First Look at Data – Nov 2017

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15/11/2017

Initial Comments

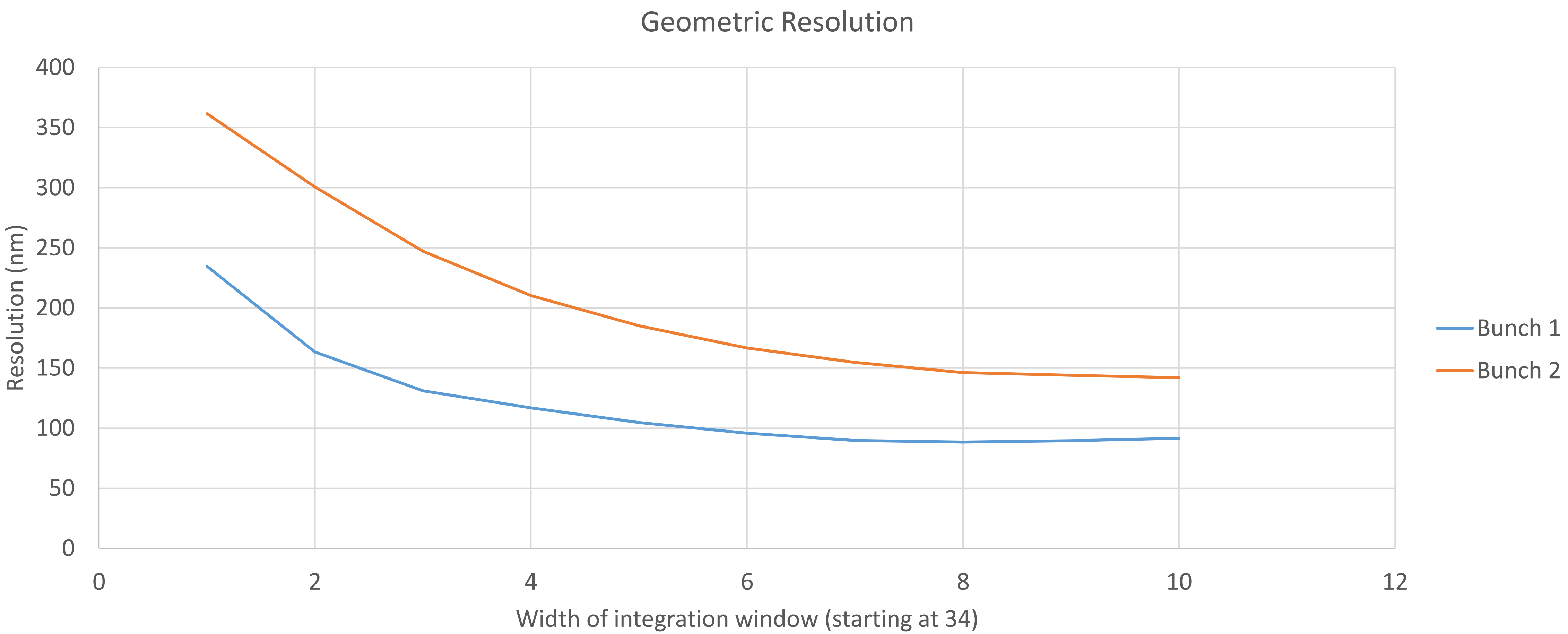
- Mostly analysed data from Friday's shift as best quality and 241 data files from that shift alone.
- Resolution consistently worse for bunch two, more information to follow.
- BPF required for 2-BPM operation, also in place for 1-BPM operation.
- Despite our best efforts, orbit and jitter considerably different for bunch two, 2-BPM feedback performed at 20dB.
- I haven't had time to fully analyse errors, so I will discuss these at a later date.
- Gain scans proved difficult to perform and analyse because of sample shifts, beam drifts and general differences in jitter and correlation between files. Certain integration windows were more stable between consecutive runs than others.

Sample Shifts

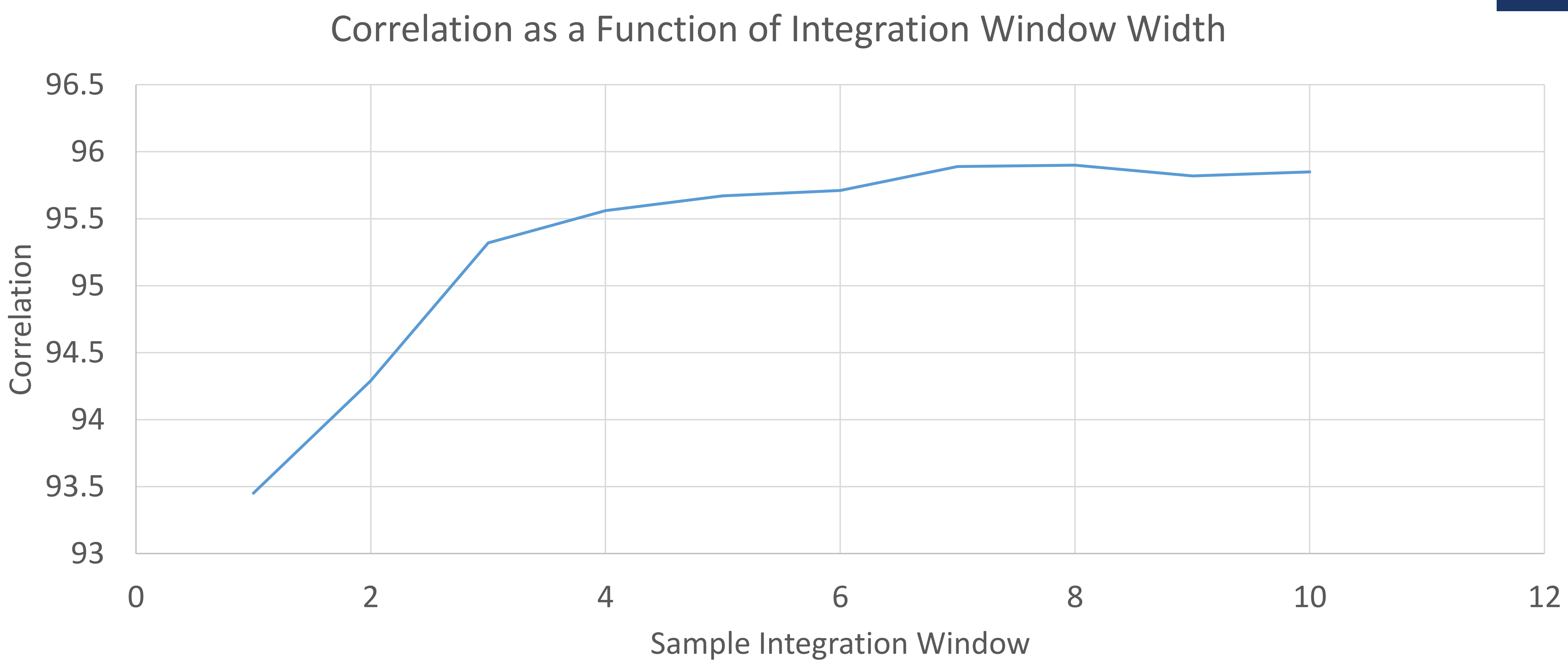
- Sample shifts dominated our data taken efforts, keep having to recentre – sometimes half sample jumps, must recalibrate etc.
- Happened typically once every ten minutes, but periods where it happened every few seconds for multiple minutes. Tried power cycling etc. nothing helped.
- Part of what made 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.
- Hypothesis from shift: Possibly jumps more when the temperature was changing rather than stable.
- Second hypothesis from shift: Possibly jumps more while we are changing sample hold off, may be a firmware bug triggered by certain circumstances.

Resolution as Function of Window

jitRun1, high beta optics



Correlation as function of sample window



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 given jitter and correlation measurements.
- Equation borrowed from Neven's thesis.

Y2= bunch 2 jitter FB on,

y2=bunch 2 jitter fb off,

y1=bunch 1 jitter,

rho=correlation.

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

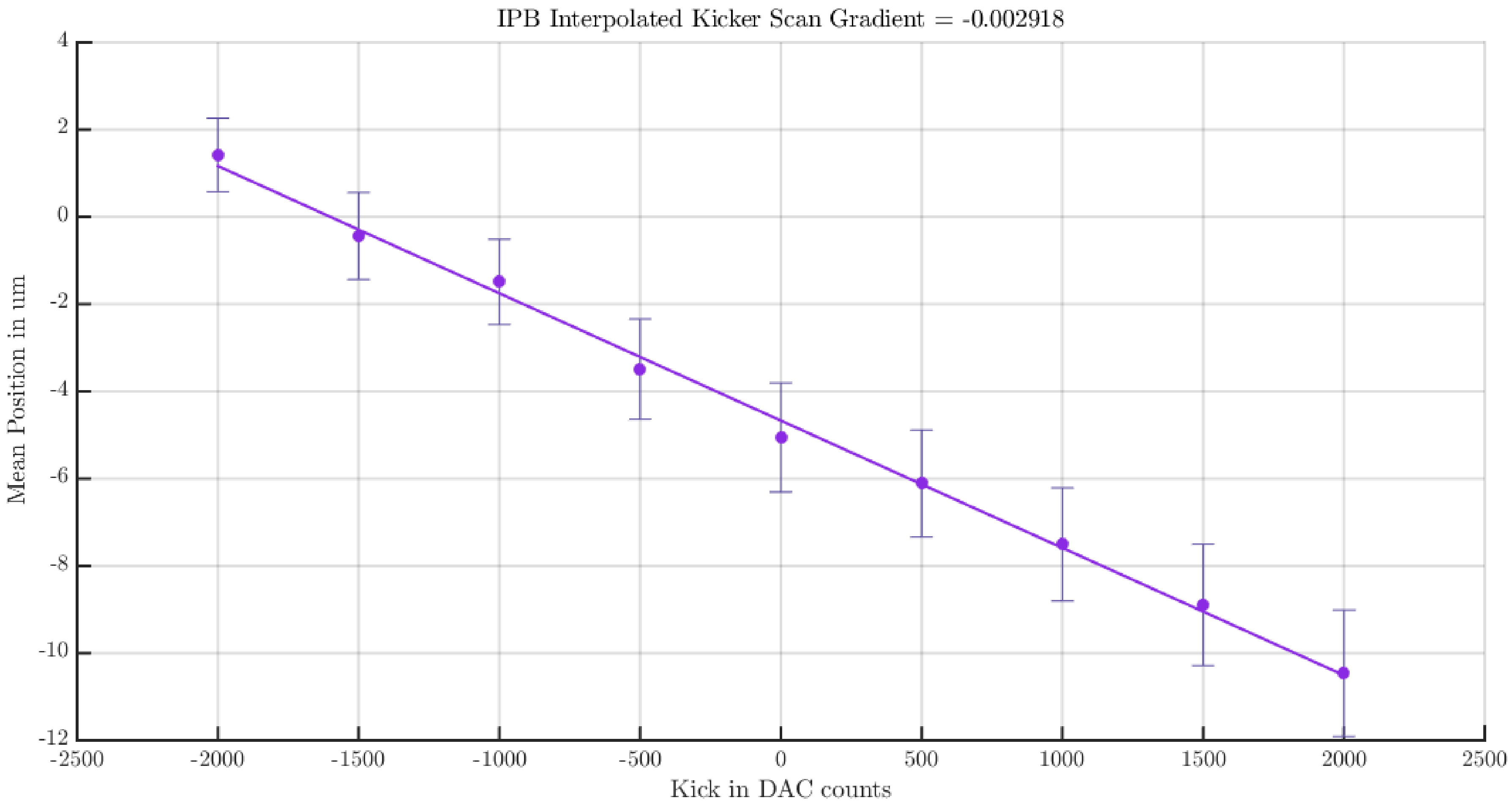
2-BPM Feedback

High Beta Optics

2-BPM Feedback

- BPF installed, parasitic waveform too large to centre in IPB.
- 20dB – as massive jitter at A in bunch 2, even when waist at IPB, cannot centre at 10dB.
- Waveform in IPA shows opposite direction peak for bunch 1 and 2, making aligning BPM difficult.

