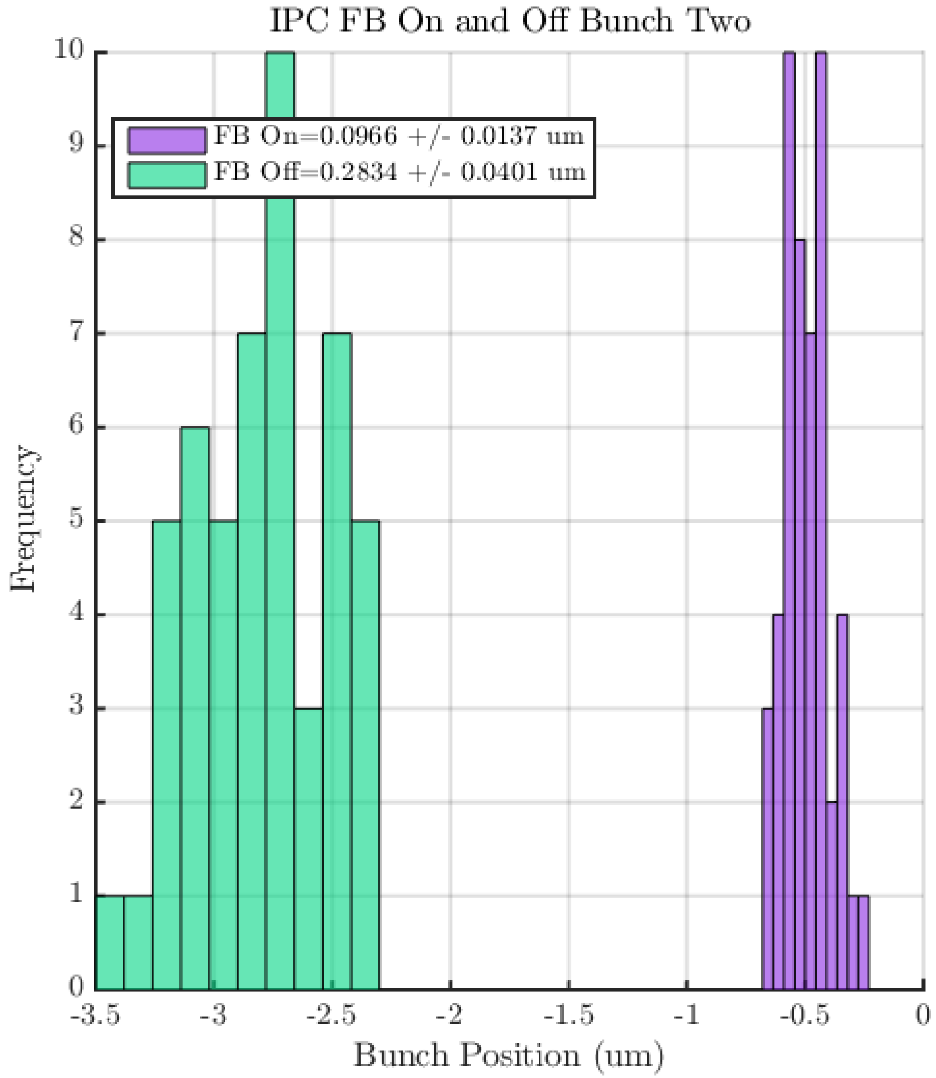
Saturated settings not used for analysis – plot in appendix

1-BPM Feedback

Nominal Optics
With C-band BPFs

3 Sample – 1-BPM Feedback





gainScan14_10dB_-5_again1

Bunch 2:

FB Off jitter:

283 +/- 40 nm

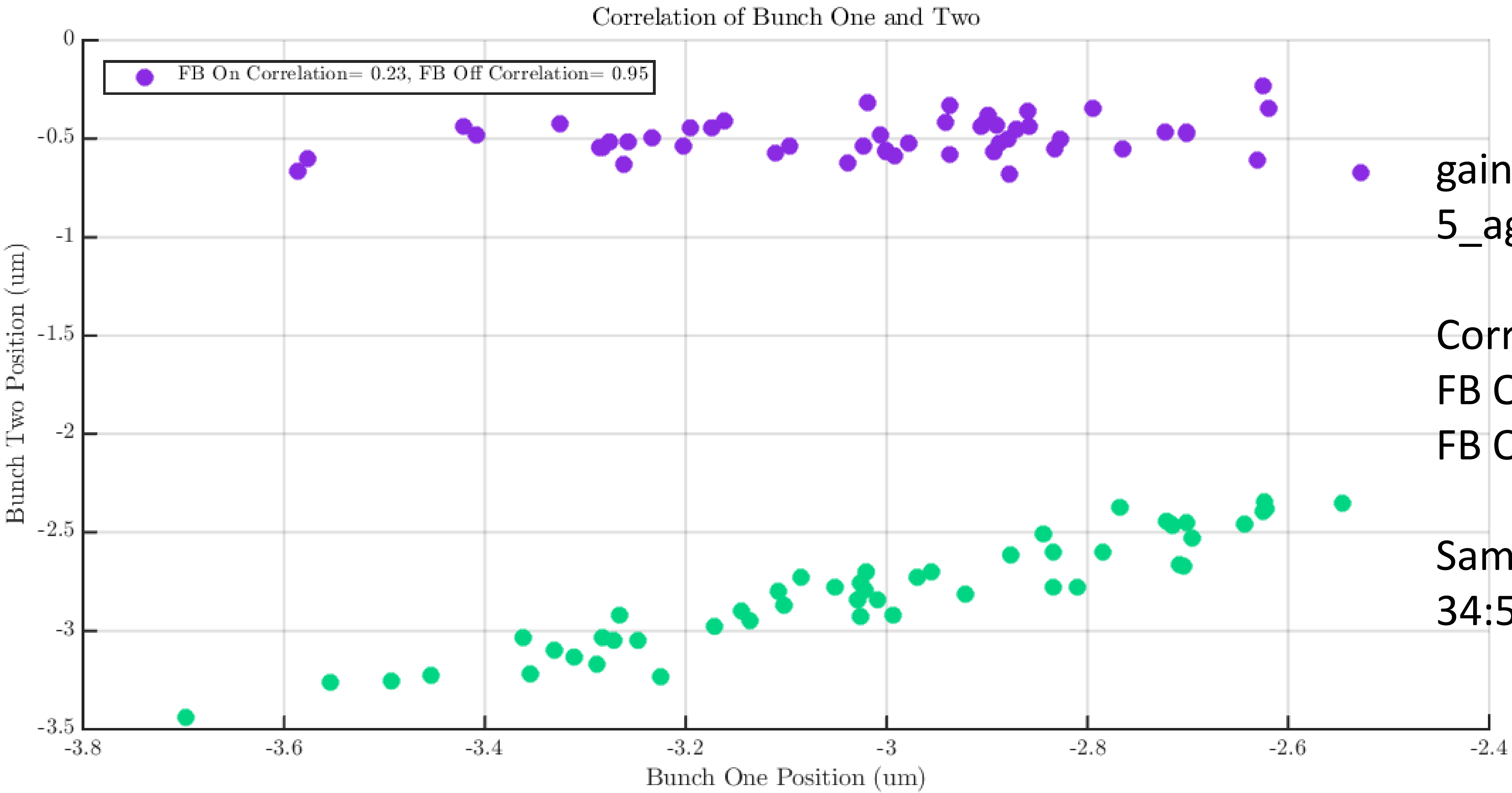
FB On Jitter:

97 +/- 14 nm

FB OFF correlation: 95%

Samples analysed: 34:50.

3 Sample – 1-BPM Feedback



gainScan14_10dB_-5_again1

Correlation
FB Off: **95** +/-2%
FB On: **23** +/- 13%

Samples analysed: 34:50.

