# ATF2 November 2018 – Initial results

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*Friday, 23nd Nov 2018*

# Overview

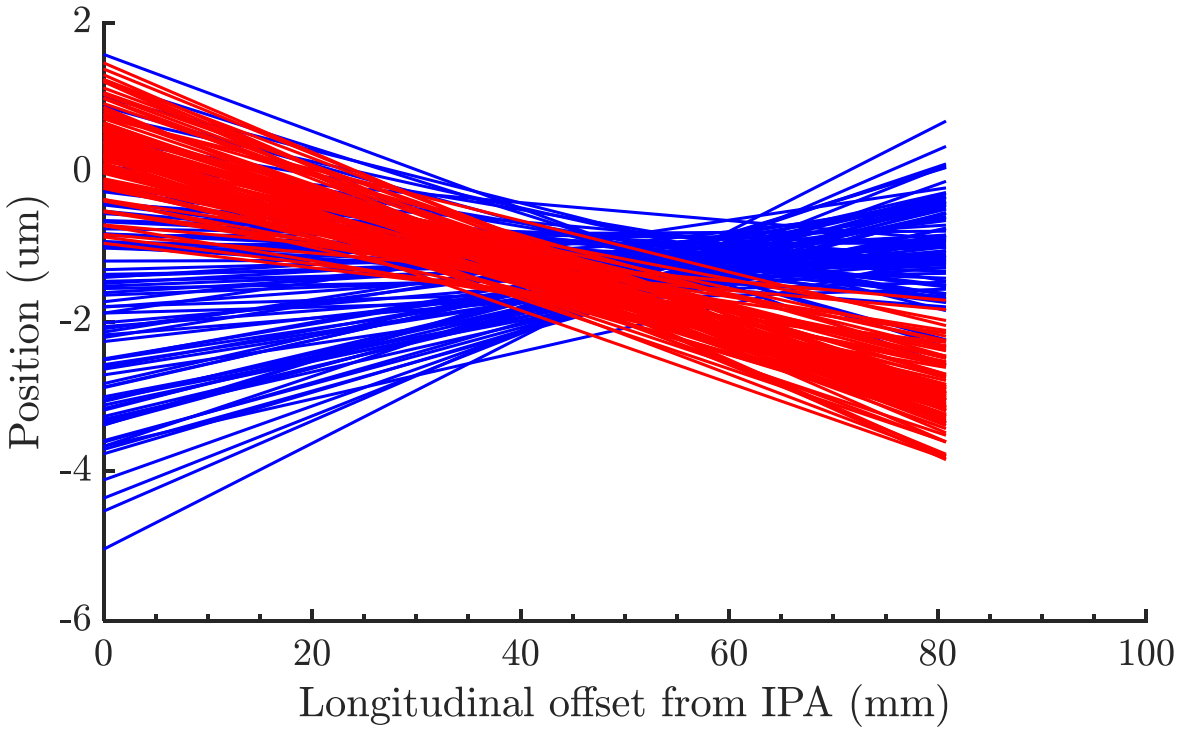
- Nominal optics: 10 dB, waist on IPC with upstream feedback stabilising the angle jitter.
  - Wide calibrations showing dynamic range of BPM – (and suspicious behaviour of IPC outside of its dynamic range)
  - Calibrations as a function of BPM tilt.
  - Calibrations as a function of waist position.
- IP BPM mover diagnostics.
- Limiter phase jitter as function of input signal level.
- High-beta optics: 10dB, waist on IPB with upstream feedback stabilising the angle jitter.
  - Resolution as a function of IPC position.

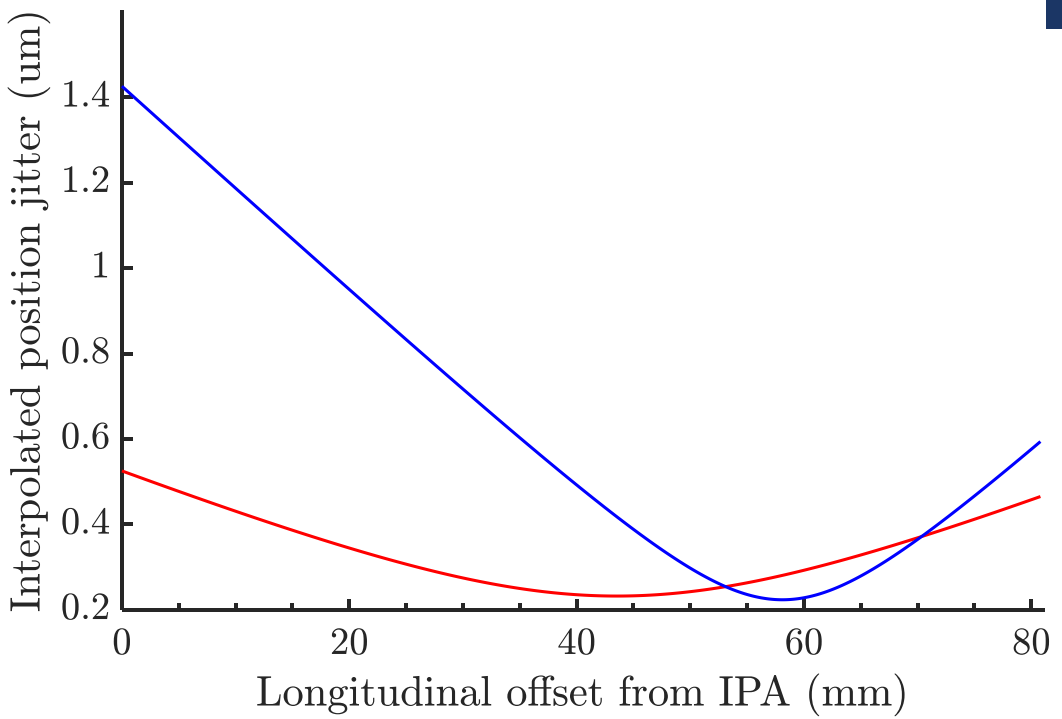
# Nominal Optics

## Angle jitter stabilisation

Beam waist on IPC, upstream FB stabilising bunch two
All analysis for bunch two – 10dB

# Upstream feedback – effect at IP



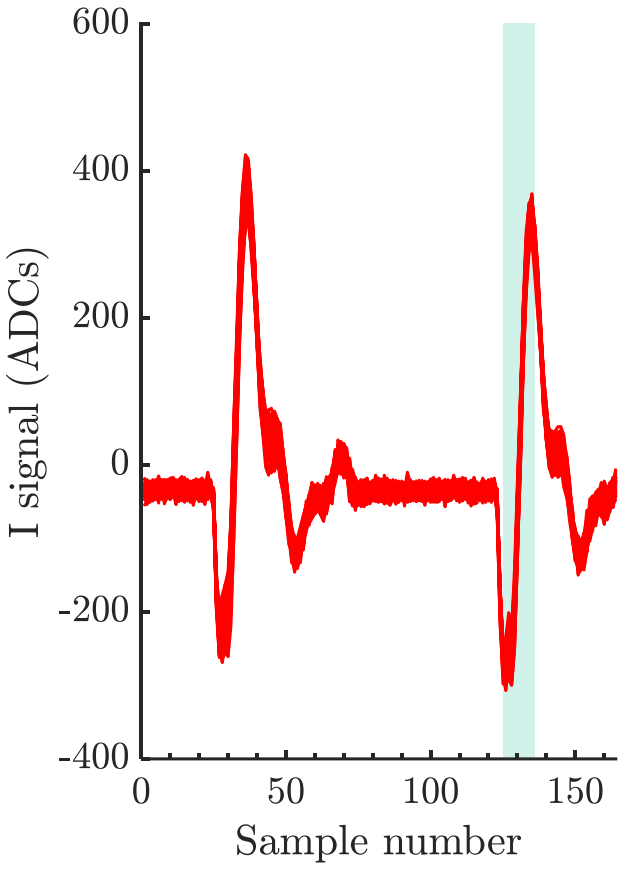

| Jitter at IPA: | Jitter on waist | Jitter at IPB: | Angle jitter: | Upstream jitter: |
|---|---|---|---|---|
| 523 nm | 232.1 nm | 549 nm | 10.8 urad | P2: 1410 (fb off), 260 nm (fb on) |
| 1422 nm | 223.5 nm | 462 nm | 24.2 urad | P3: 1610 (fb off), 271 nm (fb on) |