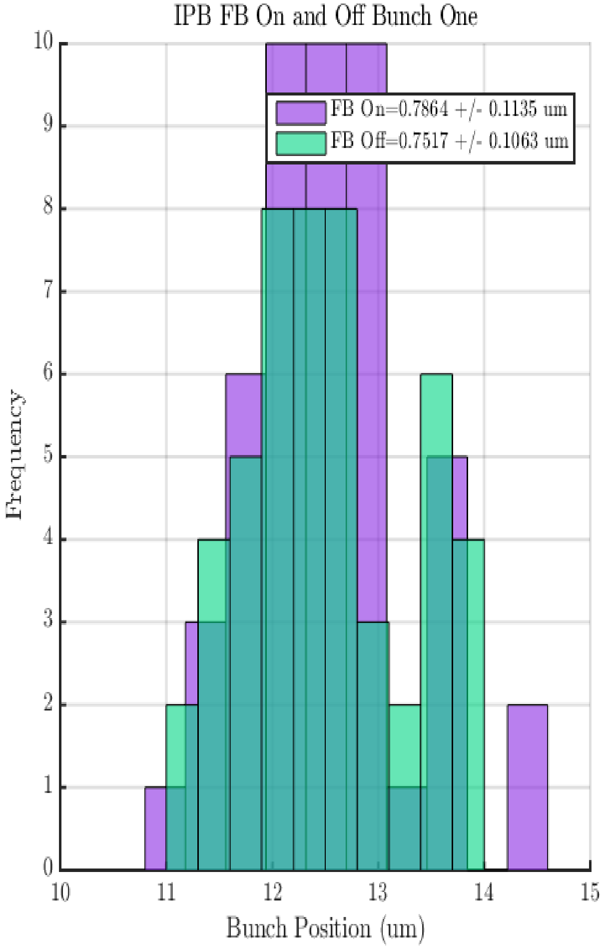
Kicker Scans – Interpolating at IPB

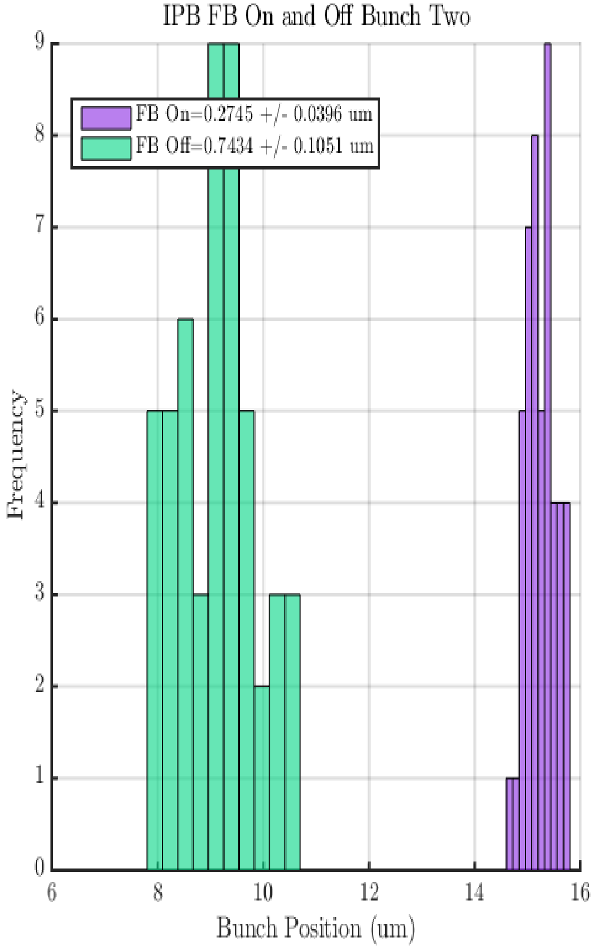


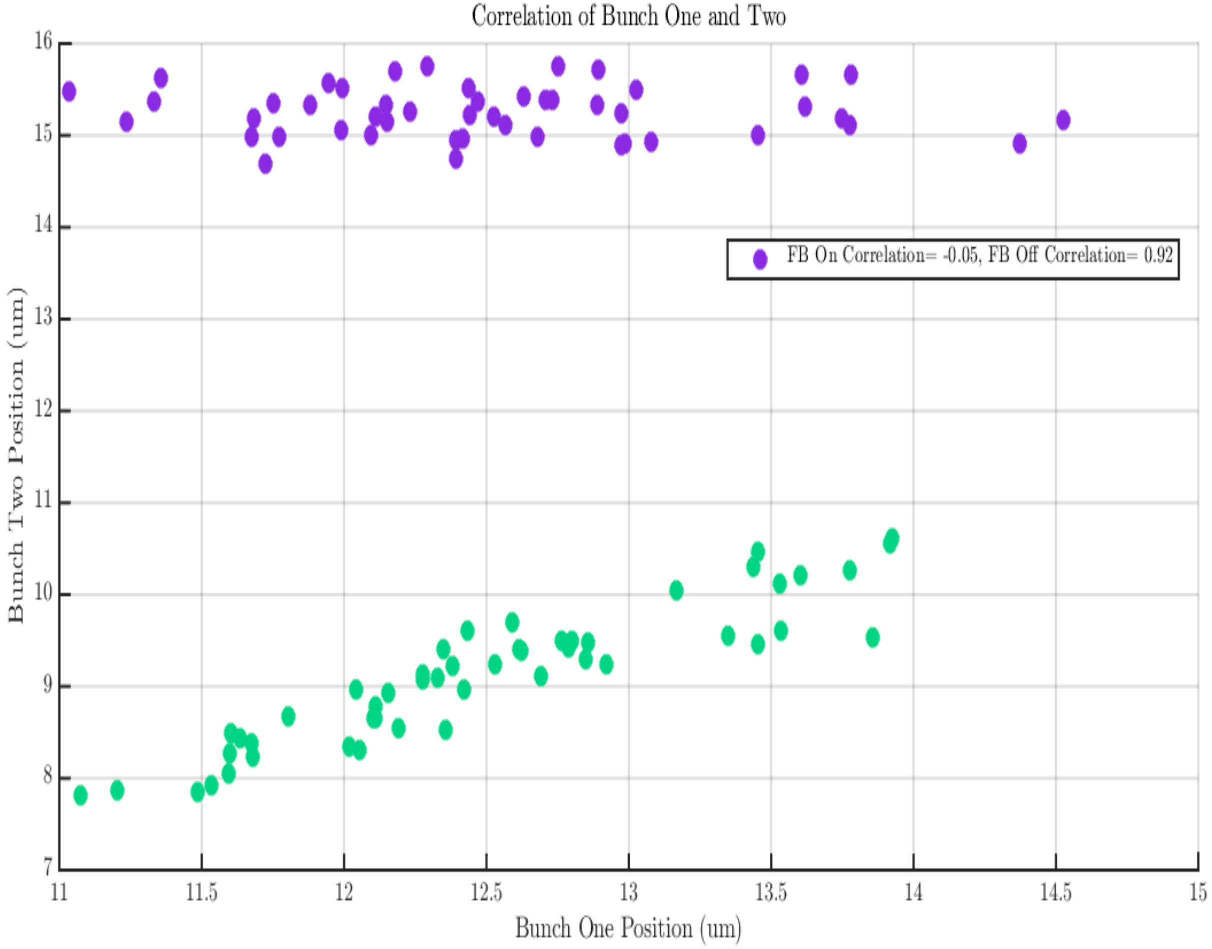
Need to check code for error bars – look large. Kicker scan interpolated from scans performed at IPA and IPC.

Multiple kicker scans performed, variation in gradient on the order of 10%. Perhaps due to changing the angle of the beam using upstream mover.

2-BPM Single Sample Feedback – Best Performance

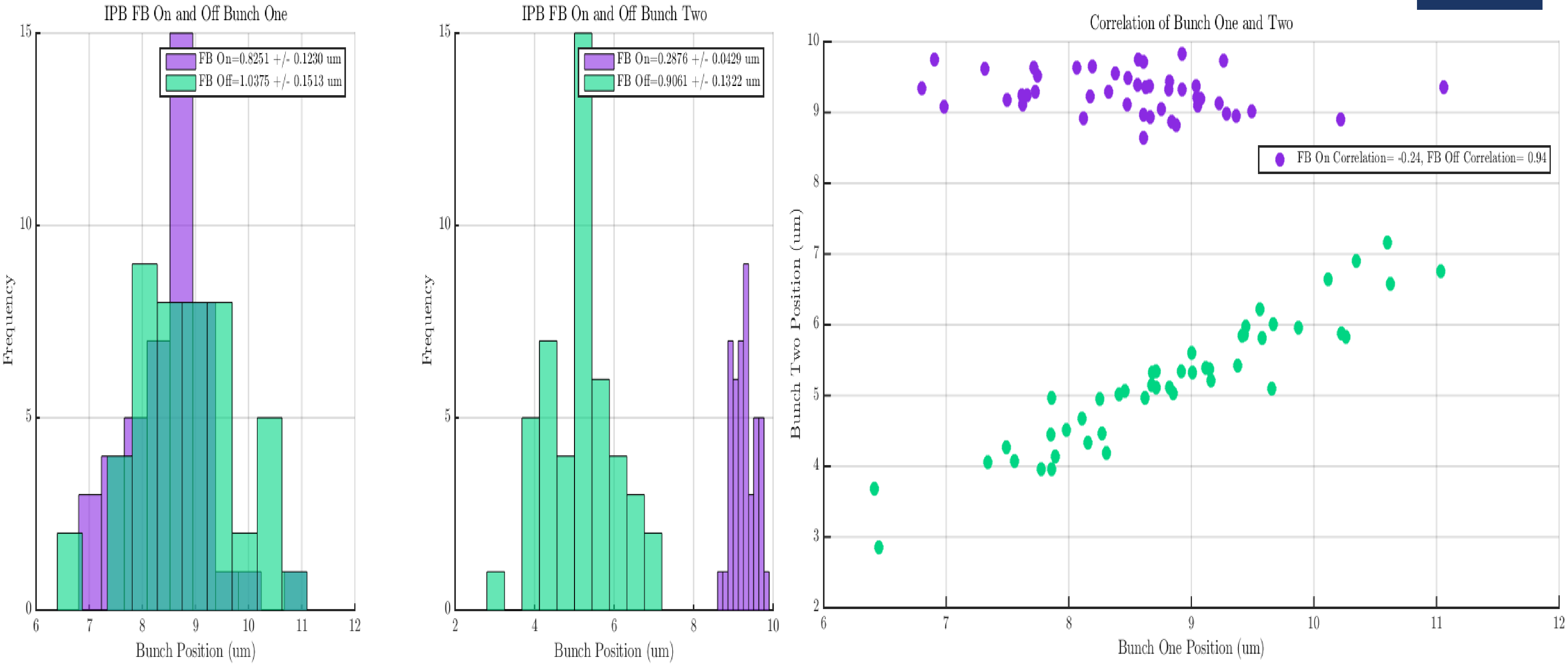






2-BPM Ten Sample Feedback- Best Performance

Geometric resolution: 111 nm, ipfbRun25.



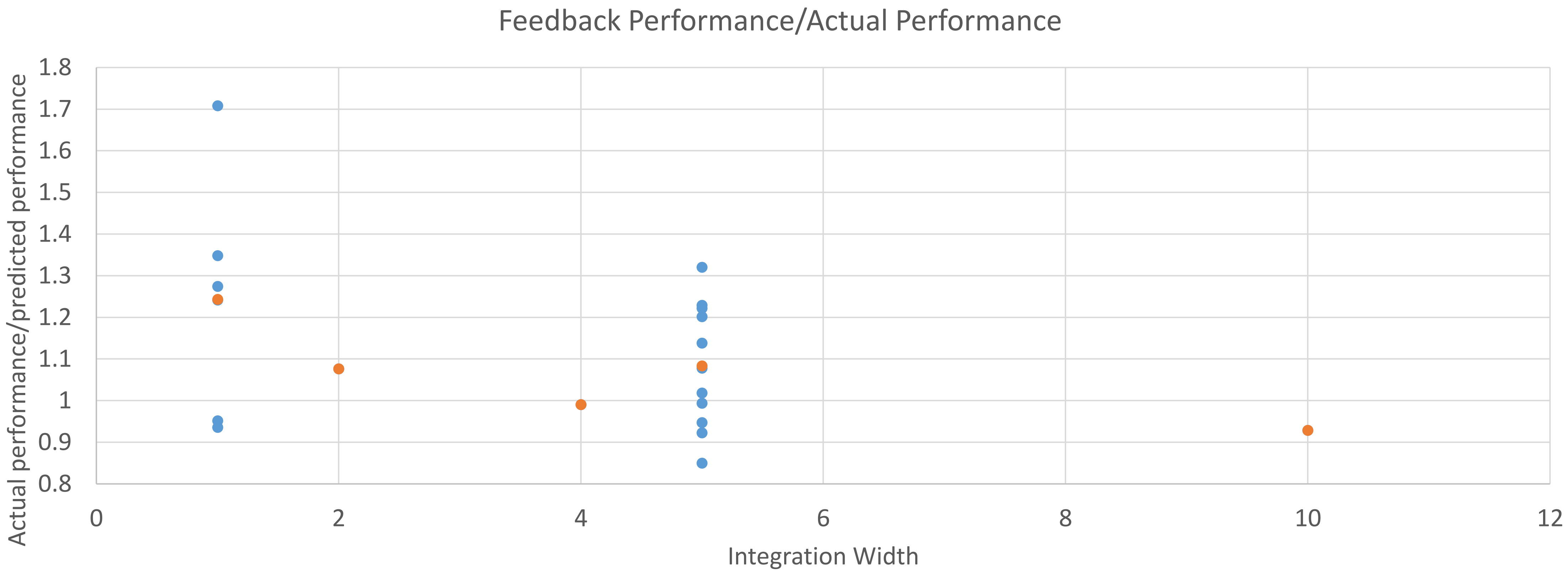
ipfbRun25 – 10 sample prediction

Using the equation quoted earlier from Neven's thesis: the expected feedback performance for this data file would be stabilisation to 310 nm. The actual feedback off jitter was 288 nm (100 triggers).