Analysis of Feedback

1-BPM Feedback

Nominal Optics
With C-band BPFs

Expected Feedback Performance

- Feedback off jitter and correlation varied a lot, so I have been comparing data files using performance compared with expected feedback performance.
- Equation borrowed from Neven's thesis.

σ_{Y2}= bunch 2 jitter FB on,

σ_{y2}=bunch 2 jitter fb off,

σ_{y1}=bunch 1 jitter,

ρ_{12}= bunch to bunch position correlation.

$$\sigma_{Y_2}^2 = \sigma_{y_1}^2 + \sigma_{y_2}^2 - 2\sigma_{y_1}\sigma_{y_2}\rho_{12}$$

Terminology

- **Feedback integration window**: The sample window integrated by the firmware for the feedback run.
- **Feedback prediction integration window**: The sample window that the feedback performance prediction was made using.

$$\sigma_{Y_2}^2 = \sigma_{y_1}^2 + \sigma_{y_2}^2 - 2\sigma_{y_1}\sigma_{y_2}\rho_{12}$$

Introducing a New Variable

- I will now introduce a new variable

$$\Psi = \frac{\textbf{measured feedback performance}}{\textbf{predicted feedback performance}}.$$

ANALYSIS 1

If we use *Feedback prediction integration window = Feedback integration window* we would expect **Ψ to be 1**, for any feedback integration window – if gains are optimum.

E.g We are comparing how well the feedback corrects at a given integration window, with how well we would expect it to correct at that integration window.

We can calculate **Ψ** for many data runs, to test whether different integration windows are performing as expected.

Ψ vs. Feedback Integration Window

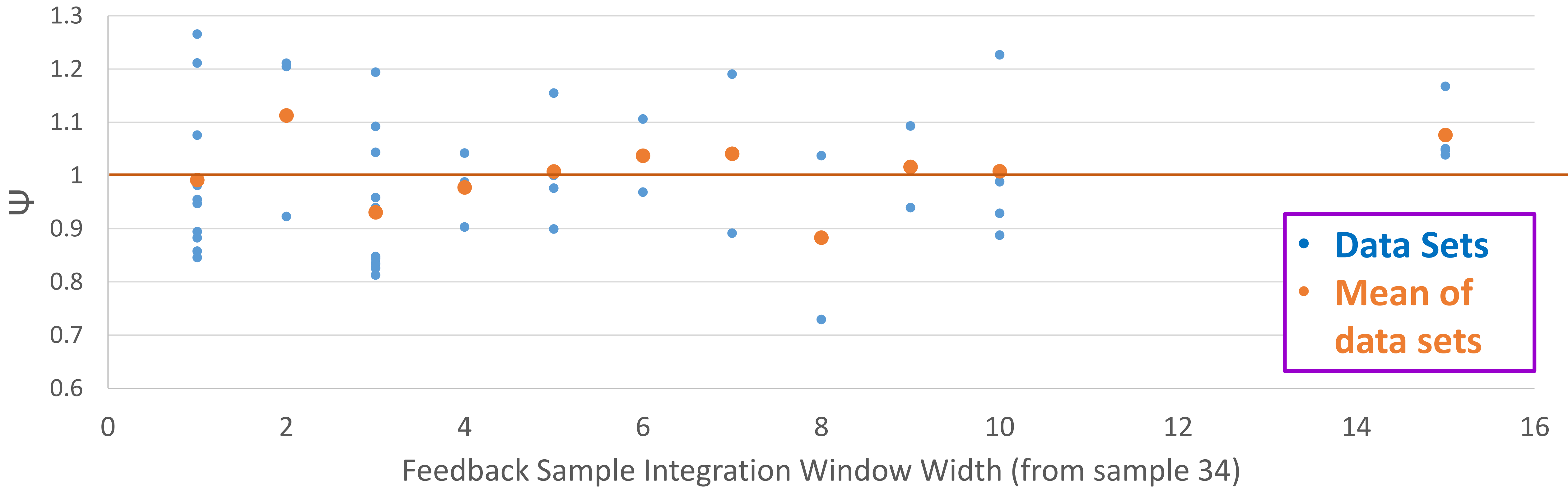
Ψ calculated for many data runs, if feedback performing as expected Ψ=1.