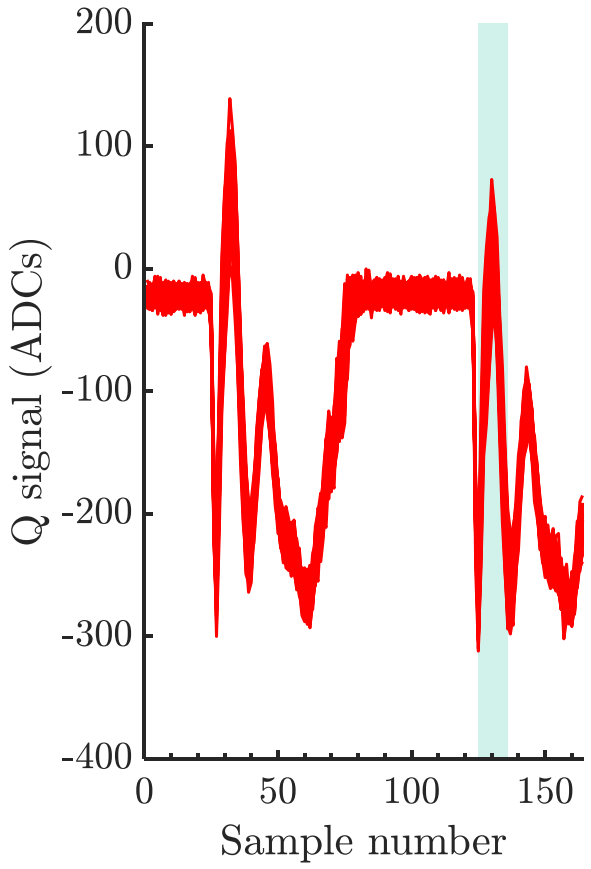
# Nominal Optics

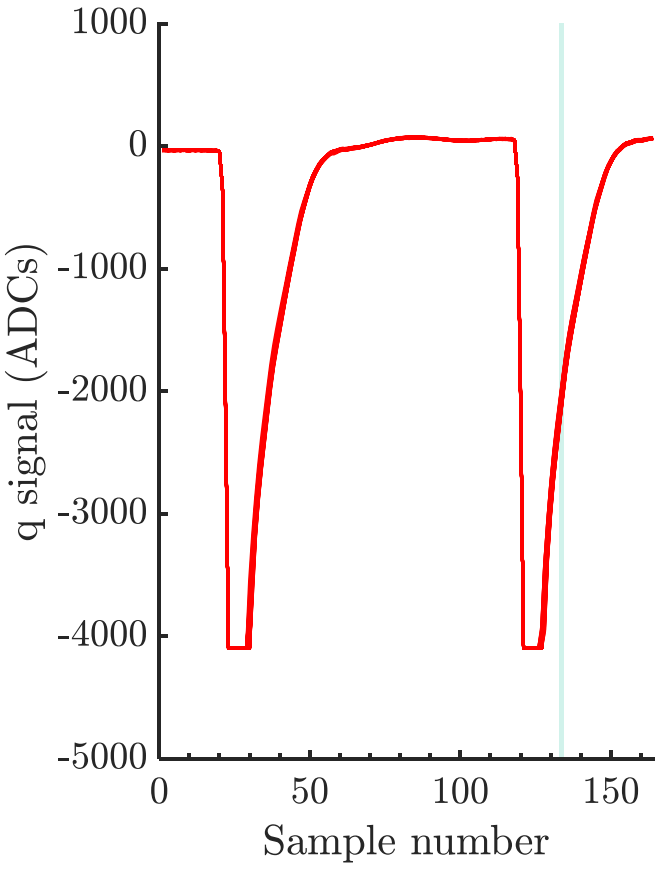
## Calibration – testing the dynamic range

Beam waist on IPC, upstream FB stabilising bunch two
All analysis for bunch two – 10dB

# IPC waveforms



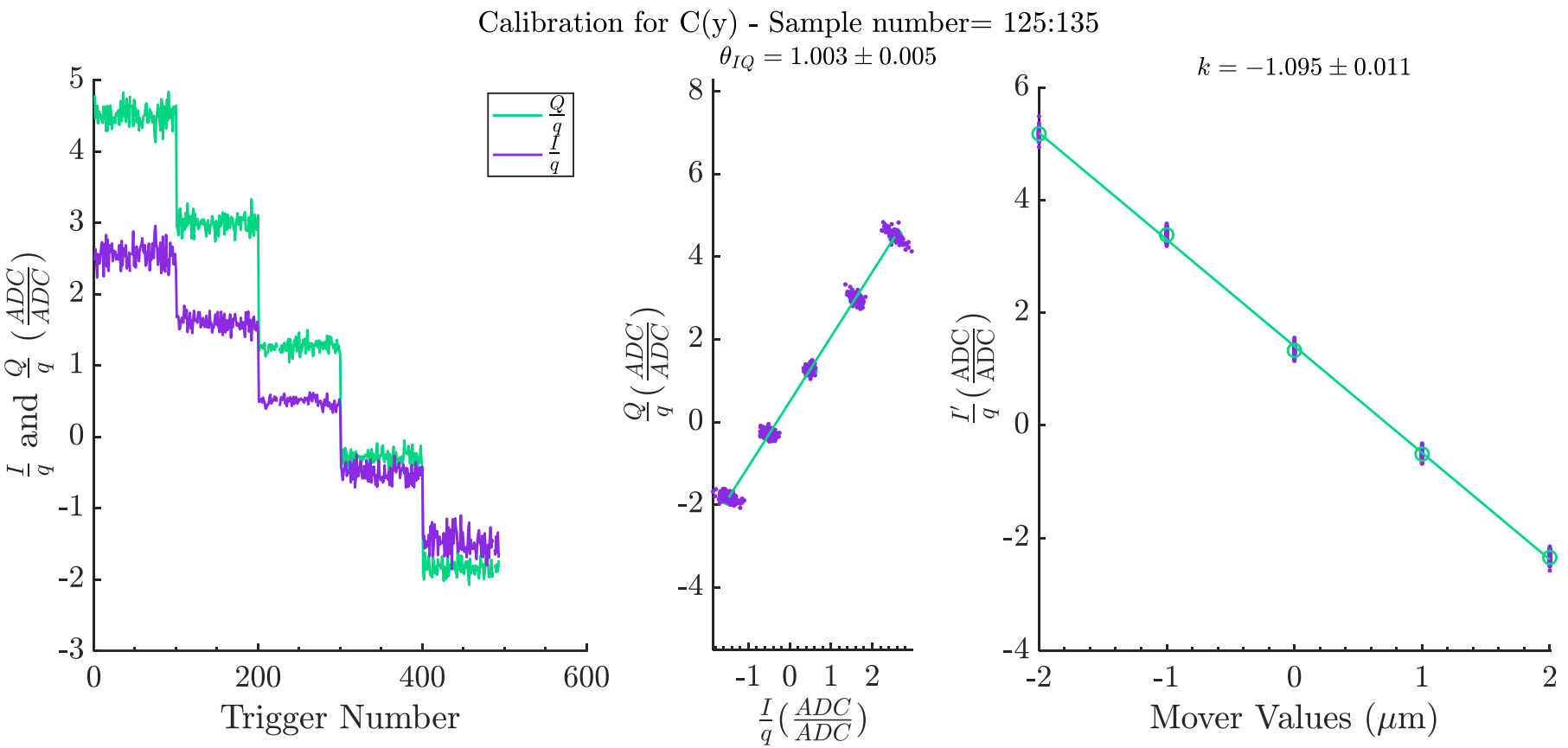




**Bunch 1**
Mean charge: -2315
Std charge: 43
Mean position: -107 nm
Jitter: 73.5 nm

**Bunch 2**
Mean charge: -2190
Std charge: 40
Mean position: -405 nm
Jitter: 77.9 nm

# IPC Calibration

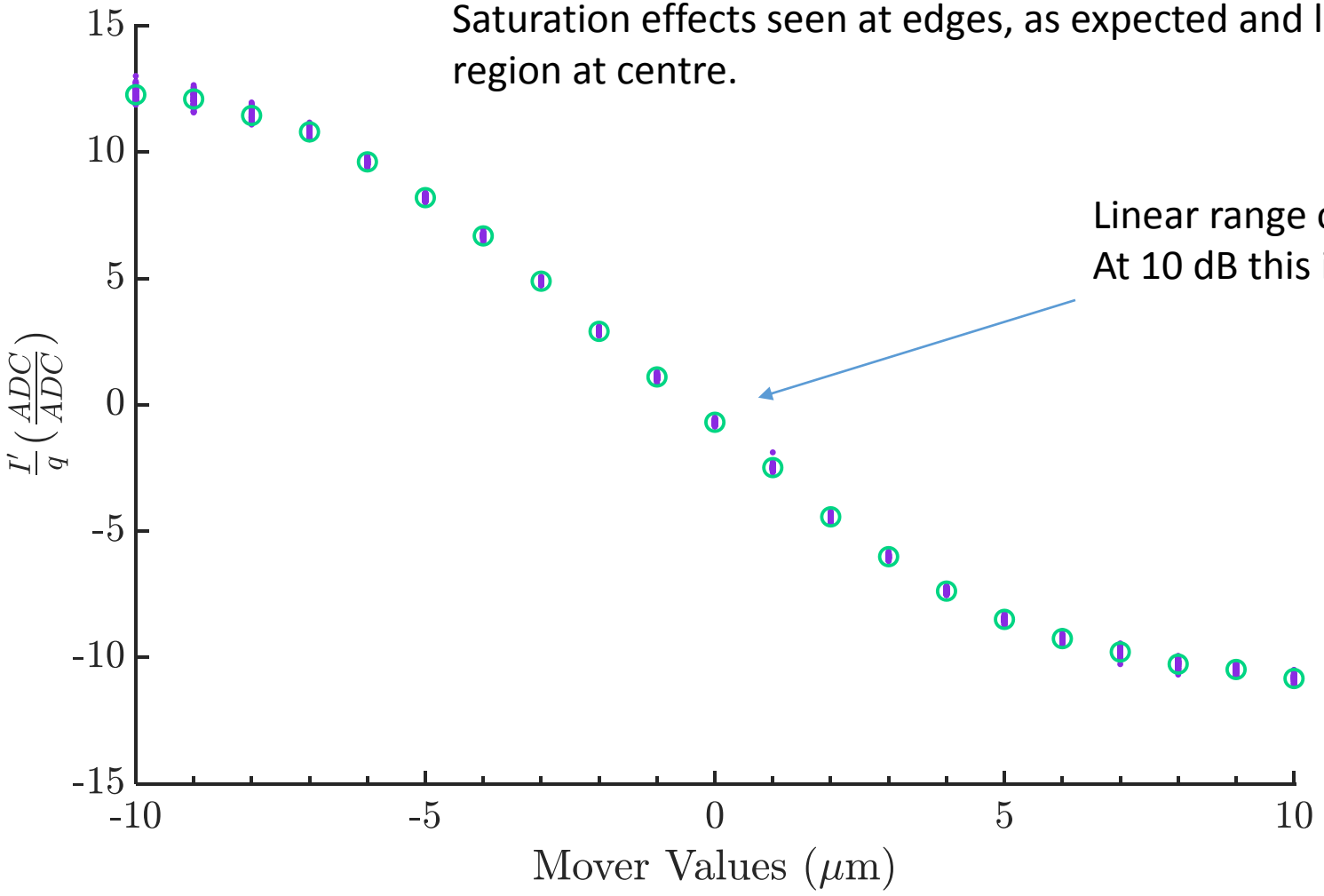



Calibration constant when normalised by number of samples integrated: 0.0995 +/- 0.001

Calibration constant as measured in Talitha's thesis: 0.1.