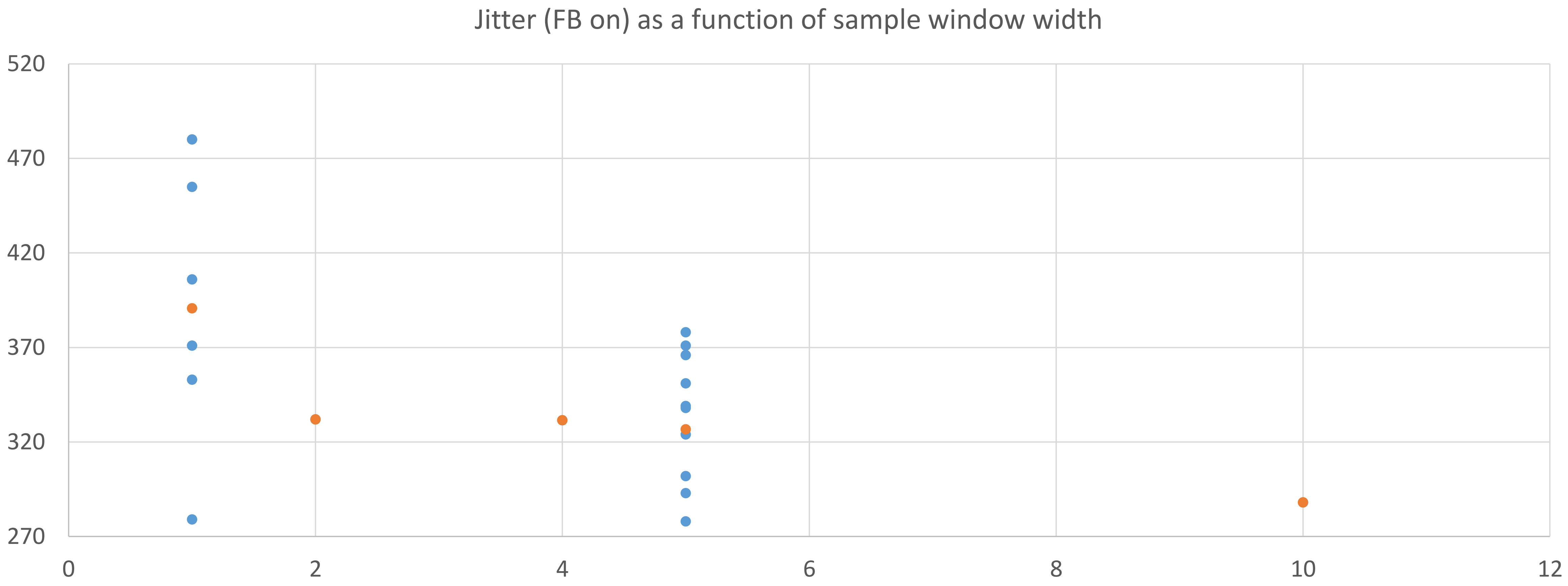
FB Off Jitter	FB On Jitter	FB Off Correlation	FB On Correlation	Predicted Correction FB On Jitter	Bunch One Jitter	Sample Window Width	Measured FB On Jitter as Fraction of Expected Performance
906	288	94%	-24%	310.2499	825	10	0.928283944

2-BPM Feedback

Orange shows mean.
Single poor performance point at single sample skews mean for this window.



Feedback Window Scan (Jitter FB On)



1-BPM Feedback

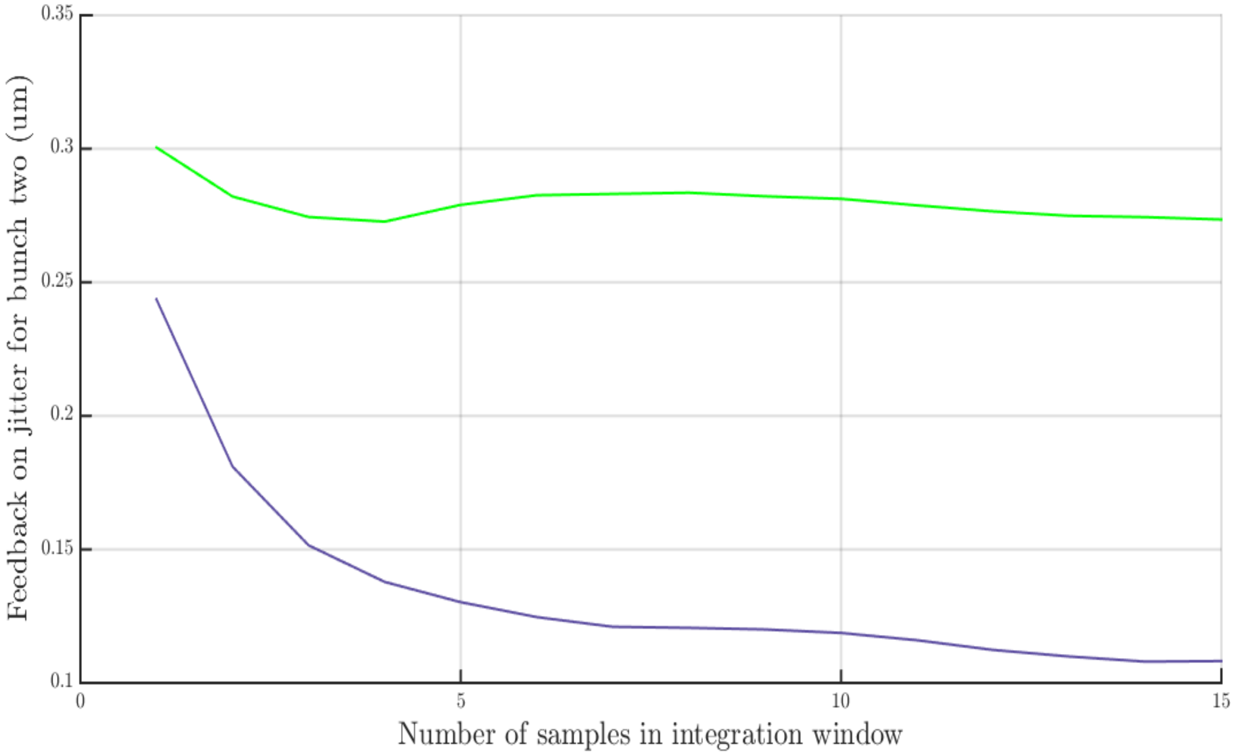
Nominal Optics

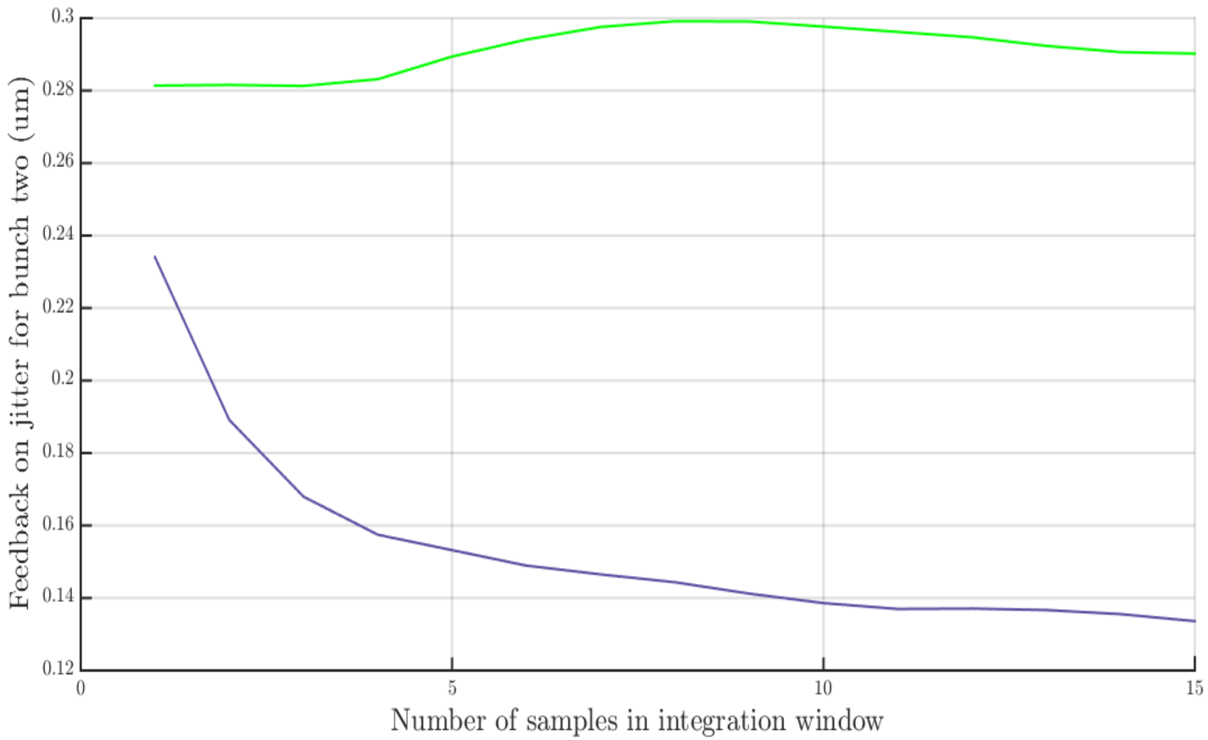
1-BPM feedback

- Converted back to nominal optics.
- Improvement to jitter measurement with integration only seen for small beam size at waist, when resolution limited. Hopeful to see more of an effect from integration because of nominal optics.
- However, not able to get a beam jitter at waist of less than ~500 nm. Suggests beam not changed properly from high beta optics.
- From beam measurements on first shift, would expect more effect from integration with smaller waist.

Jitter as a Function of Window Range

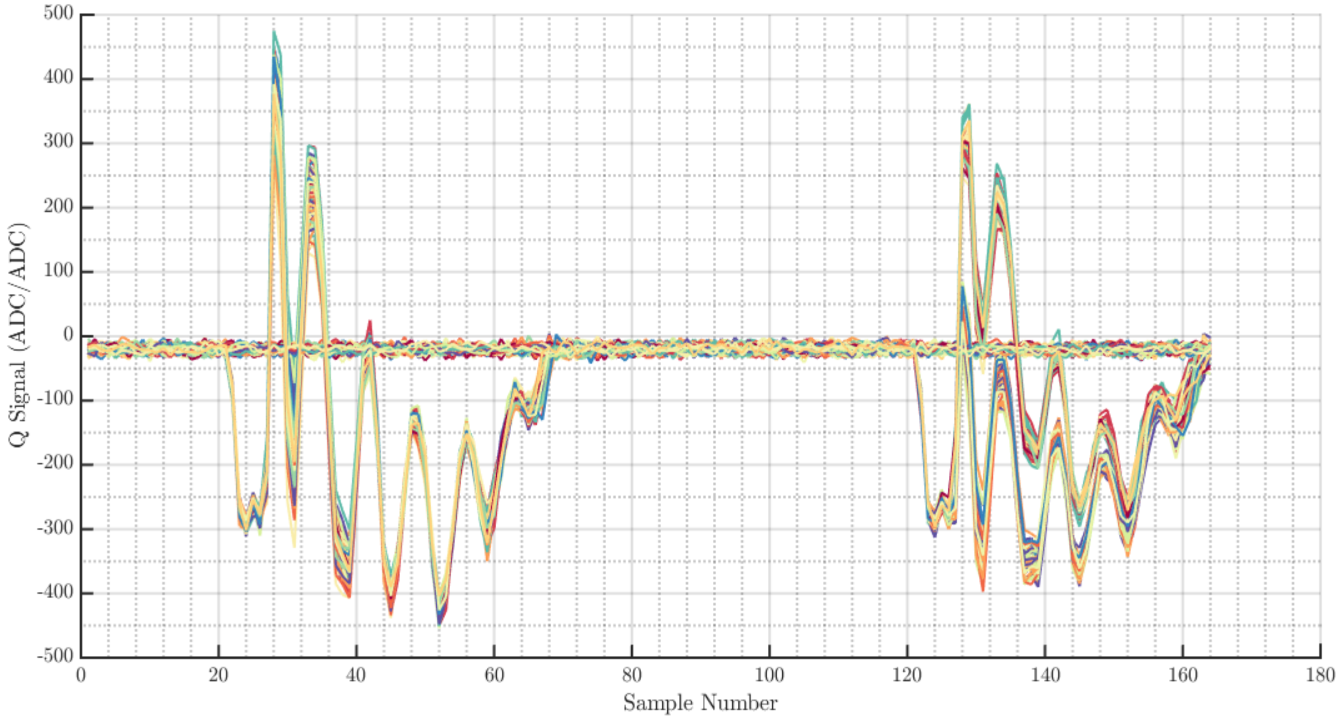
Green – feedback off jitter
Purple – feedback on jitter
ipfbRun 42, 44
Sorry about the scaling! But both seem to demonstrate resolution limitation to the feedback on jitter.





First Shift – 1 BPM Feedback

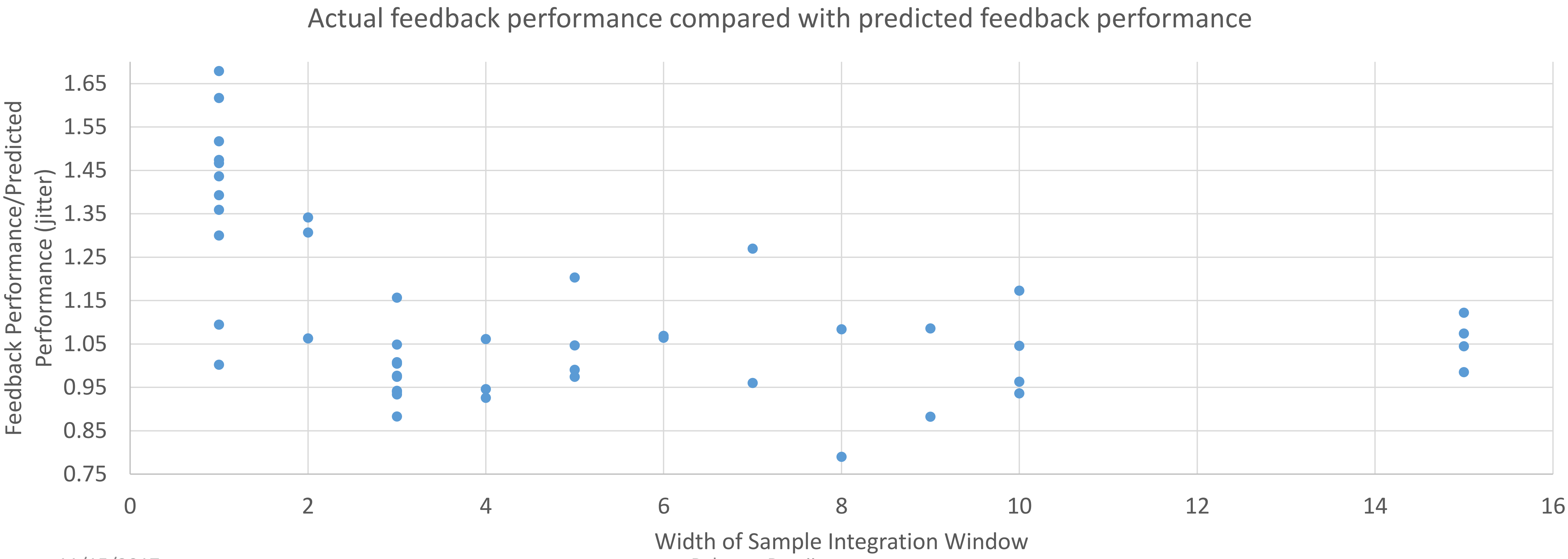
- I haven't had time to analyse much of the first shift, so the analysis on the following slides is all from our final double shift.
- One concern, voiced by Doug, about the feedback calculation when the beam is very well centred is that, by integrating, you are reducing the sum to near zero – because 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.