Feedback prediction integration window = feedback integration window

1-BPM feedback, nominal optics, feedback correcting at IPC.

Errors on single sample large ~30% as high error on lower correlation

– further error analysis to follow.



Best Feedback Prediction

$$\Phi = \frac{\text{measured feedback performance}}{\text{best predicted feedback performance}}.$$

ANALYSIS 2

Feedback prediction integration window = Best feedback performance integration window.

We can then compare the feedback performance at various feedback integration windows with the **best** possible feedback performance for that data set.

If the feedback performance at any feedback integration window is worse than the optimum integrated feedback prediction then **Φ>1.**

Φ vs. Feedback Integration Window

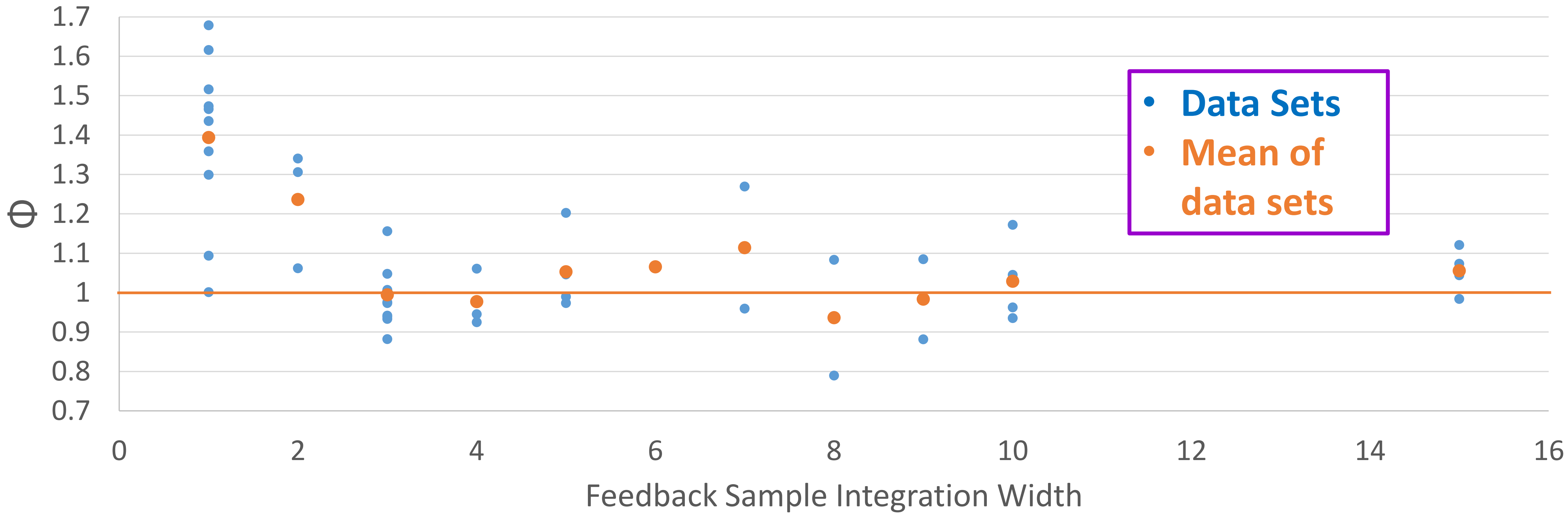
Φ calculated for many data runs, if feedback performing as well as best feedback prediction Φ=1.

Feedback prediction integration window = 17 samples

1- BPM feedback, nominal optics, feedback correcting at IPC.