# Calibration – with saturation at edges

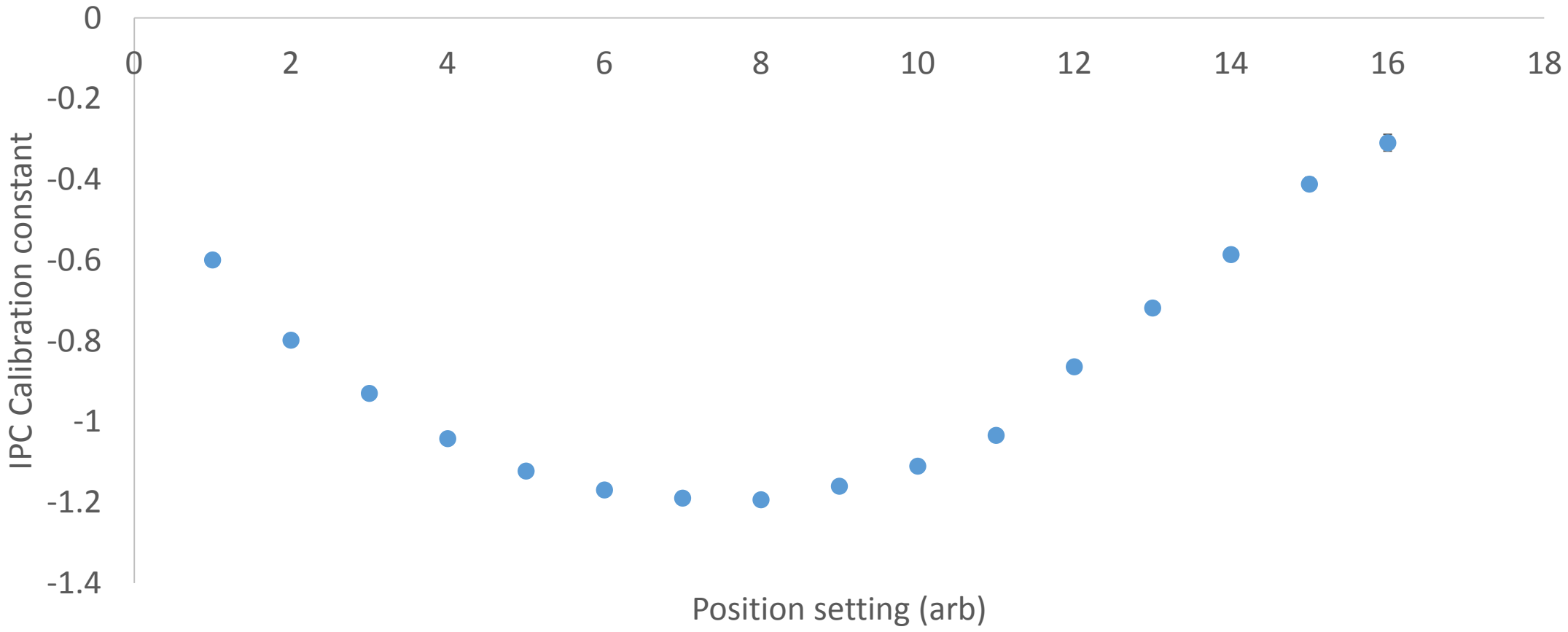
IPC Calibration :
Saturation effects seen at edges, as expected and linear calibration region at centre.




Linear range of calibration.
At 10 dB this is expected to be +/- 4.5 um.

# Position Scan (rolling calculation)

Rolling calibration constant determined for calibration shown on previous slide. With rolling window width of 4 um, which is our usual calibration window width at 10 dB.

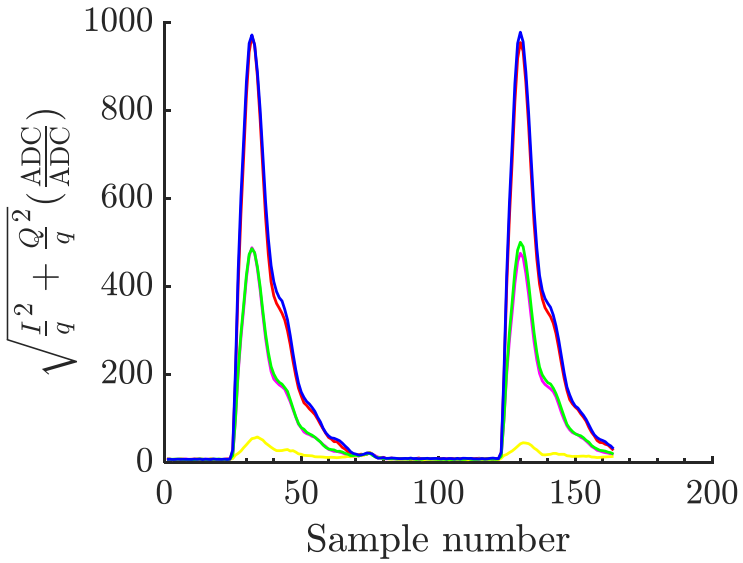


# IPC Signal Magnitude – slight saturation

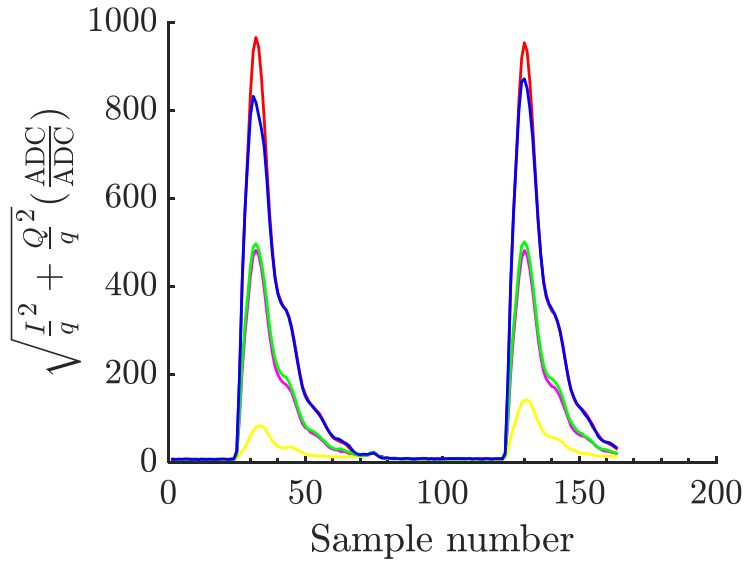
Mean waveforms at settings from the calibration shown on the previous slide.
The mean waveform from the central setting is subtracted from all five waveforms.

Saturation effects seen even a few microns offset from nominal alignment.

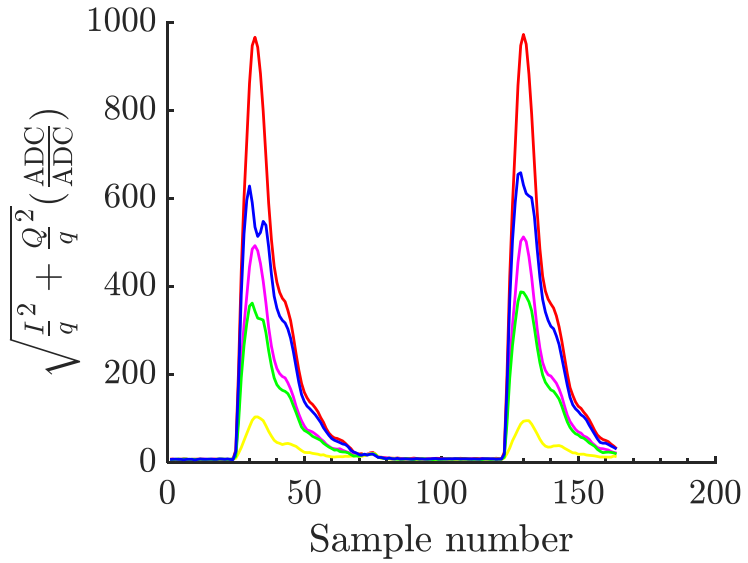
-2:1:2 um




-1:1:3 um




0:1:4 um

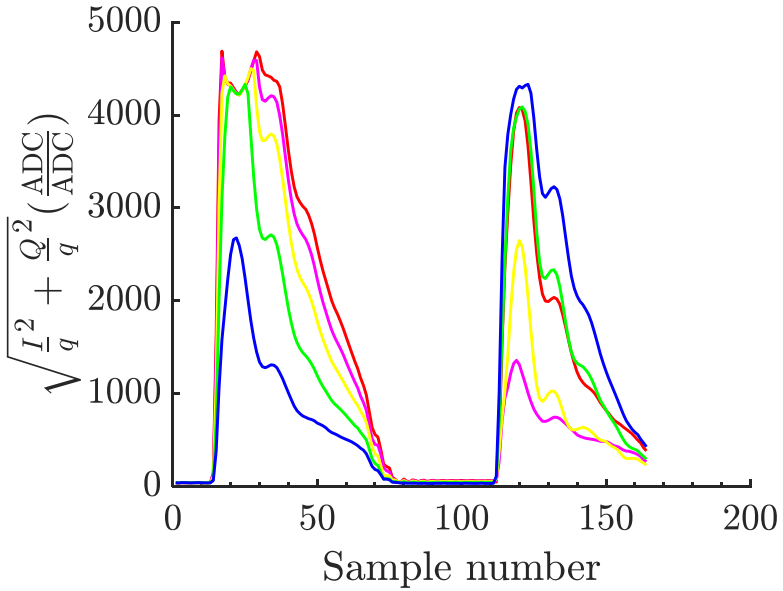


# Signal magnitude – further into saturation

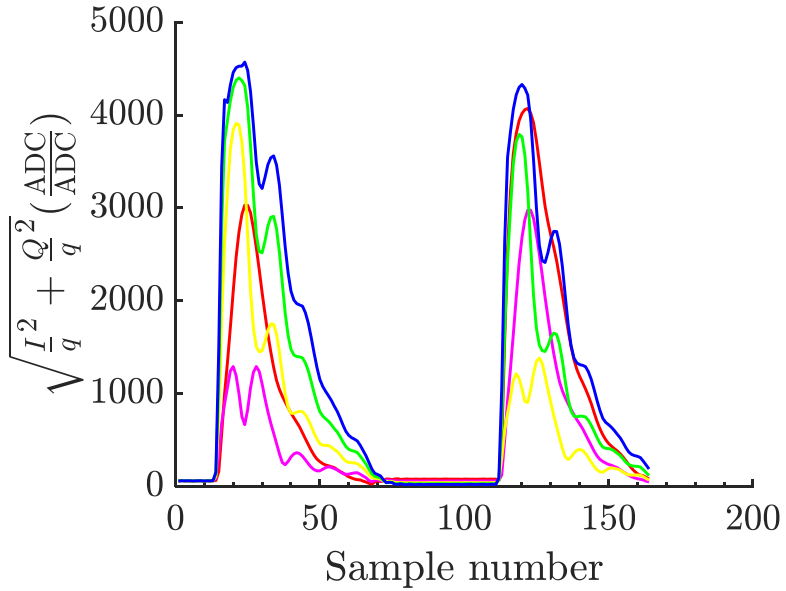
-10, -5, 0, 5, 10 um
Mean calibration signal magnitude