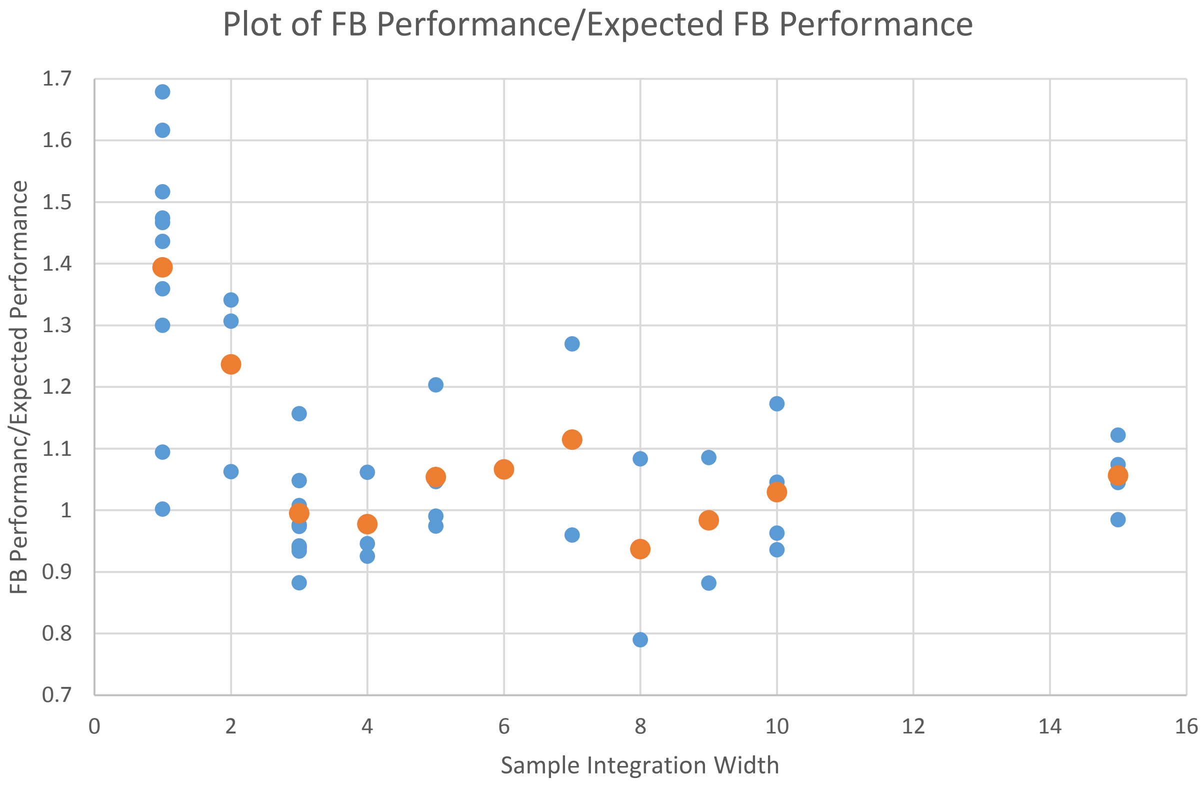
1-BPM Feedback Scans - ALL

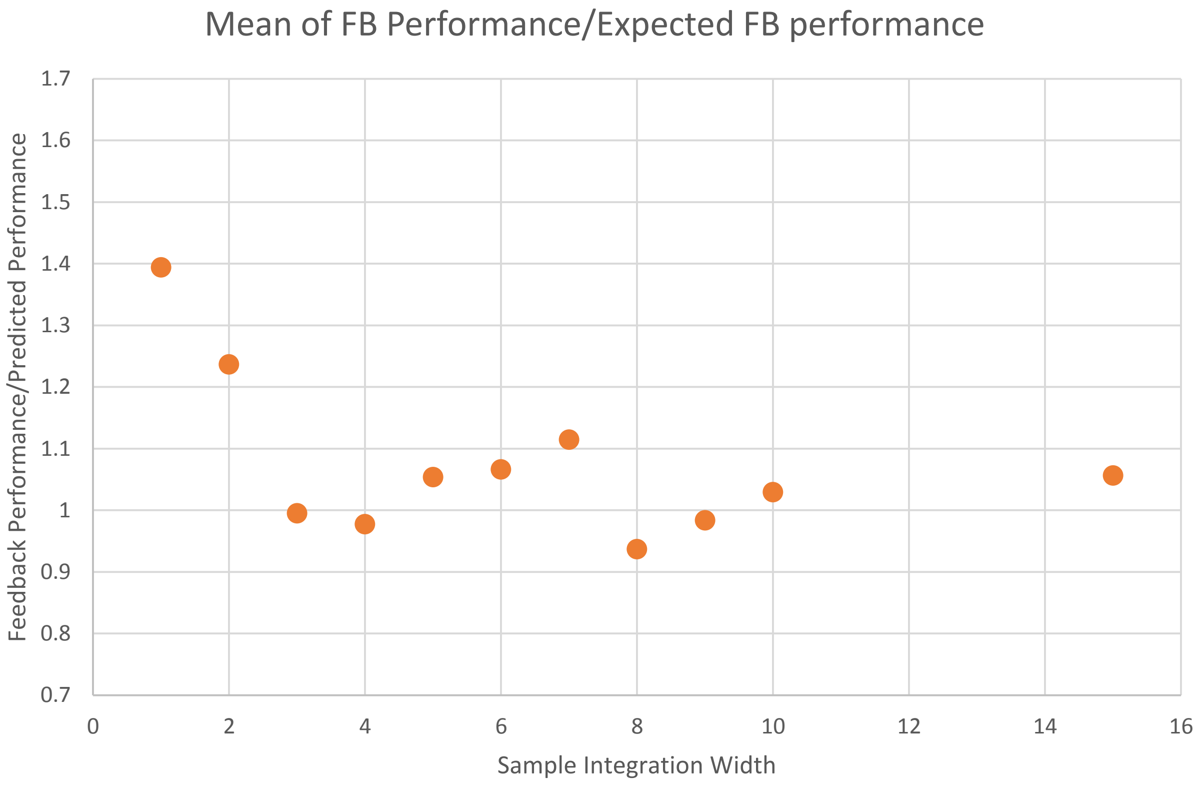
- Nearly all feedback scans performed in 1-BPM mode showed significant correction, so I plotted all of the ones that did against the width of their respective integration window.
- Single BPM feedback provides the least repeatable correction level.



Predicted Performance/Actual Performance - AVERAGE

The same plot as the previous page, but with the mean values added.