As integrating over 17 samples, correlation is higher and errors are much smaller ~16%

– further error analysis to follow



Concern About FB Integration

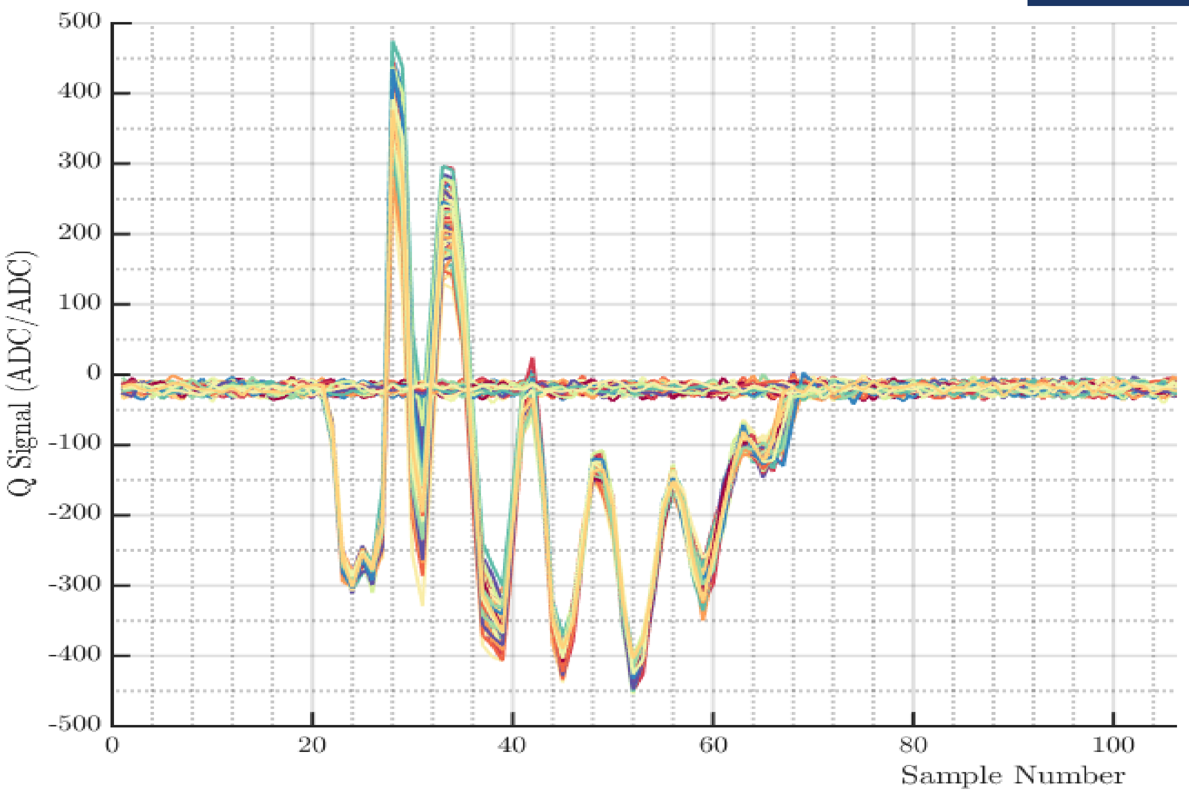
1-BPM Feedback

Nominal Optics

Without C-band BPFs

First Shift – Without BPFs (Nominal)