Signals for IPC even when very offset could not be driven above ~3000 ADCs

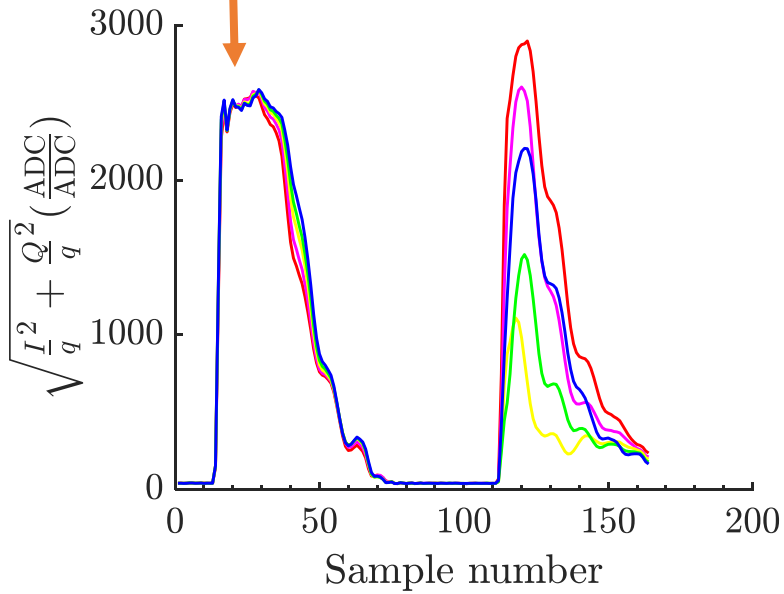
IPA




IPB




IPC



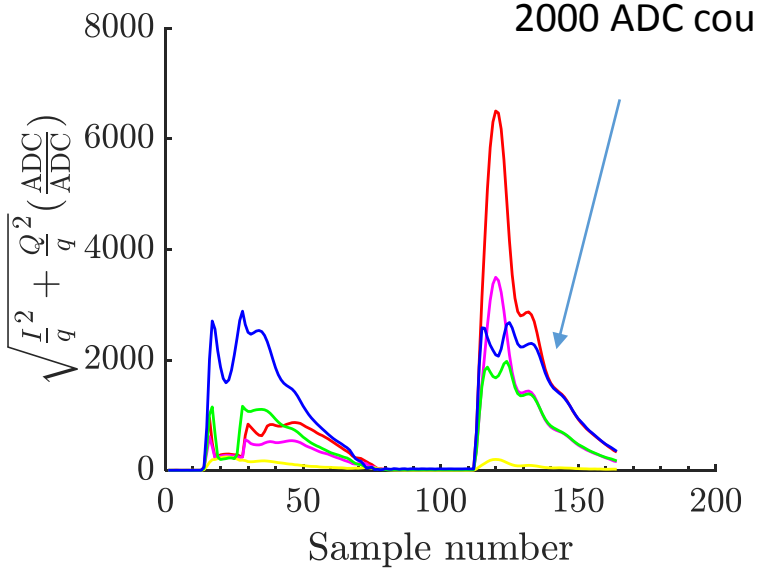
# Further into saturation

-10, -5, 0, 5, 10 um

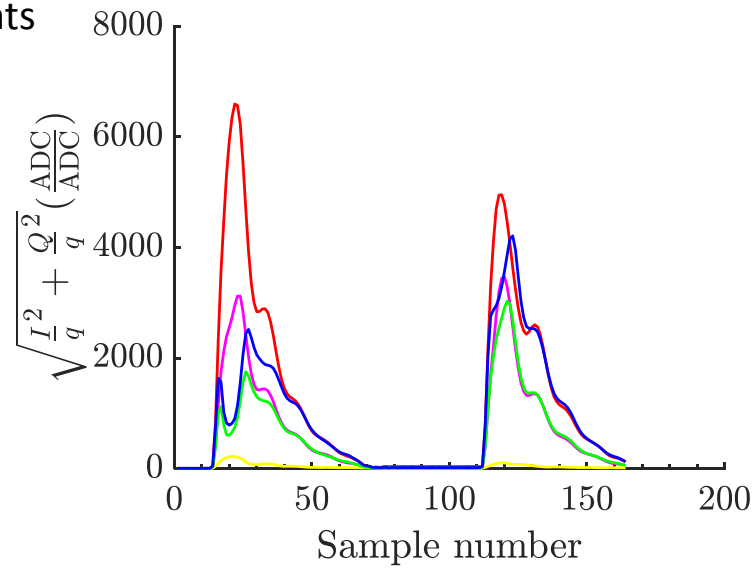
Calibration signal magnitude with centre waveform subtracted

IPA

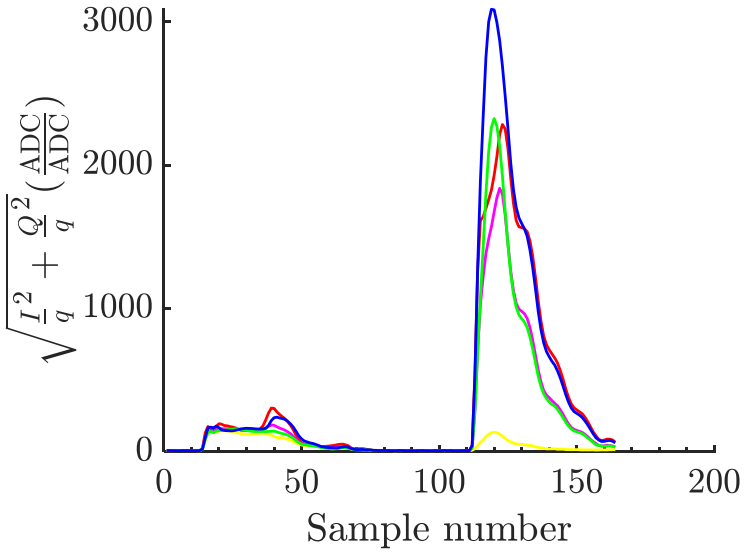
Reasonable symmetry up to 2000 ADC counts




IPB



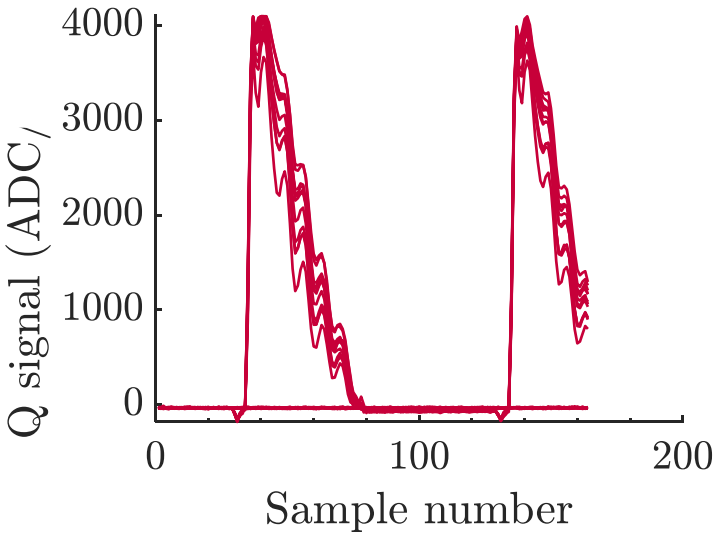

IPC



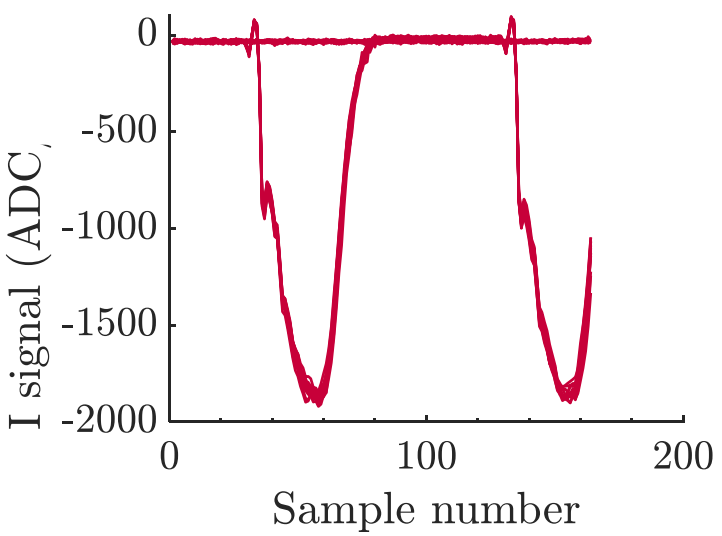
# 15th June 2017

Calibration for IPA with IPB and IPC not centred.