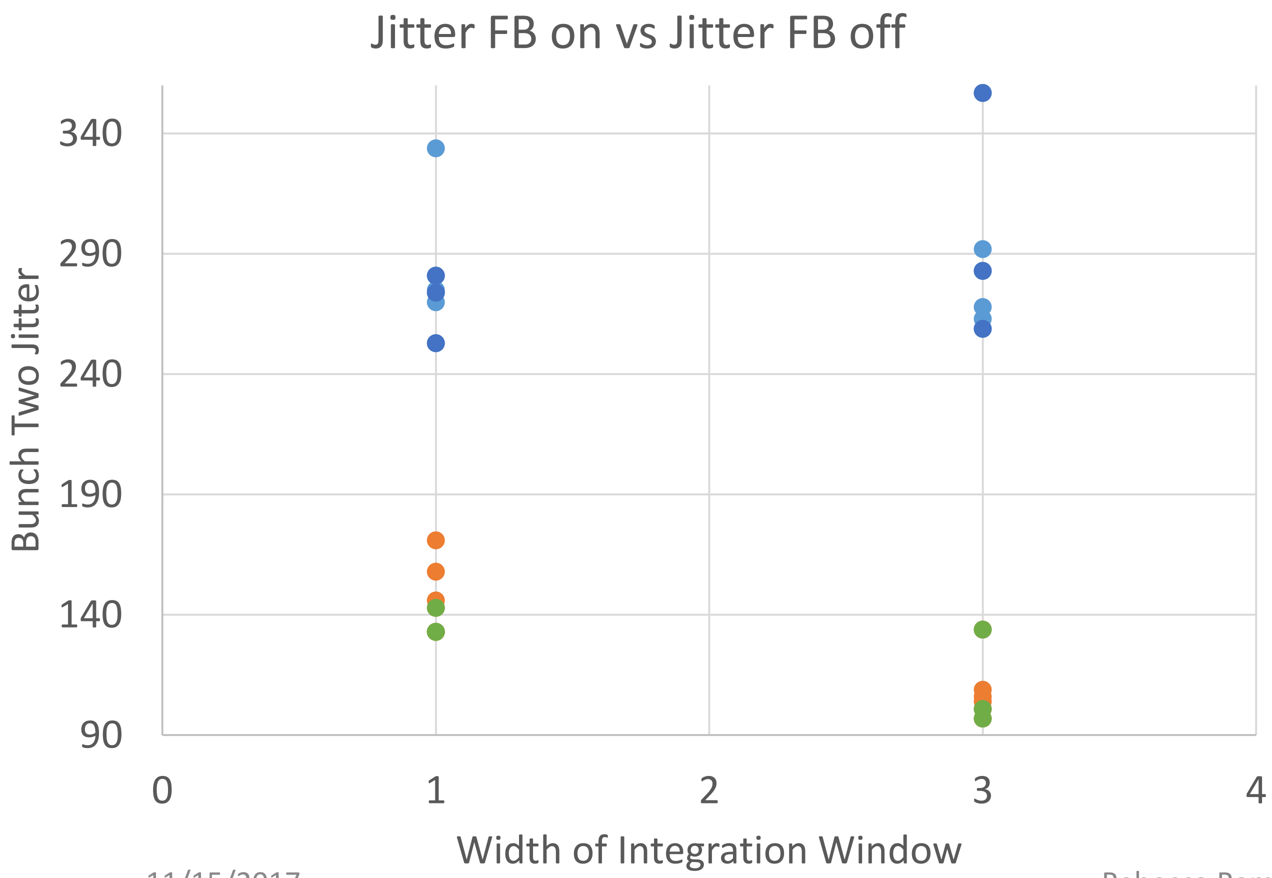


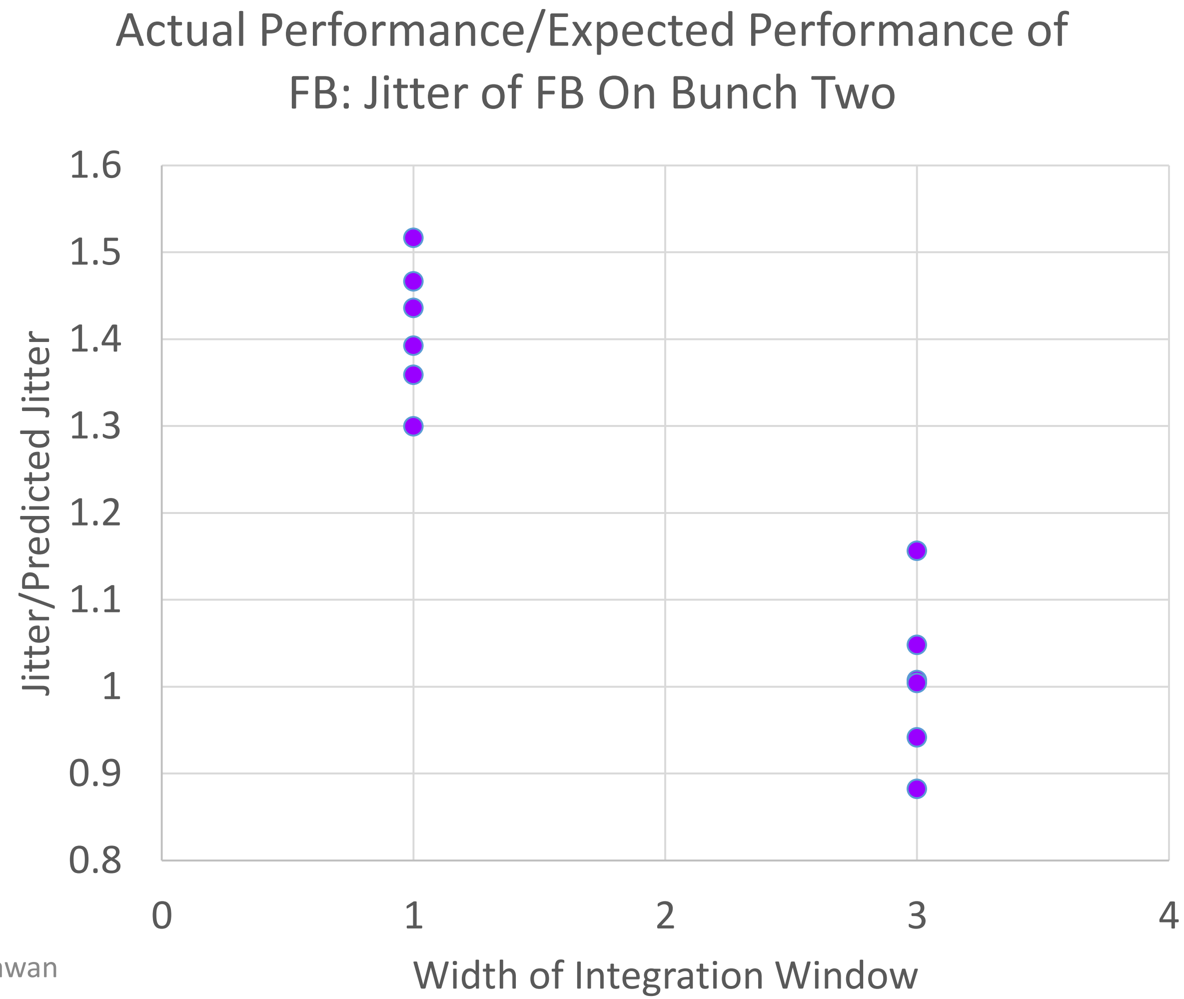
1-BPM Feedback Scan - ALL

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

Single Sample Compared With Three Samples

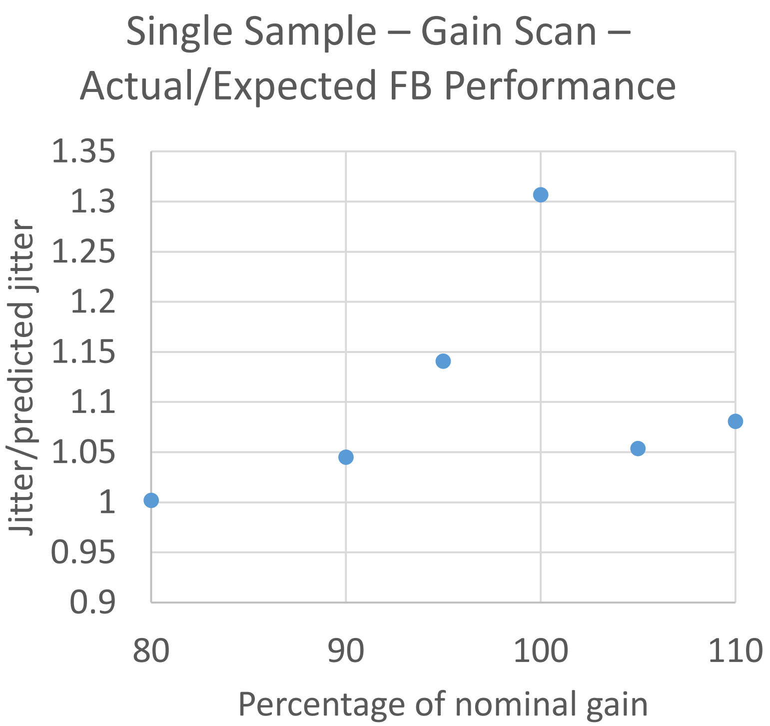
Twelve files taken consecutively.
ipfbRun49-54, gainScan14_-5_again1,2,3, gainScan14_0_again1,2,3.
3 files at 100% gain (orange) and 3 files at 95% gain (green).

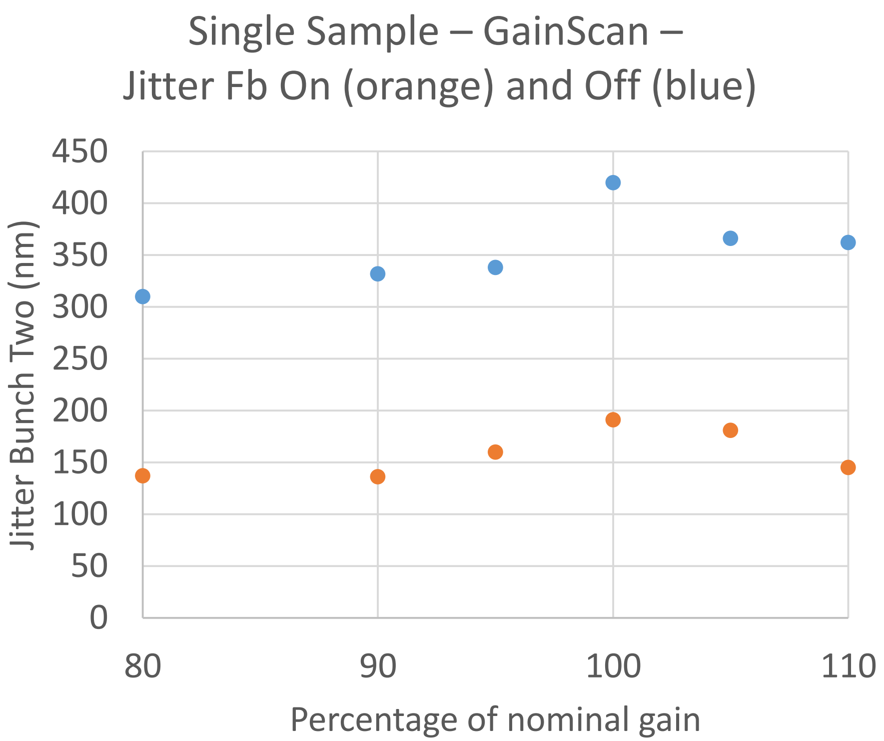


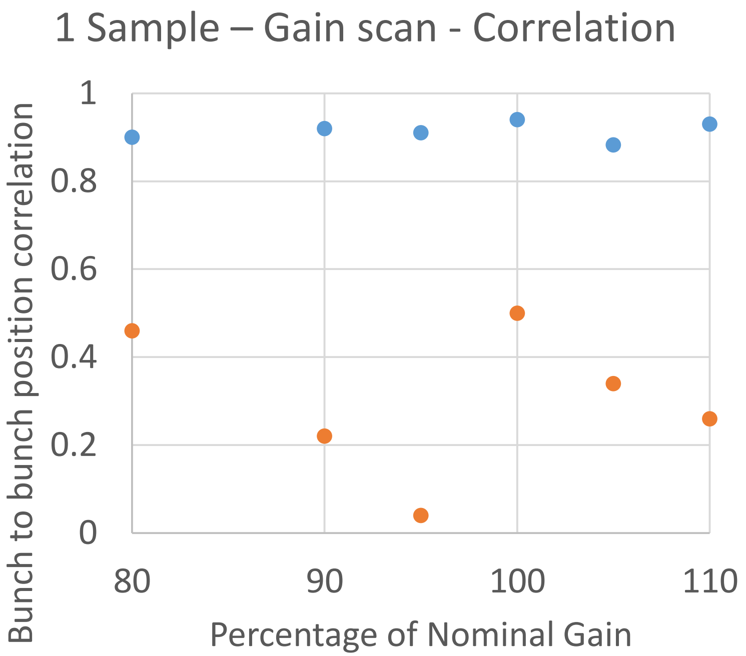


1-BPM Gains Scans –Single Sample

Single sample feedback the most unstable, with respect to running consecutive repeat runs and getting the same result.

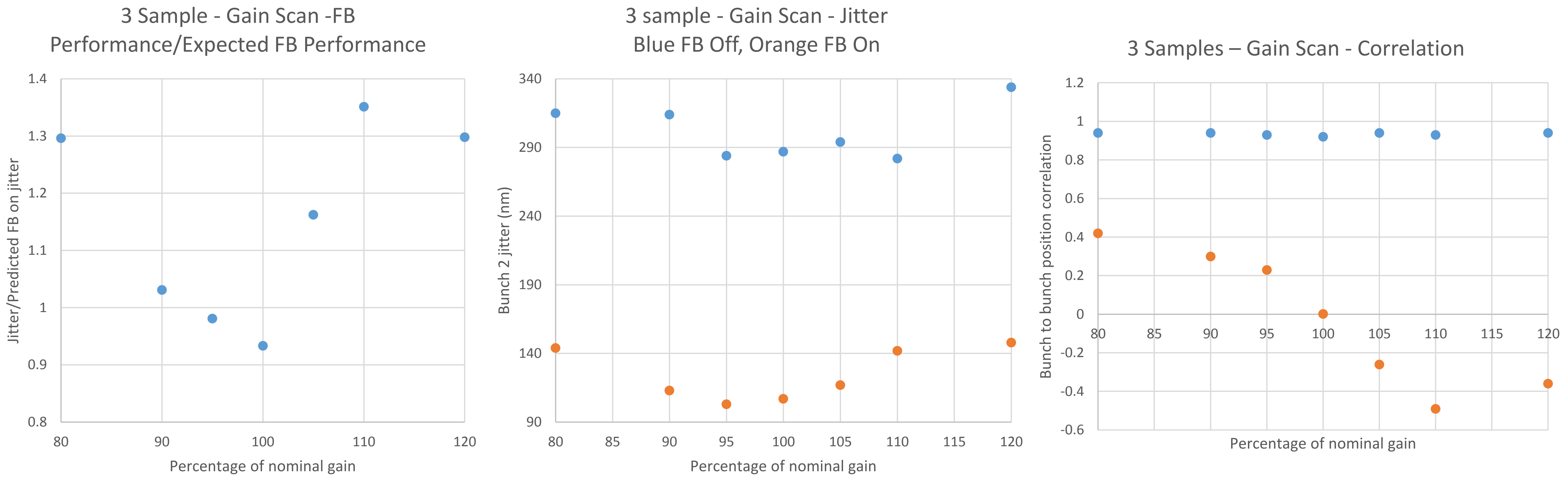




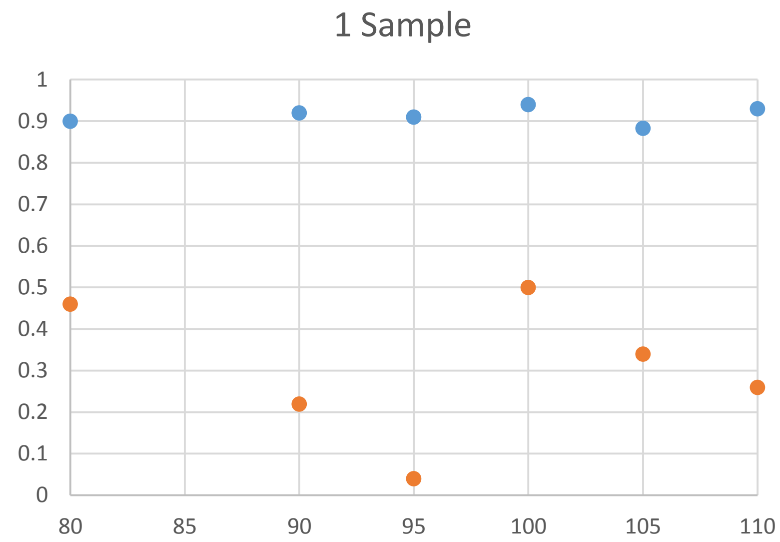


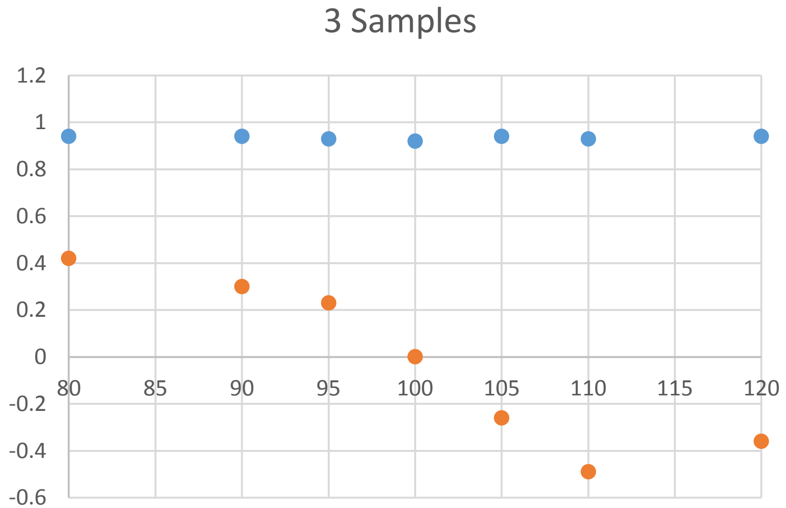
1-BPM Gains Scan – 3 sample

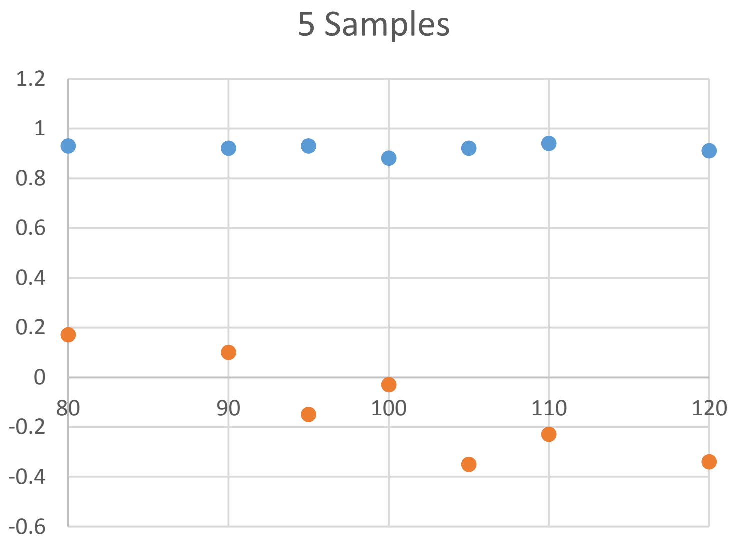
3 Sample integration consistently best and most stable integration.
Coincidentally??, corresponds to half a period of parasitic waveform.