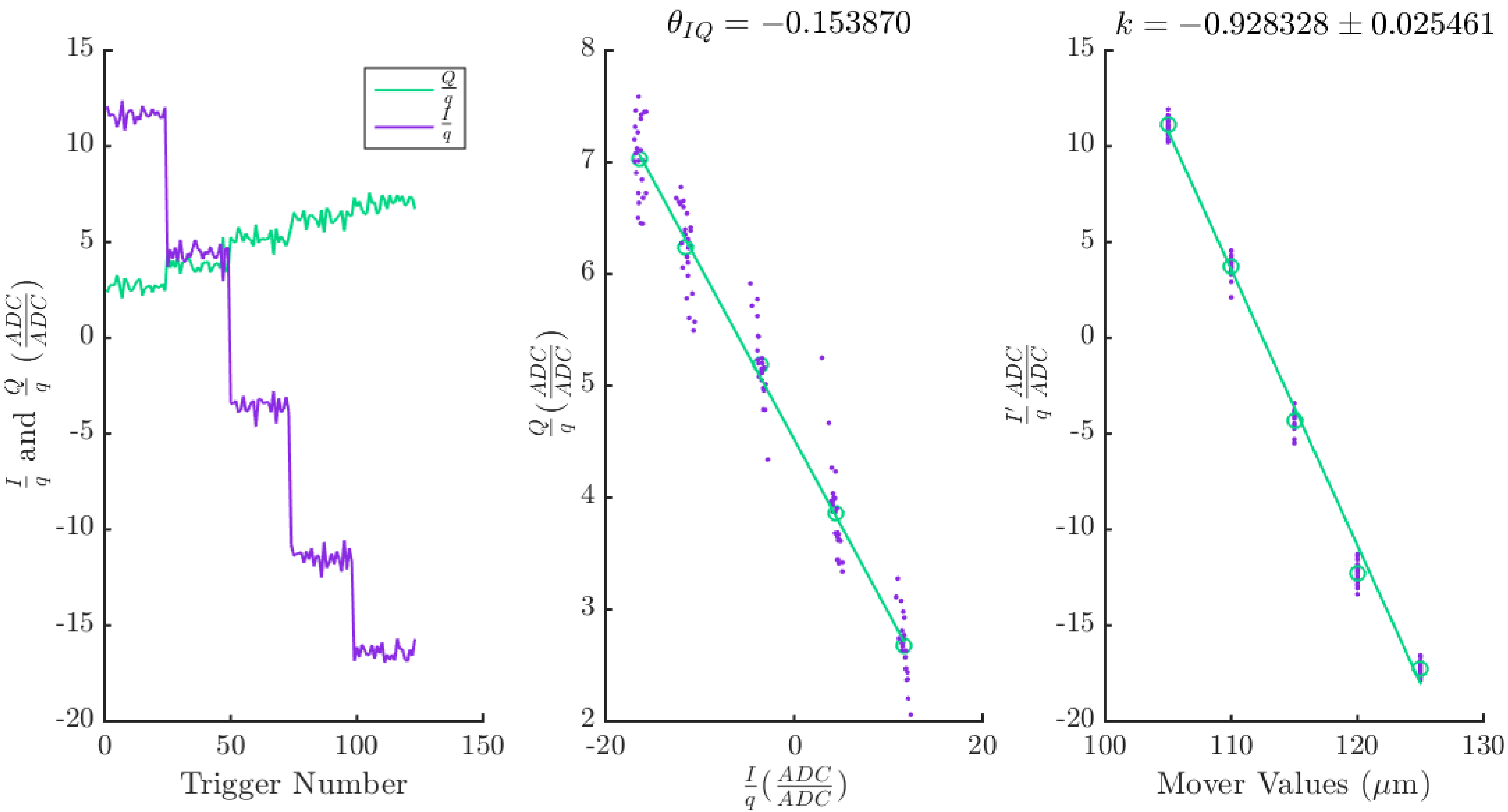
- Our first shift was performed without C-band BPFs.
- One concern, voiced by Doug, about the feedback calculation when the beam is very well centred is that, by integrating, you are reducing the sum to near zero – because of the parasitic waveform crossing zero.
- With such a well centred beam, the contribution from the parasitic waveform might be large compared with the position information.
- If you integrate over the wrong number/range of samples it will exacerbate the parasitic waveform.



For our first shift, most of the position information was contained within Q. After summing the signal, the summed value would tend to zero.