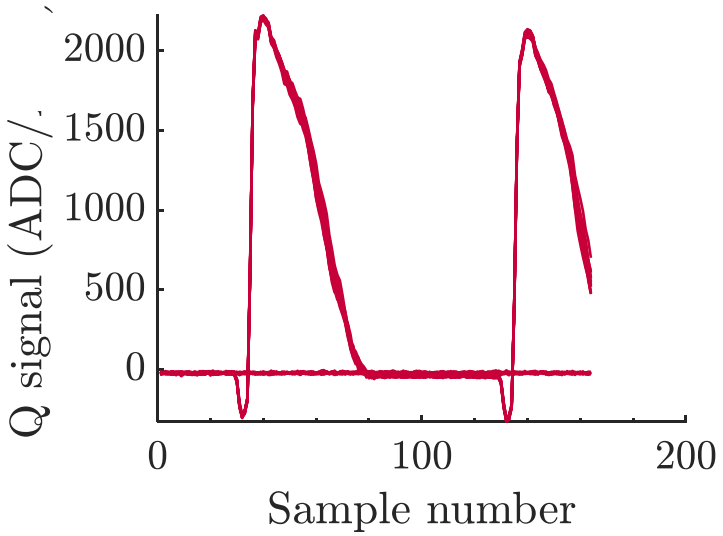
IPB




IPC



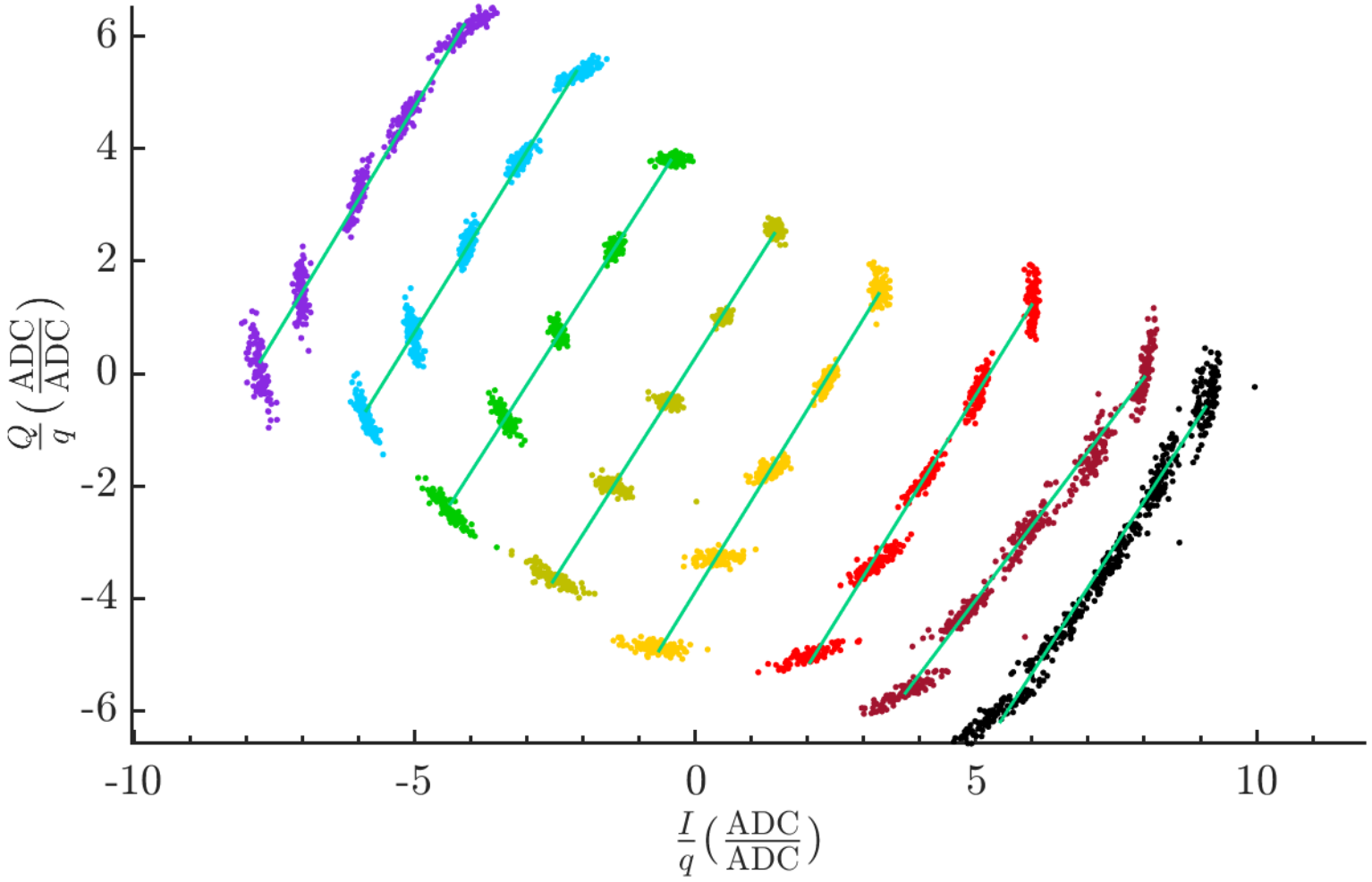

Even last year IPC didn't get much above 2000 ADCs



# Nominal Optics

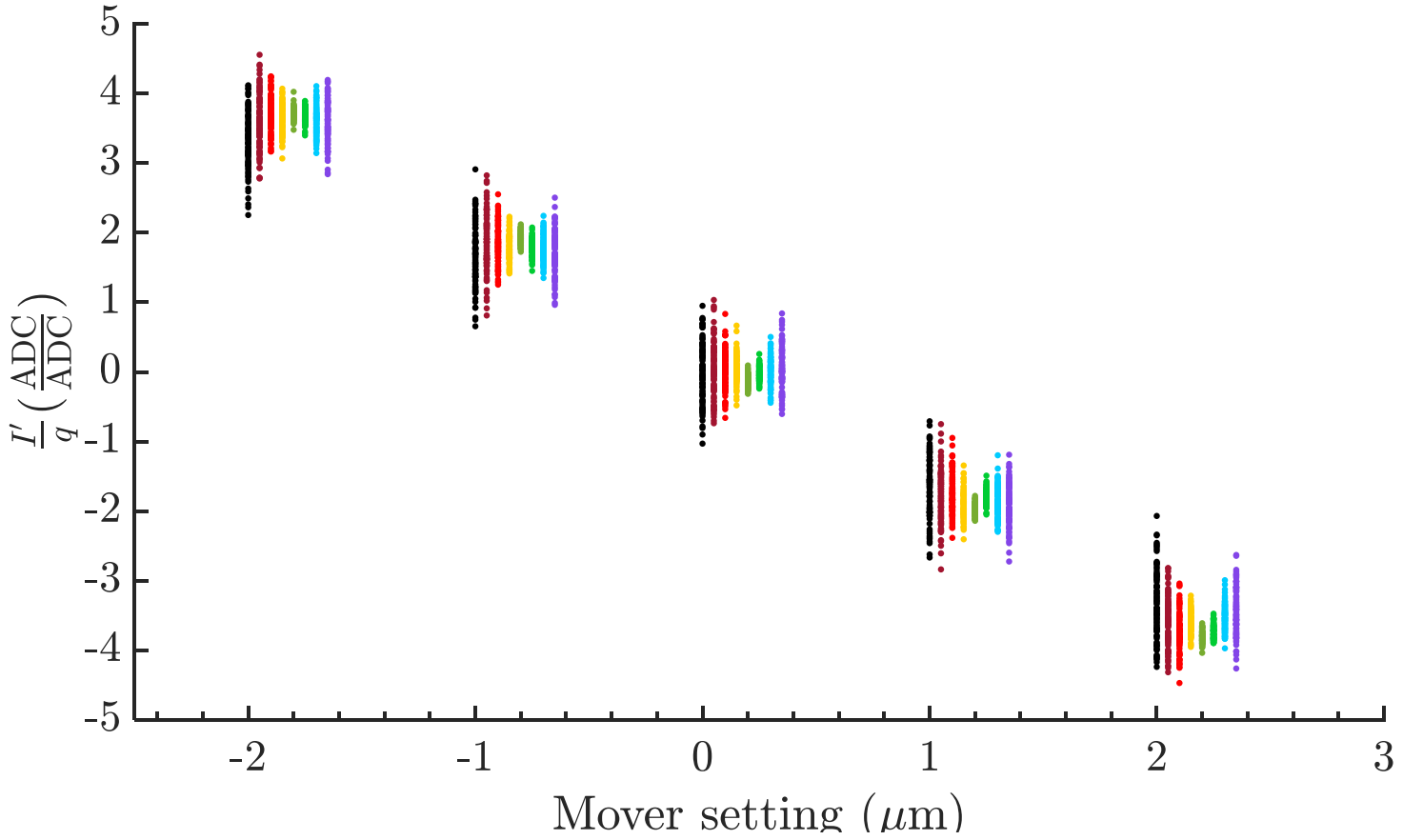
## Calibrations – as a function of BPM tilt