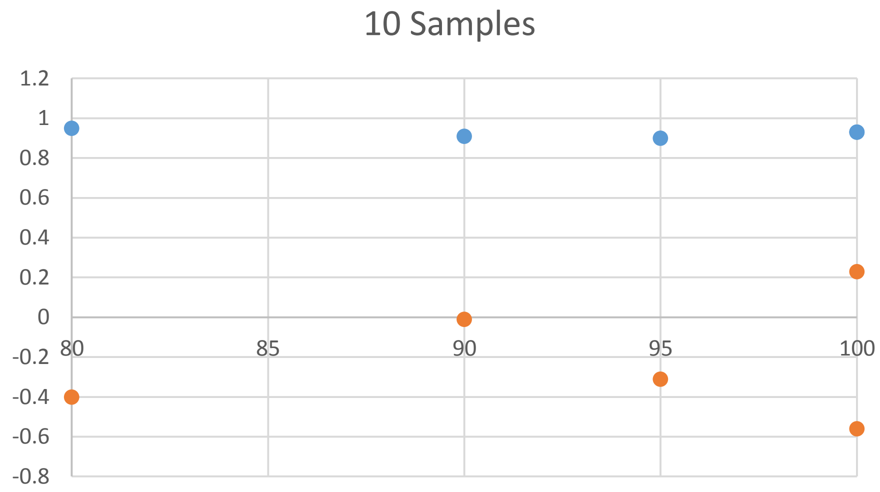


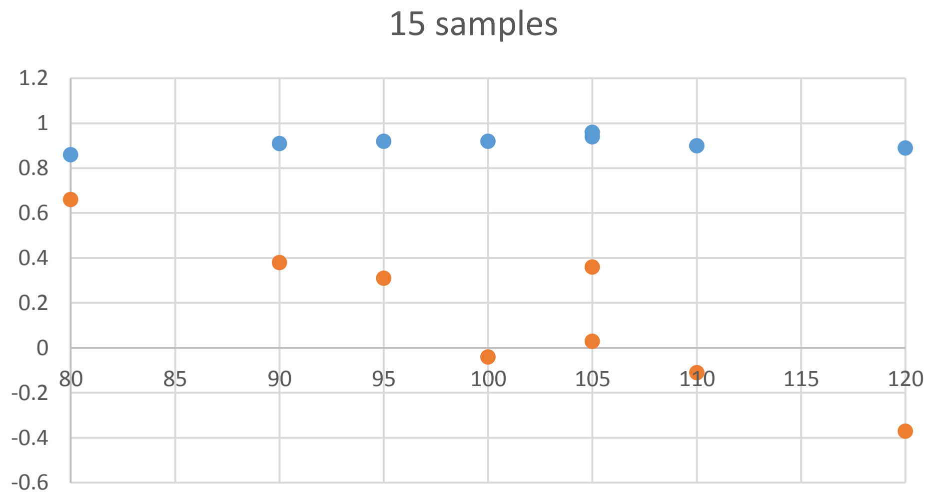
Percentage of nominal gain vs. correlation



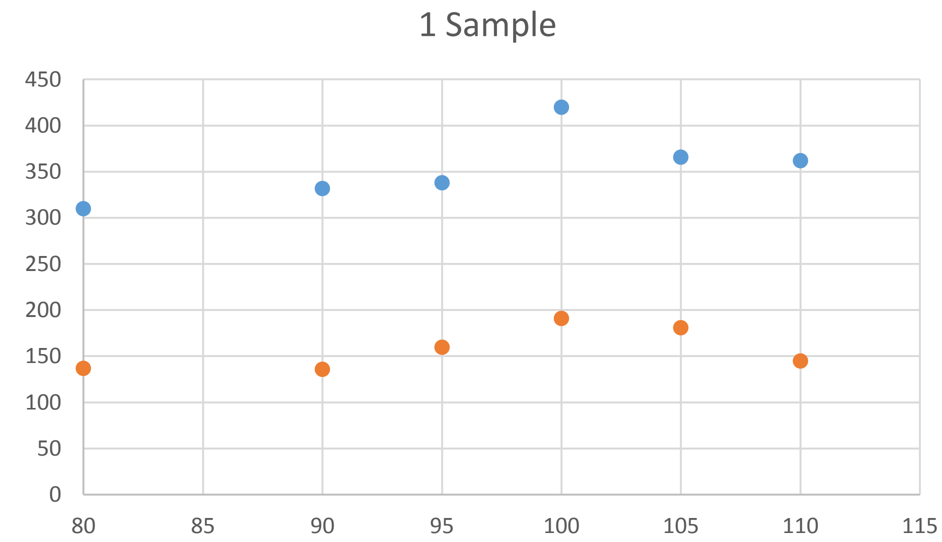


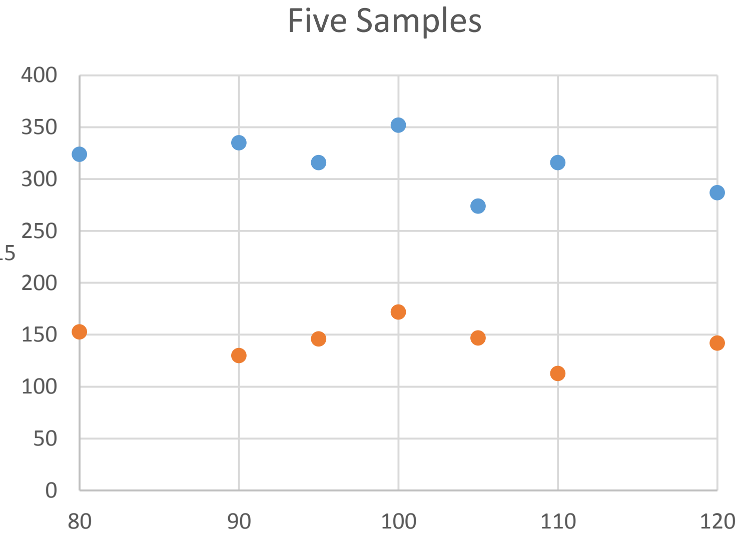


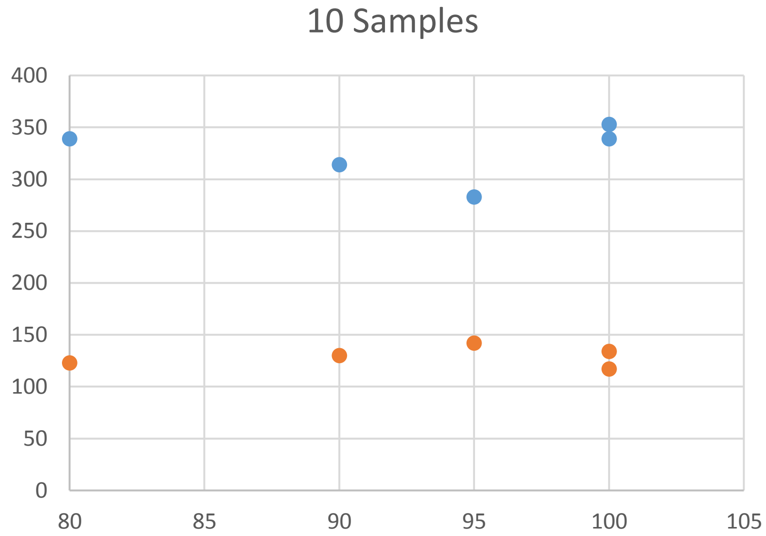


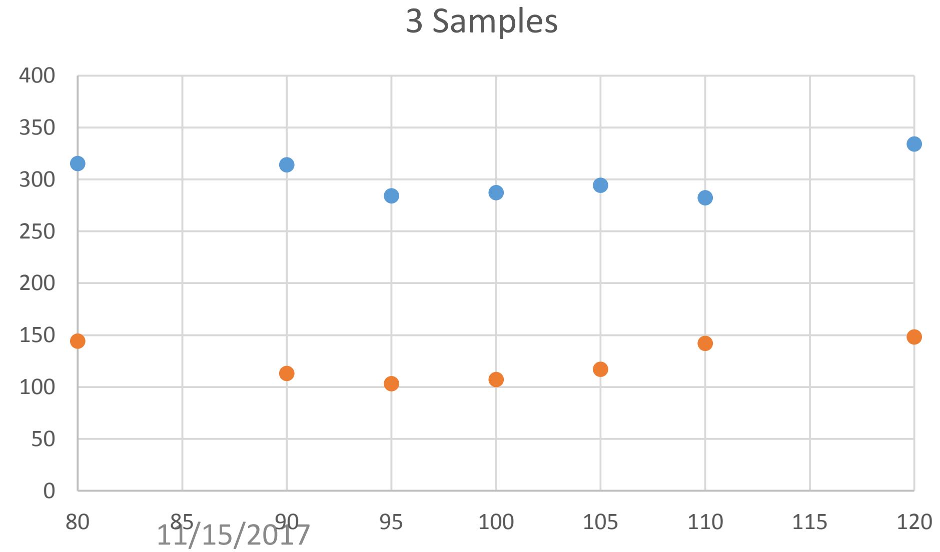


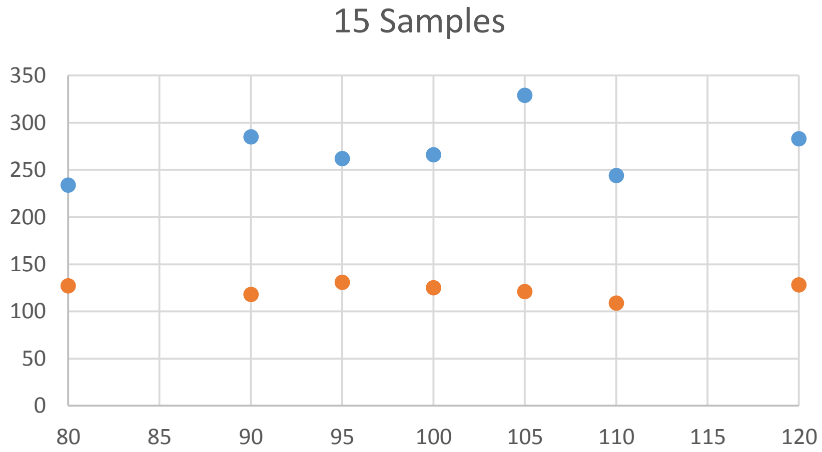
Percentage of nominal gain vs. bunch 2 jitter