Appendix

1-BPM Calibration – Bunch 1

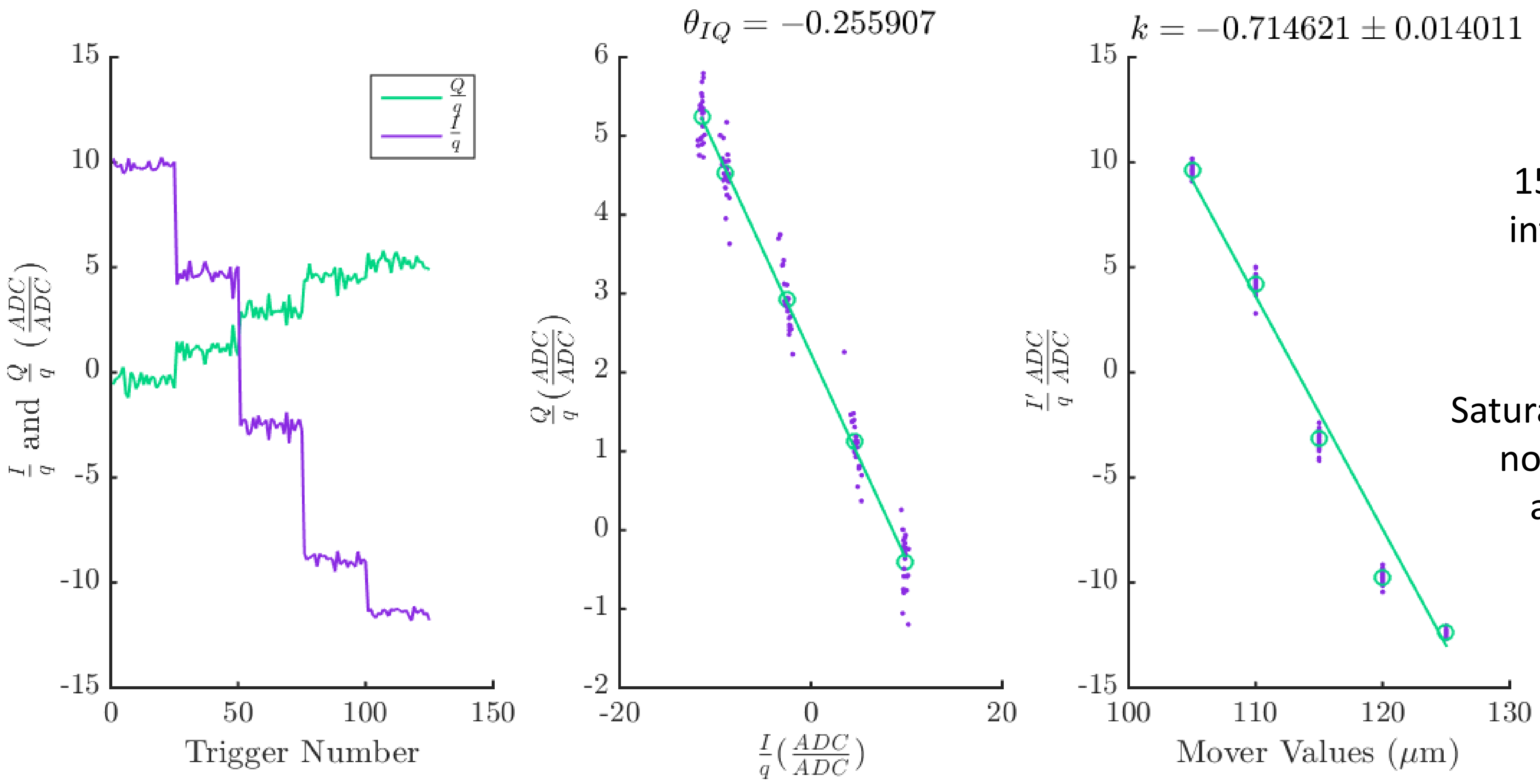


15 Sample integration 34:48

$\theta_{IQ} = -0.15$

$k = -0.93 \mp 0.03$ (ADC/ADC)/um

1-BPM Calibration – Bunch 2



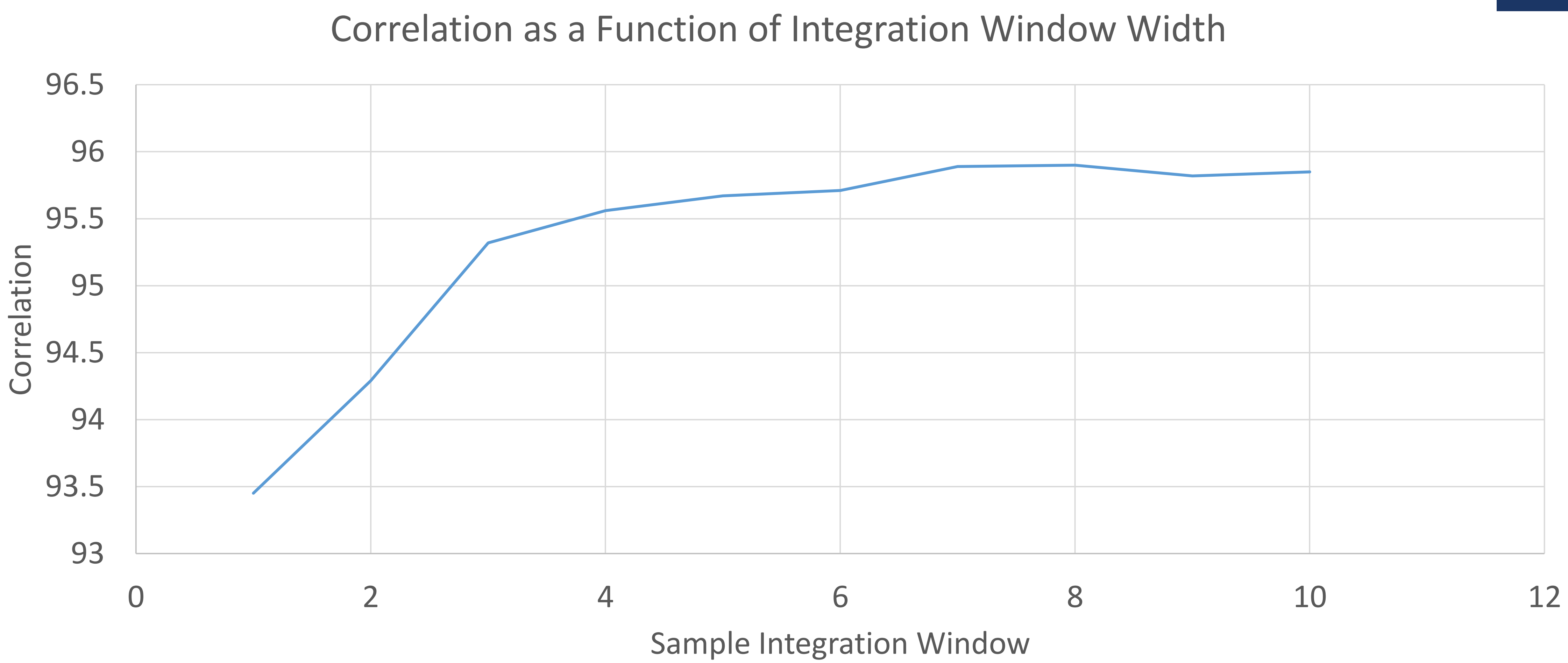
15 Sample integration 34:48

Saturated settings not used for analysis.

1-BPM Feedback Scan - ALL

Take results with a pinch of salt as correlation and FB off jitter varying.

Correlation as function of sample window



Jitter as a Function of Window Range

Green – feedback off jitter
Purple – feedback on jitter
ipfbRun 42, 44