# Calibrations at a range of BPM tilts




IPC tilt in mrad:
-2.5,
-1.875,
-1.25,
-0.625,
0,
0.625,
1.25,
1.875

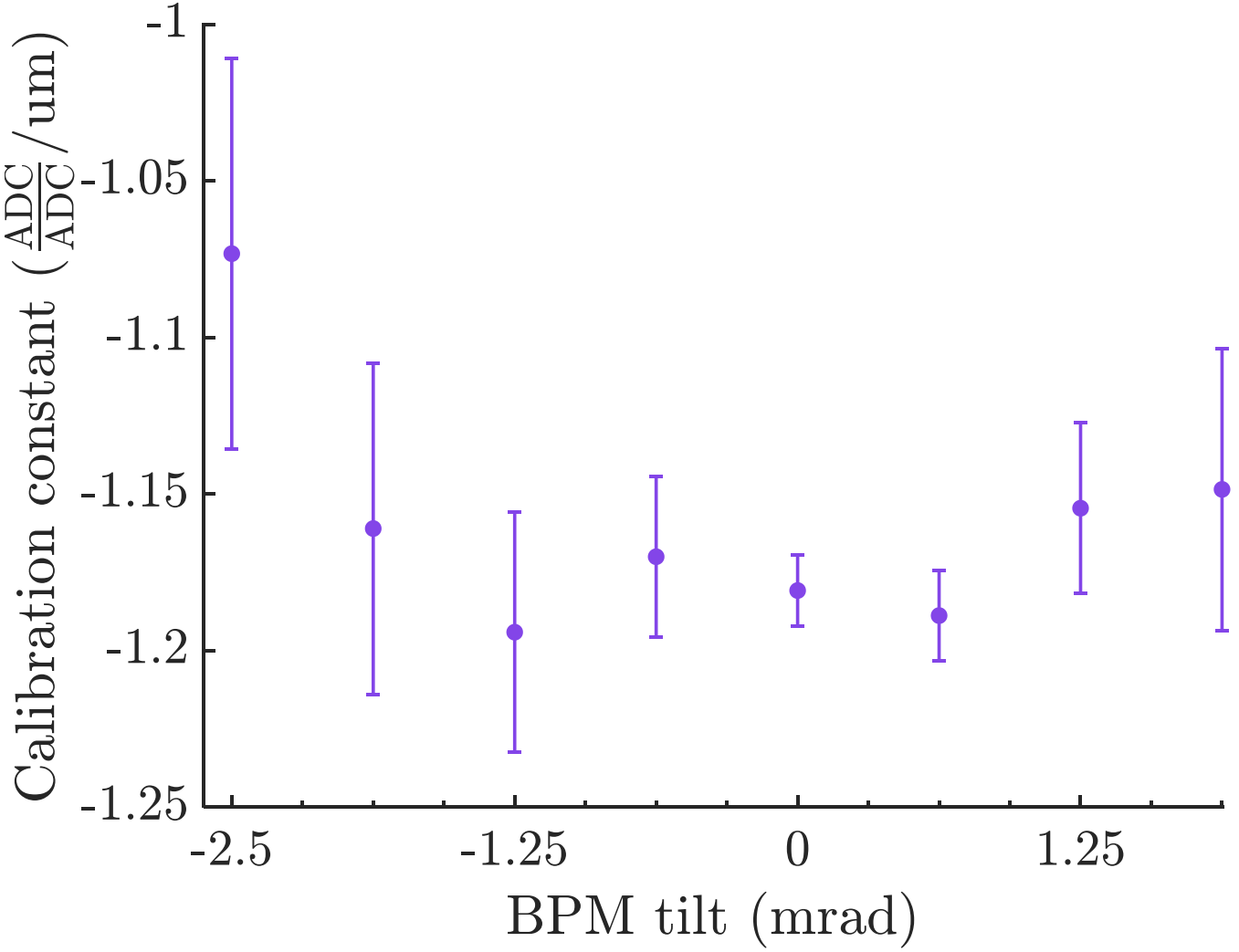
# Calibrations at a range of BPM tilts




Arbitrary offset between tilt settings for clarity.

IPC tilt in mrad:
-2.5,
-1.875,
-1.25,
-0.625,
0,
0.625,
1.25,
1.875

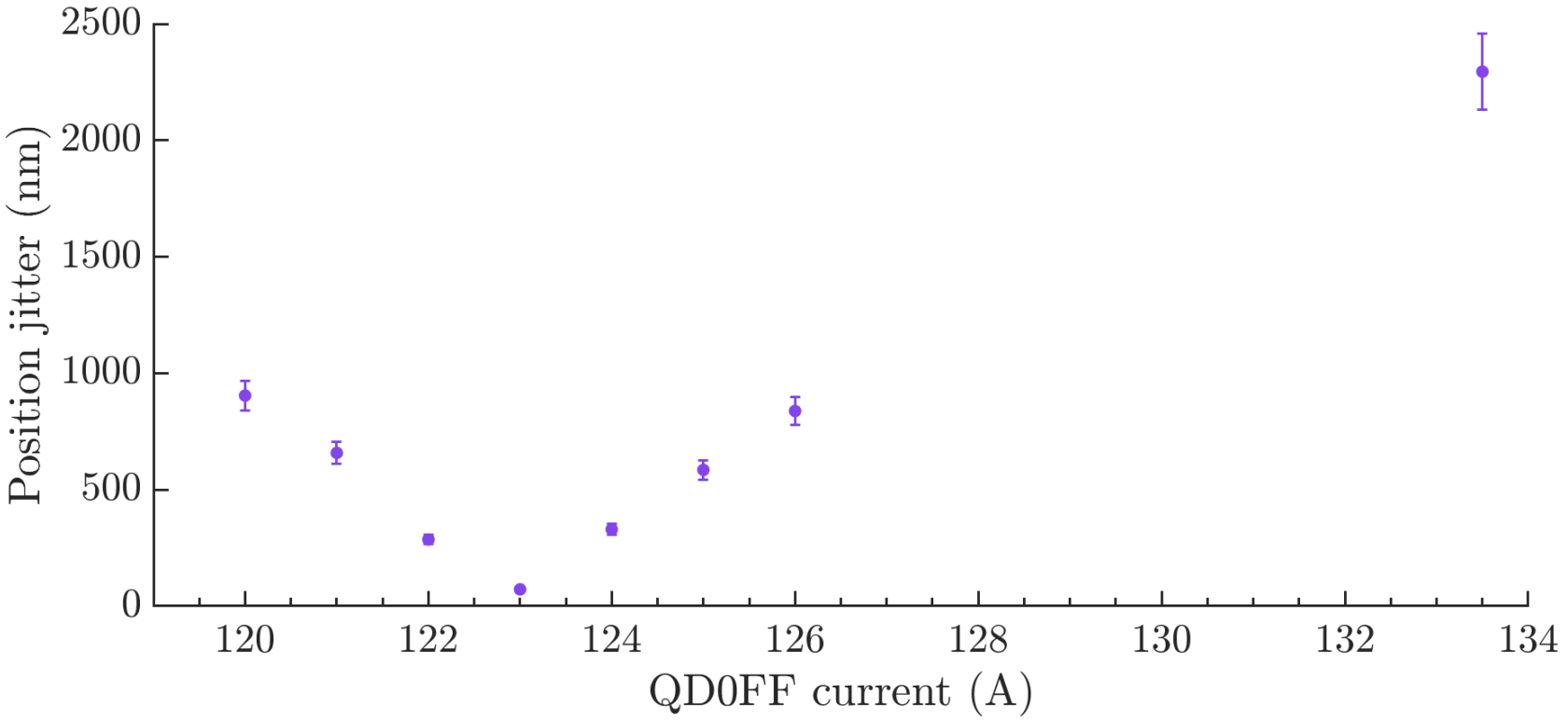
# Calibration constant vs. tilt



# Nominal Optics

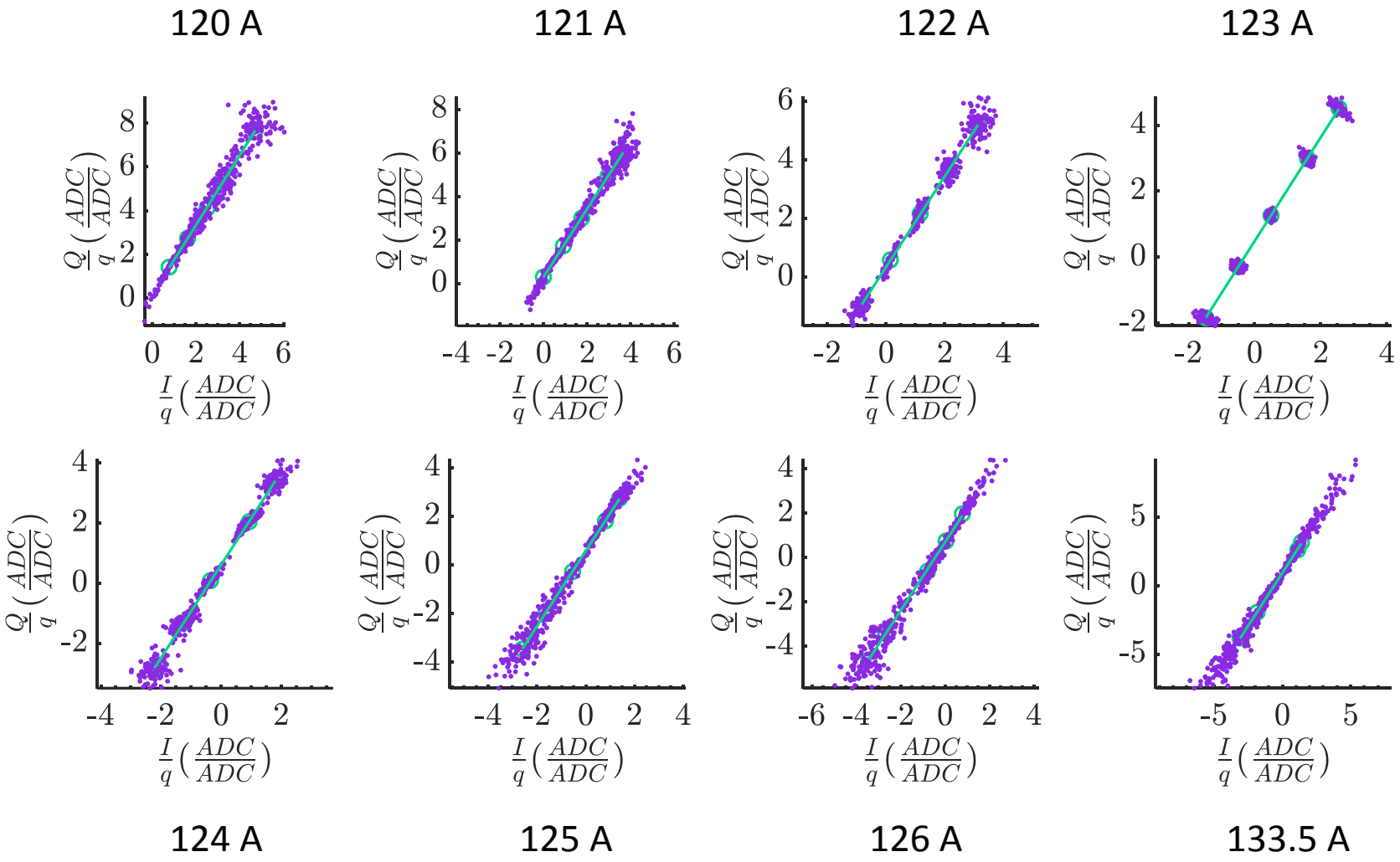
## Calibrations – as a function of waist position