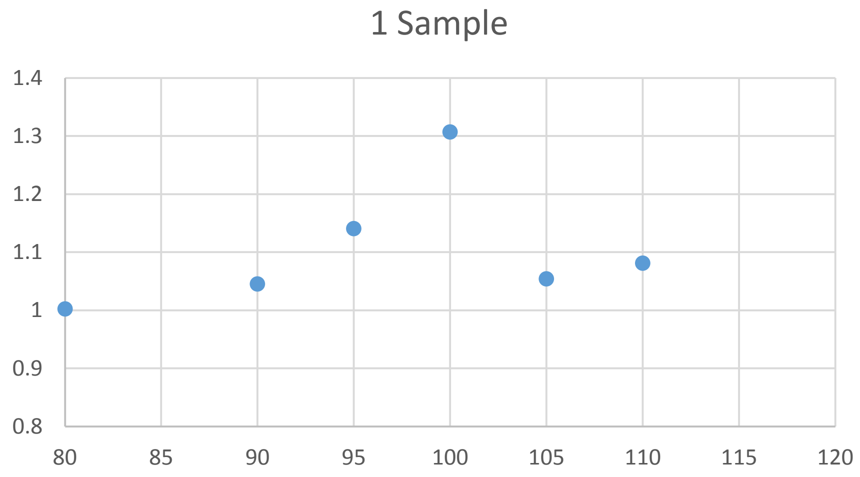


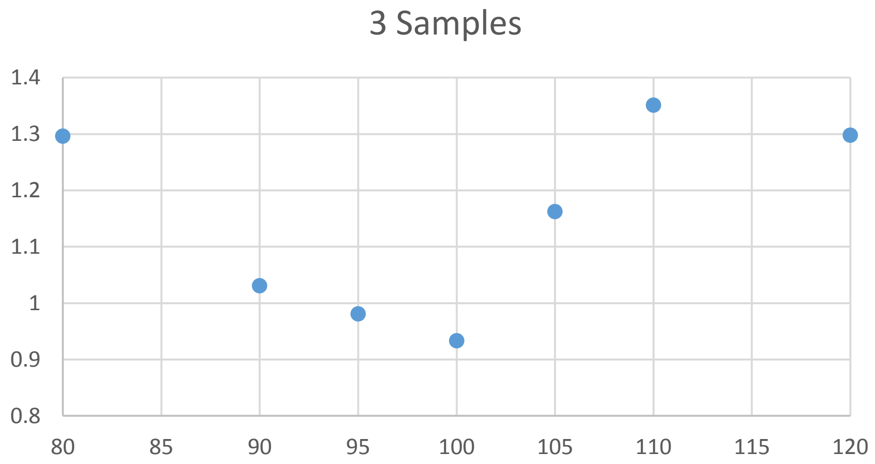


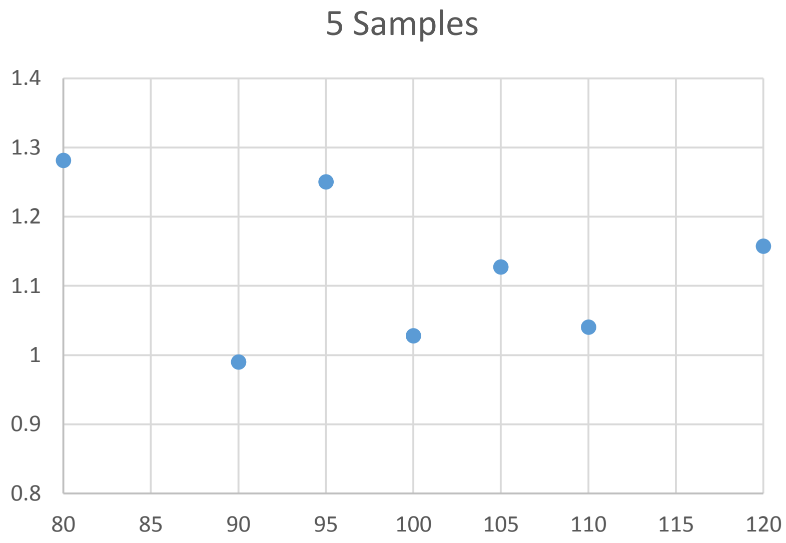


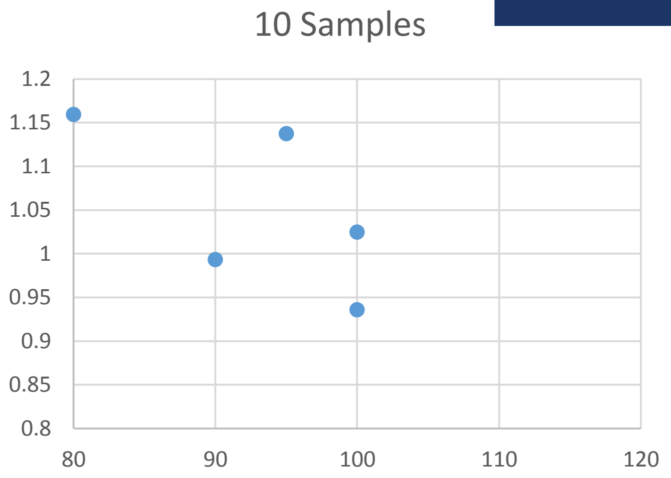


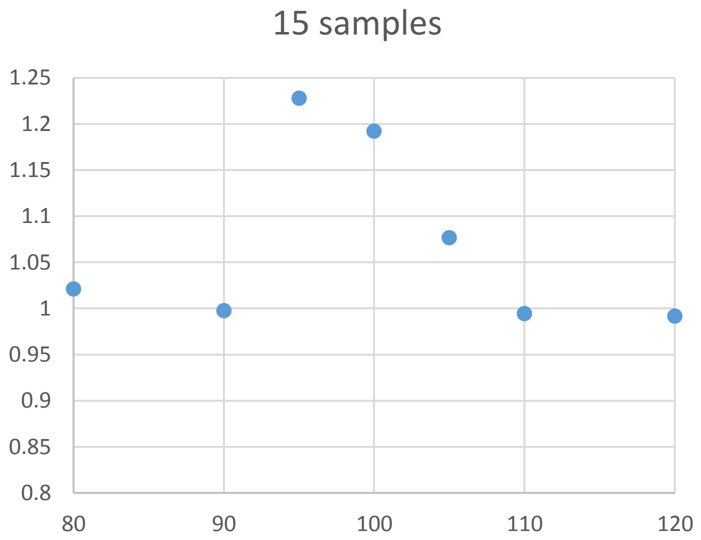
Gain Scan – Expected vs. Actual FB Performance





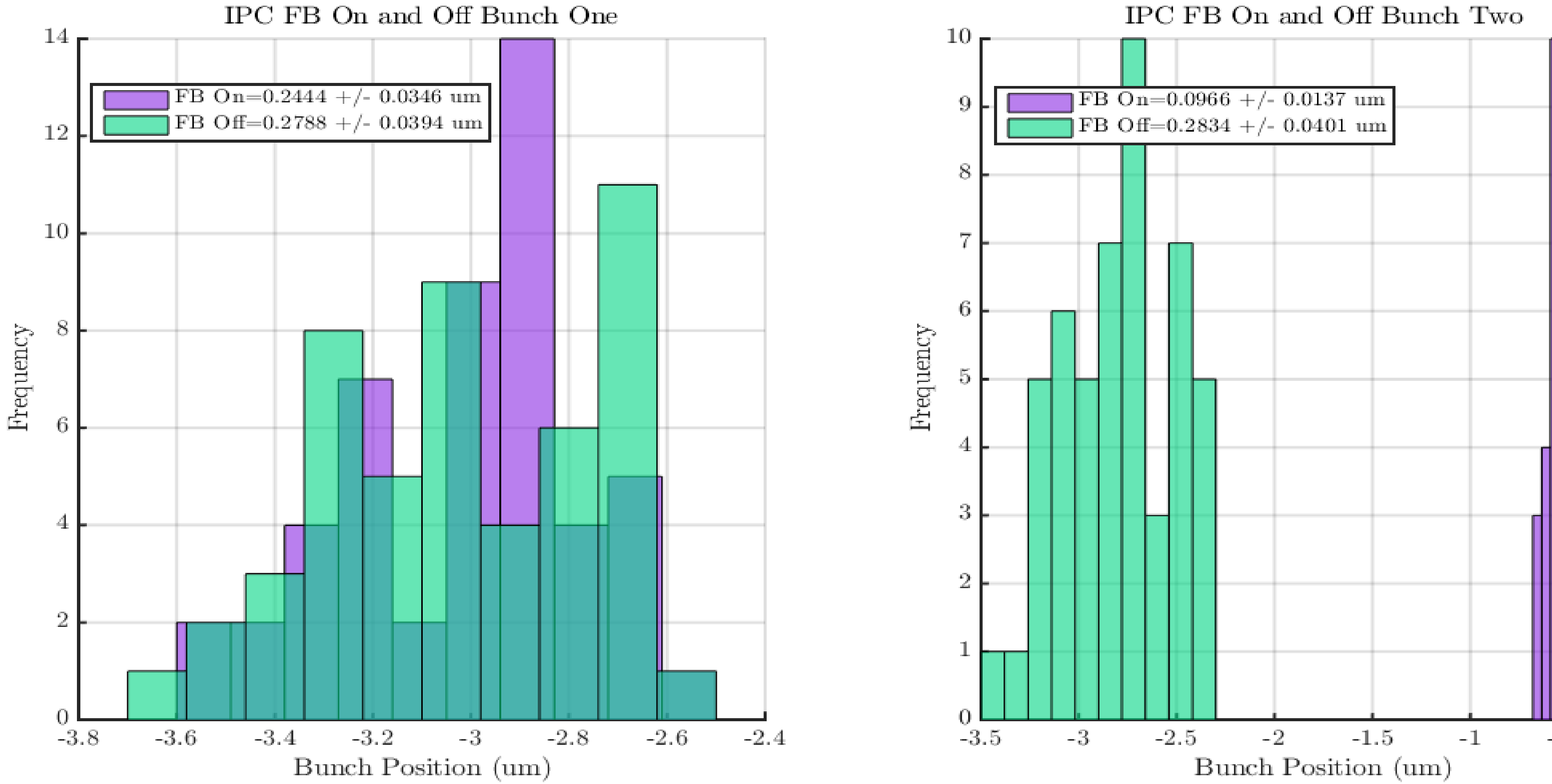






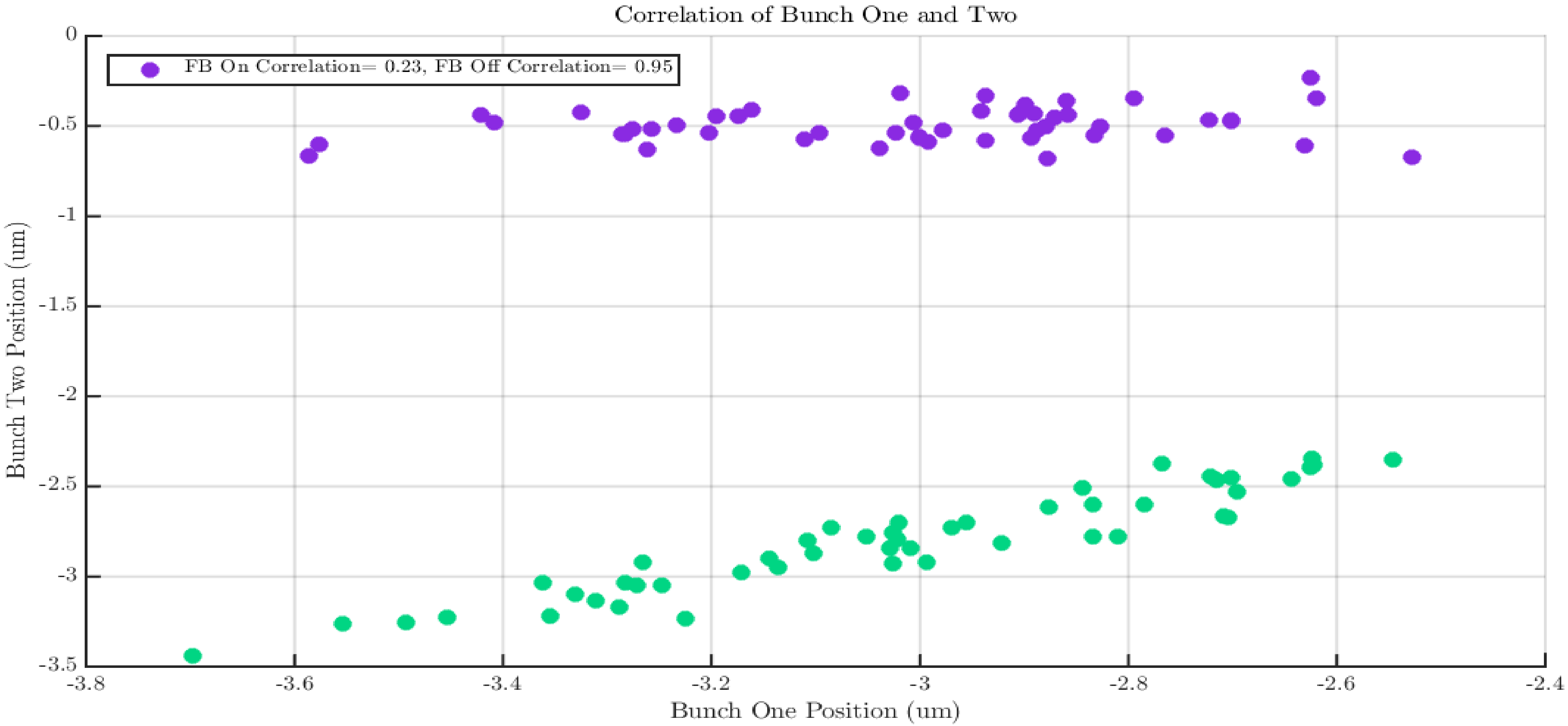
Best Feedback Performance (in terms of jitter FB On)

gainScan14_10dB_-5_again1



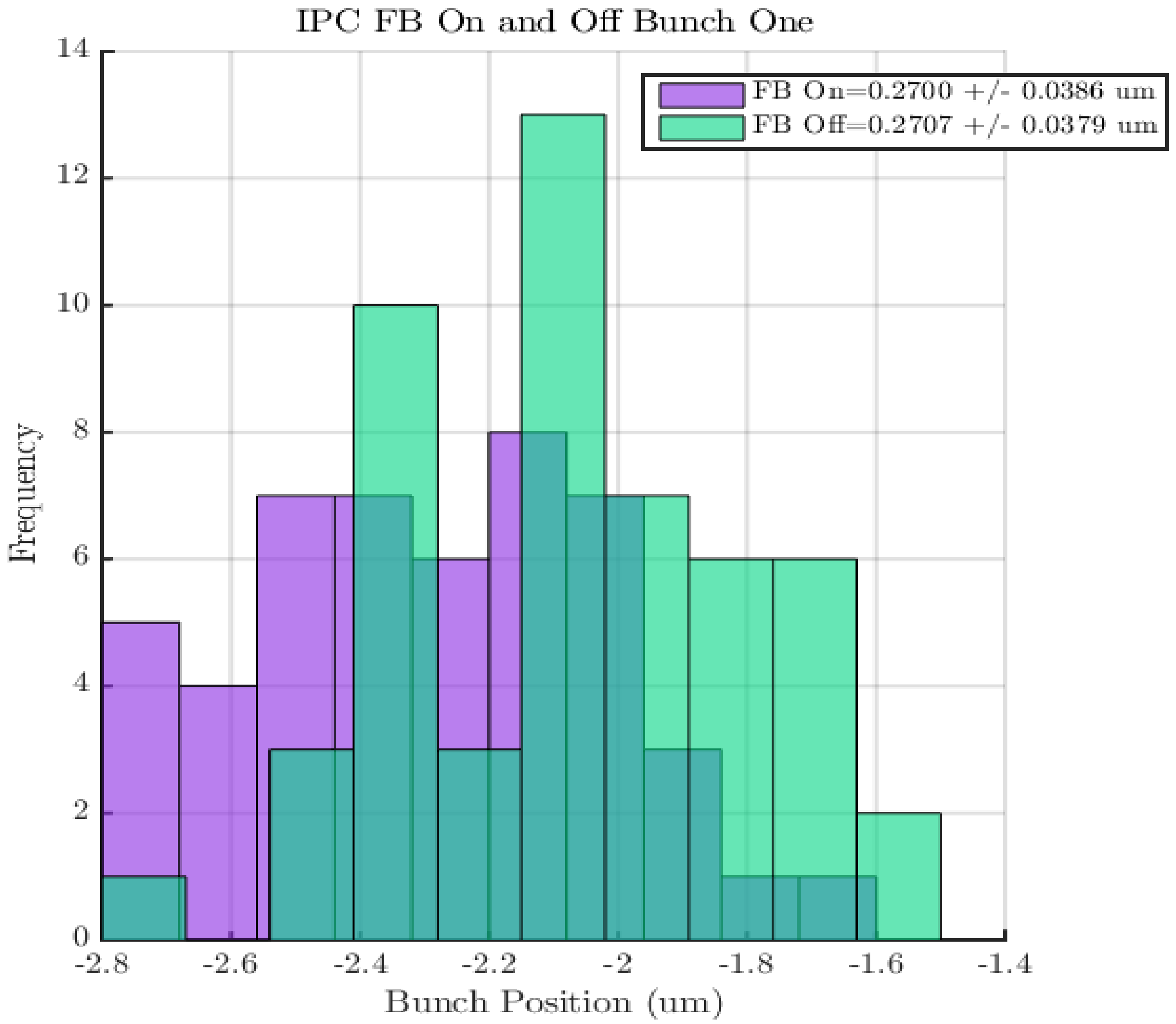
Best Feedback Performance (judged by jitter FB On)