# Waist scan (around IPC 123 A)




| QD0FF current (A) | Position jitter (nm) | Error (nm) |
|---|---|---|
| 120 | 904 | 64 |
| 121 | 658 | 47 |
| 122 | 286 | 20 |
| 123 | 72.2 | 5.1 |
| 124 | 330 | 23 |
| 125 | 585 | 41 |
| 126 | 838 | 59 |
| 133.5 | 2295 | 162 |

# Calibration as a function of BPM waist position



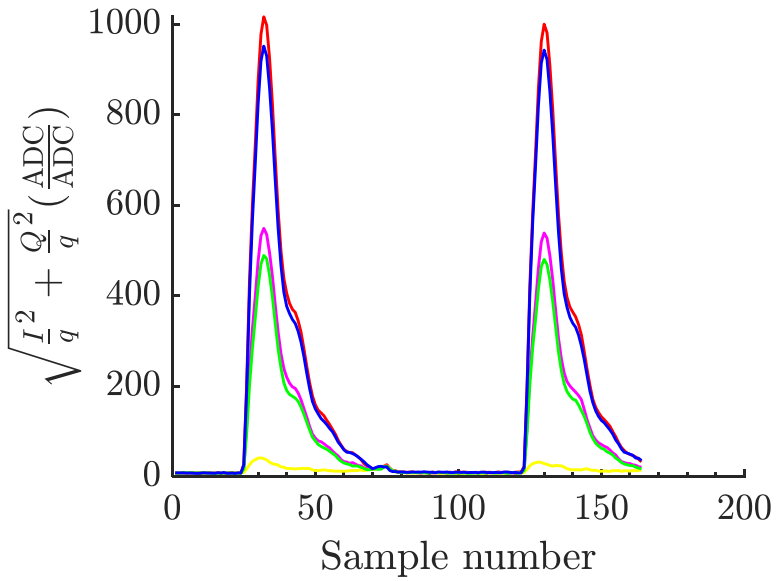

Nominal

Waist half way between IPA and IPC

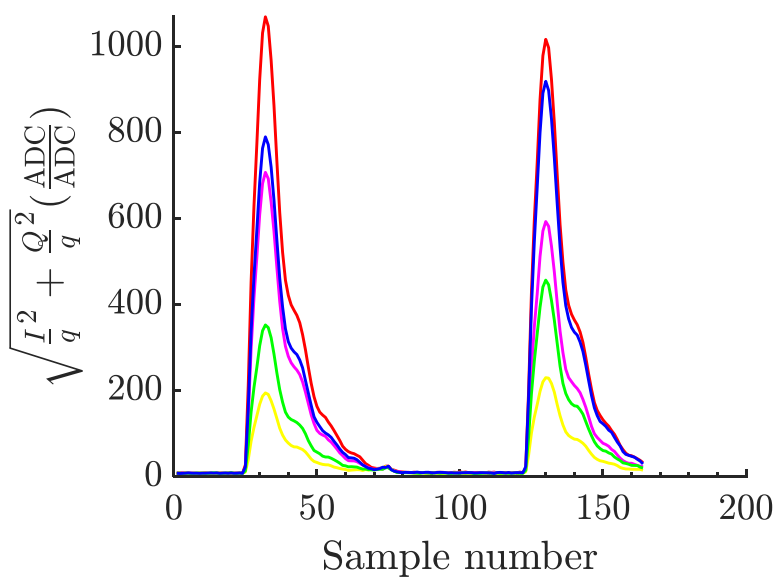
# Signal magnitude

Mean waveforms at settings from the calibration shown on the previous slide.
The mean waveform from the central setting is subtracted from all five waveforms.
The degradation seen with increasing distance from the IP made it difficult to operate with all three BPMs in nominal optics, even with the upstream system helping to reduce the angle jitter.

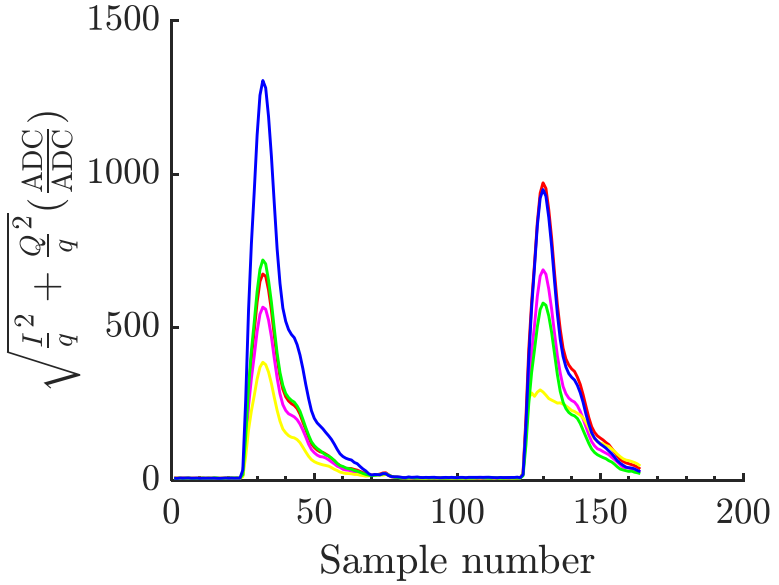
123 A – waist on IPC



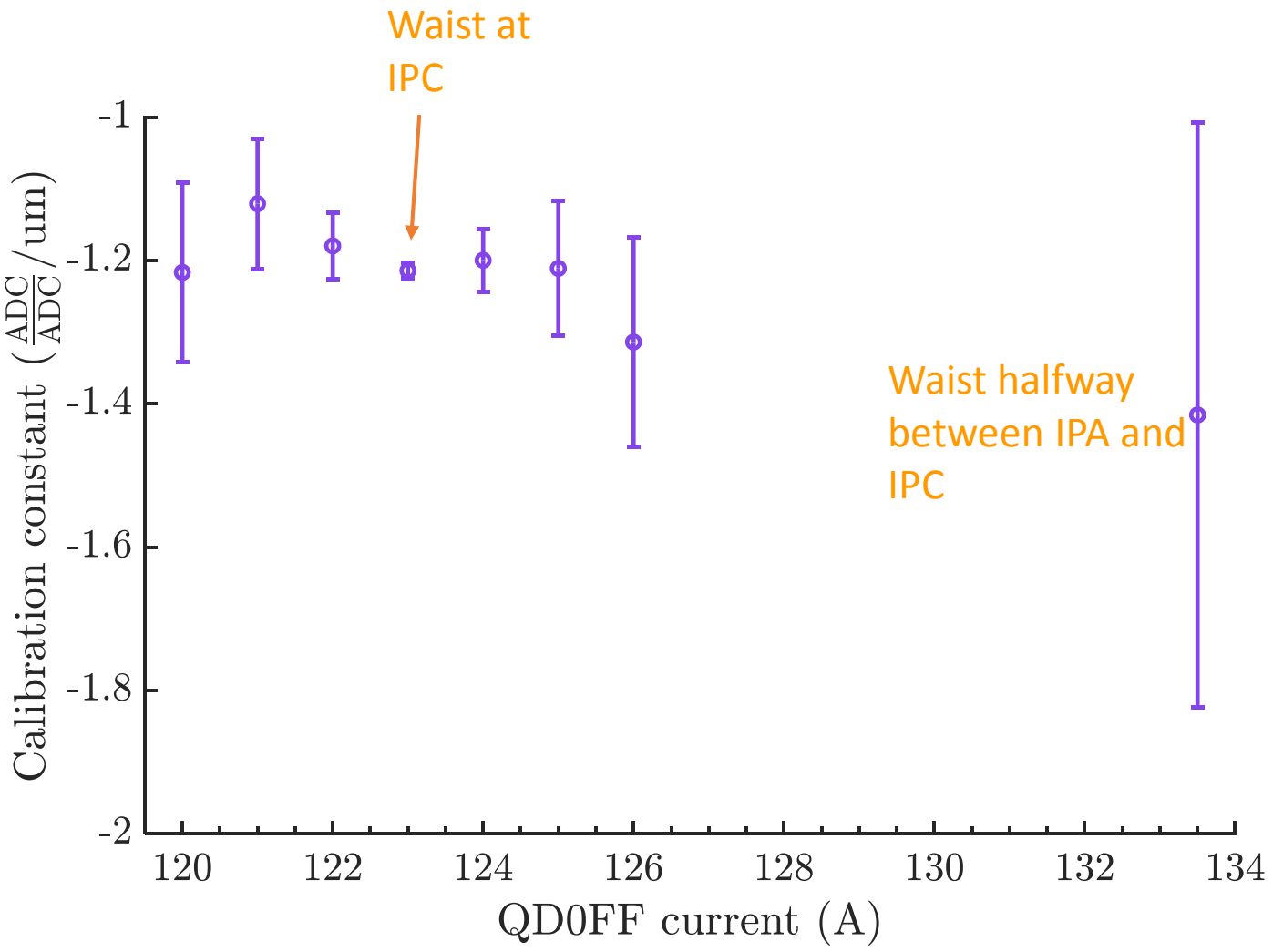

124 A (12 mm offset)




125 A (24 mm offset)



# IPC calibration constant vs. QD0FF current




| QD0FF current (A) | IPC *k* (ADC/ADC)/um | Error on *k* |
|---|---|---|
| 120 | -1.216 | 0.125 |
| 121 | -1.120 | 0.091 |
| 122 | -1.179 | 0.047 |
| 123 | -1.214 | 0.011 |
| 124 | -1.199 | 0.044 |
| 125 | -1.211 | 0.094 |
| 126 | -1.314 | 0.147 |
| 133.5 | -1.415 | 0.408 |