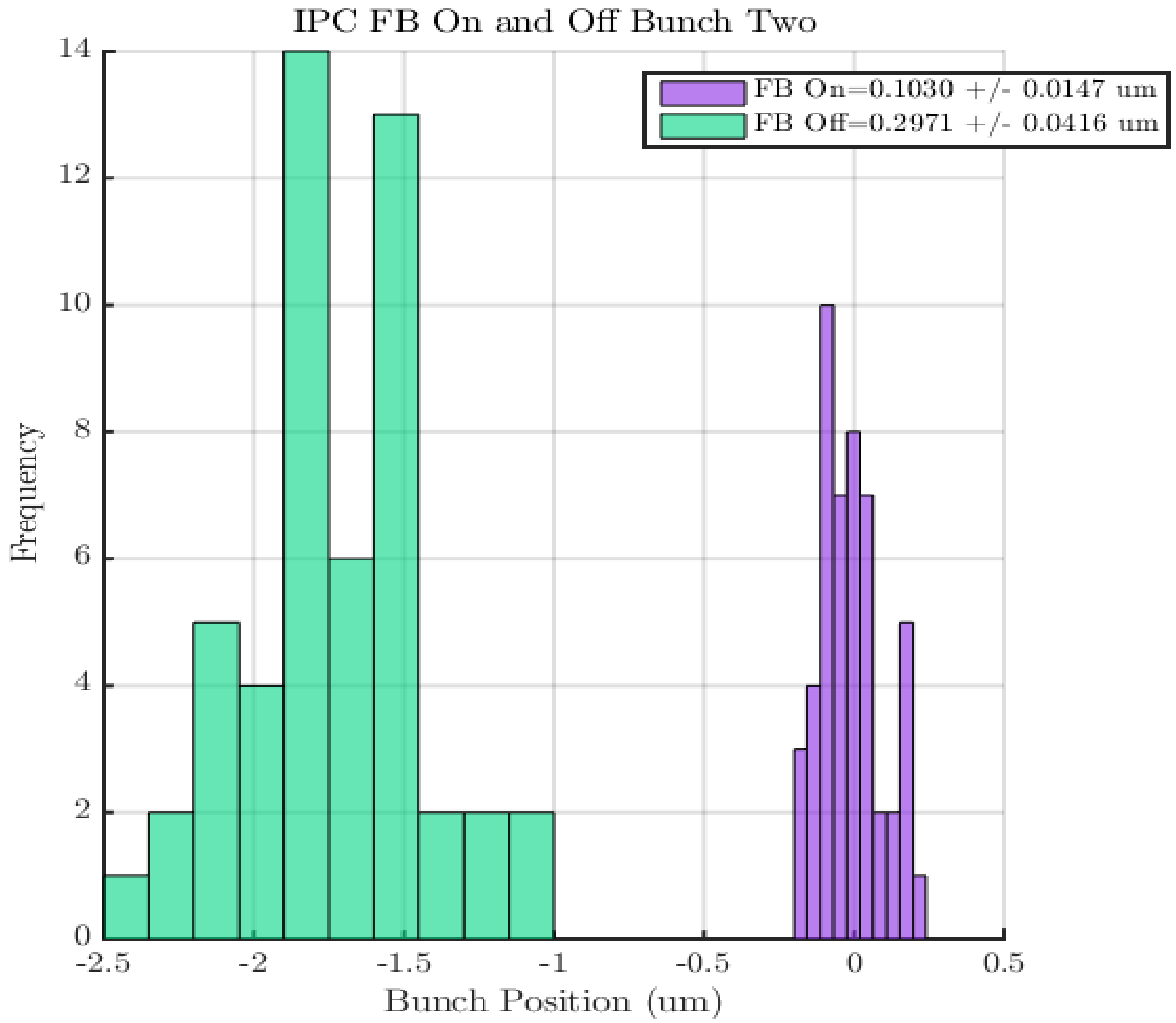
gainScan14_10dB_-5_again1



Second Best Feedback Performance (when compared with expected feedback performance)

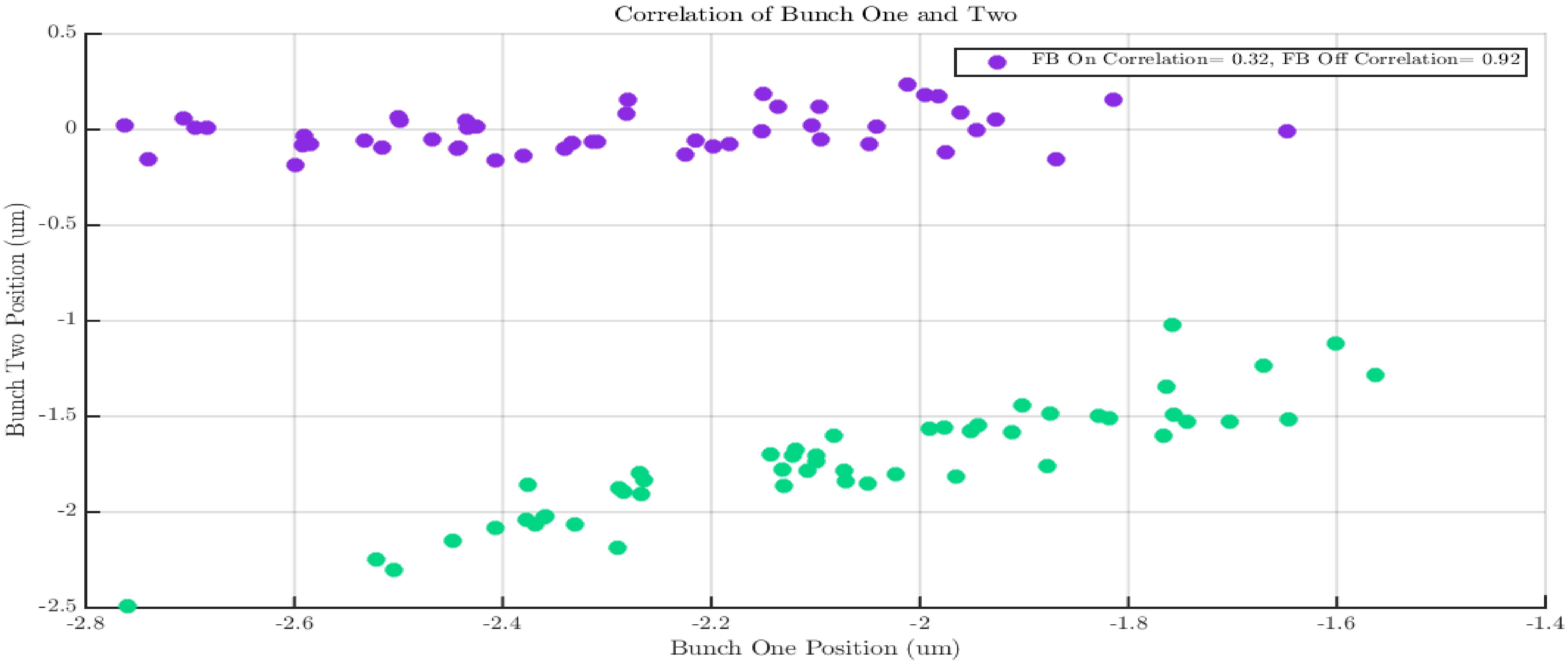
windowScan2_10dB_ 9



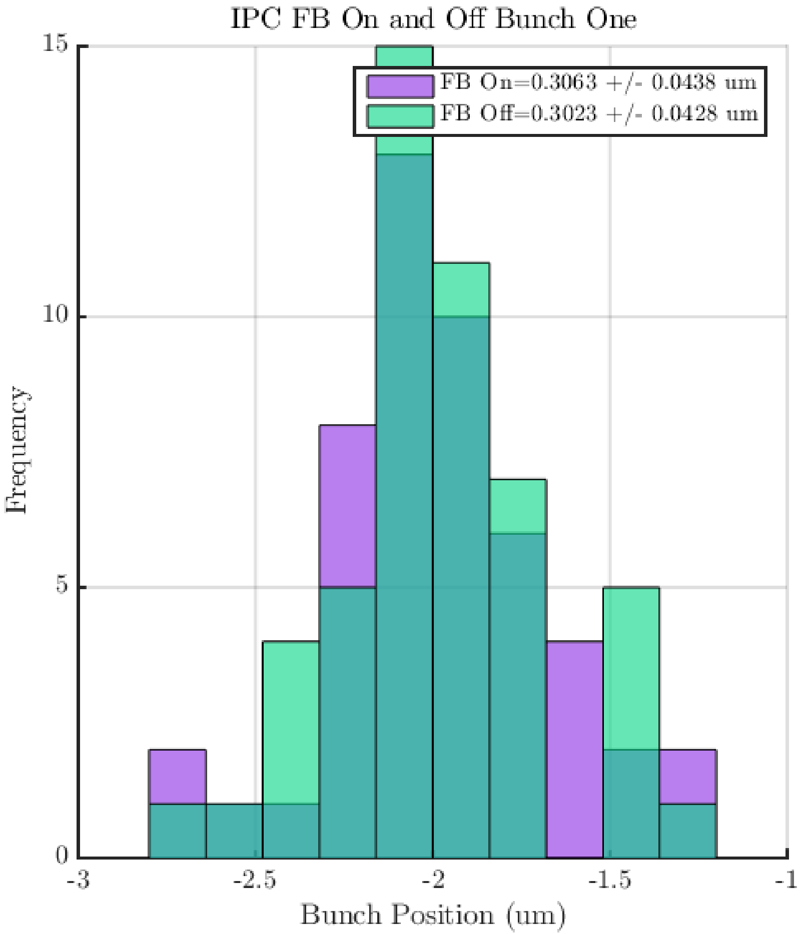


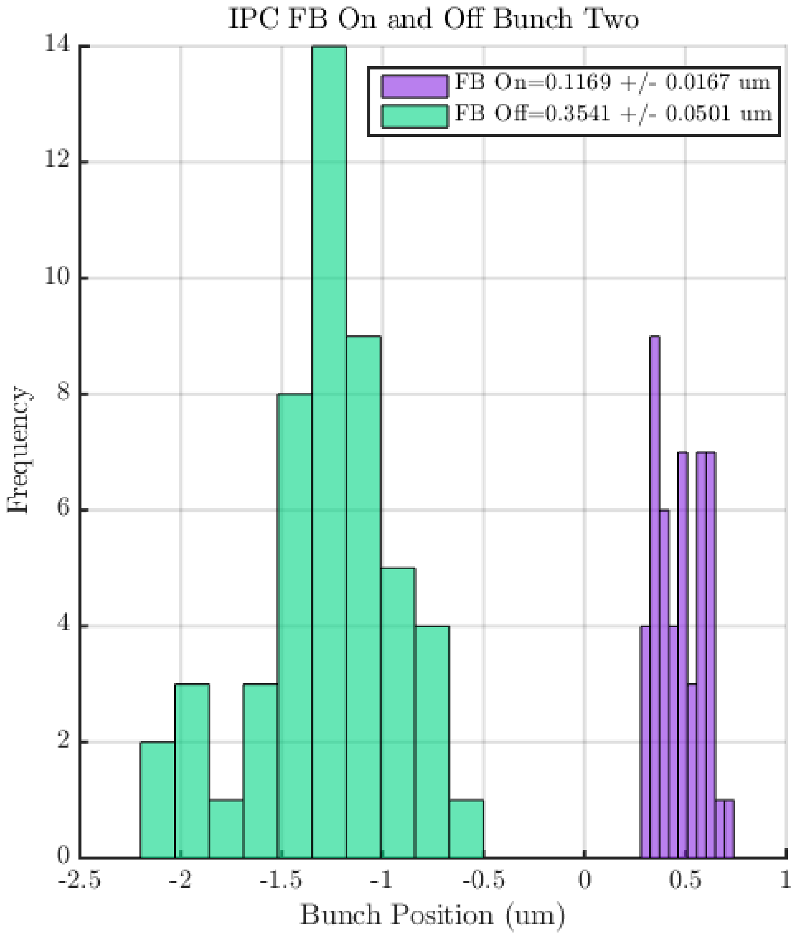
Second Best Feedback Performance (when compared with expected feedback performance)

windowScan2_10dB_ 9



Over-performing Feedback (8 sample integration)

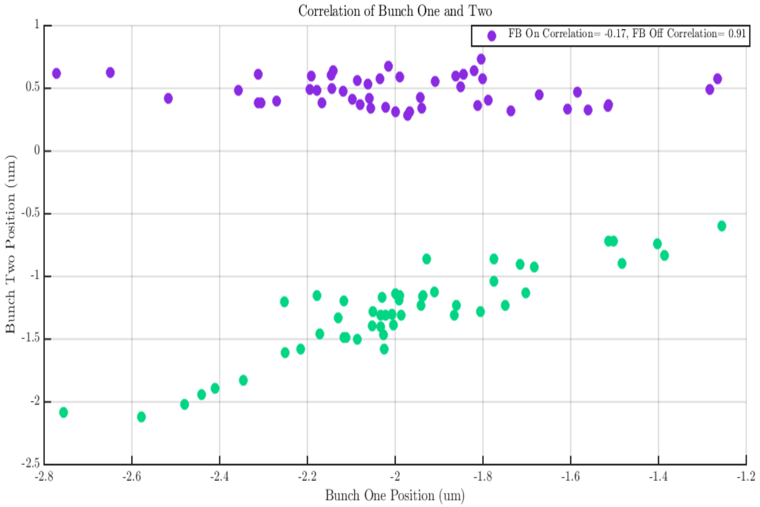




Predicted FB On Bunch Two Jitter: **148 nm.**

Actual FB On Bunch Two Jitter: **117 nm.**

Correlation correction: **91% to 17%**



Tentative Conclusions

- We struggled to get the gains right for 2-BPM feedback, which has contributed to less results and poorer quality corrections. Repeat results seemed less stable in 2-BPM mode.
- Consecutive repeat scans sometimes offered wildly different results, although mostly when stable beam, did not.
- Single sample feedback had the potential to match the performance of integrated sample feedback although on average did not.
- Variation in performance of single sample feedback noticeably worse than for integrated sample feedback.
- I am working on reverse engineering optimum gains for a few data sets to compare with the gains we actually used and whether we were under or over correcting.