# Nominal Optics

## Suspicious mover behaviour

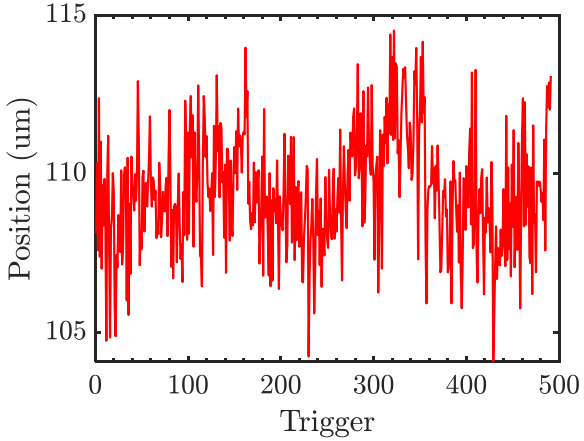
# Behaviour noticed in June

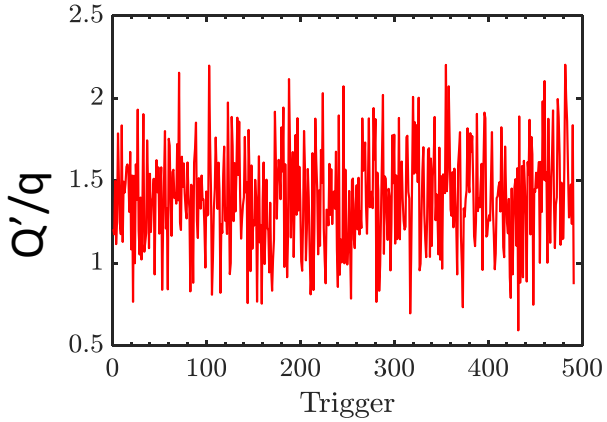
- From the data for Colin's position and angle BPM scan we noticed suspicious patterns in the data. The scan was moving the IPC mover only, and analysing the resolution as a function of IPC position and tilt. However, we saw changes in the IPB and IPA signals which looked like the IPA and IPB movers might be moving as well.
- We performed a dedicated study, where we periodically moved the IPC mover from one end of its range to the other and recorded data at all three BPMs.

# IPC mover cycle

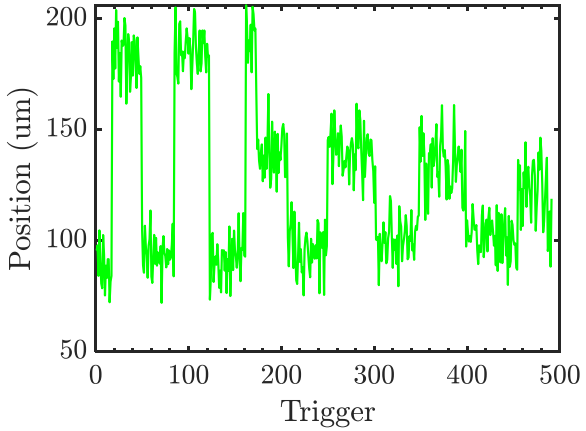
BPMs A and B far off waist, so the calibration is poor, i.e  the scale of the position measurements are incorrect.

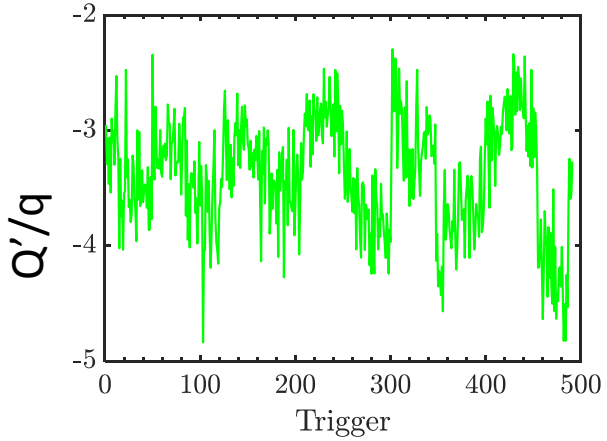
IPA



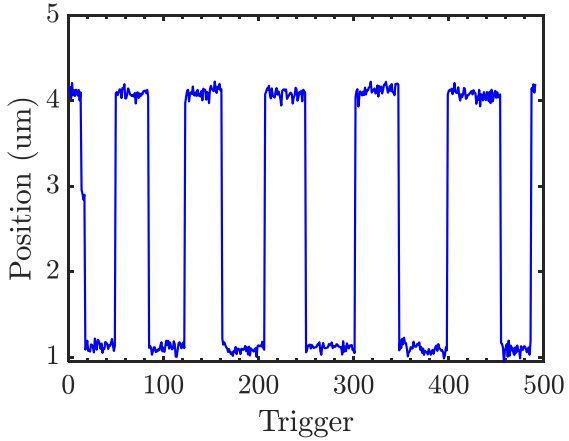



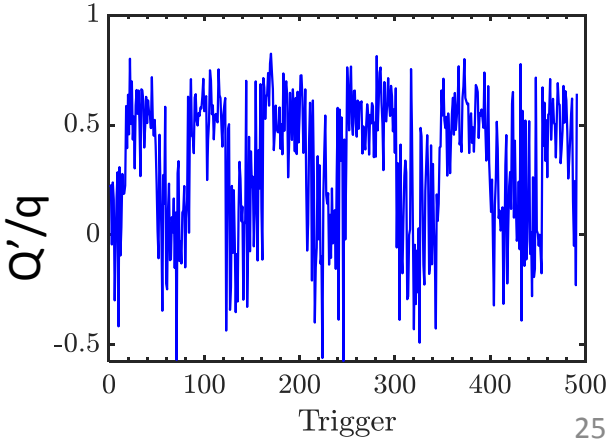

IPB




IPC

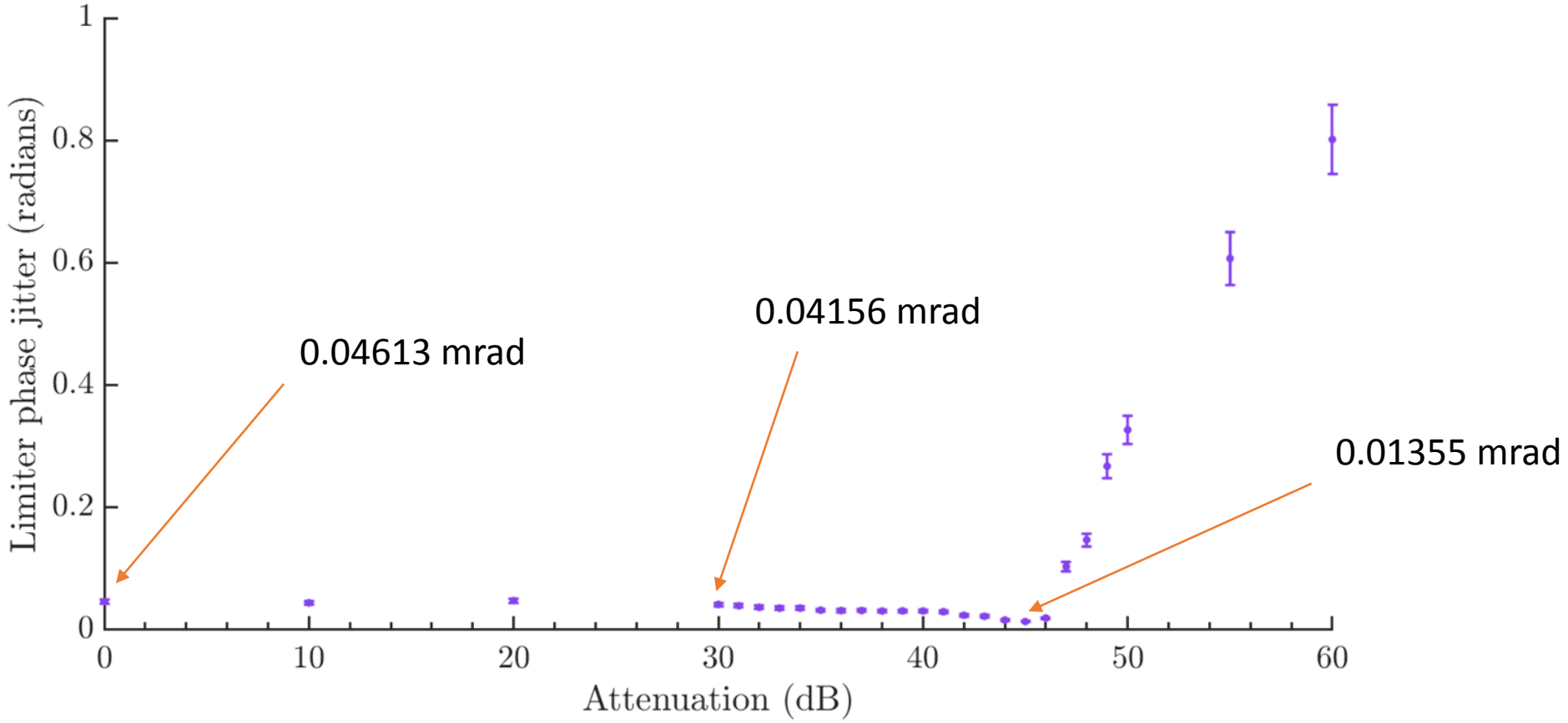


# Limiter phase jitter study

# Limiter phase jitter vs. reference attenuation

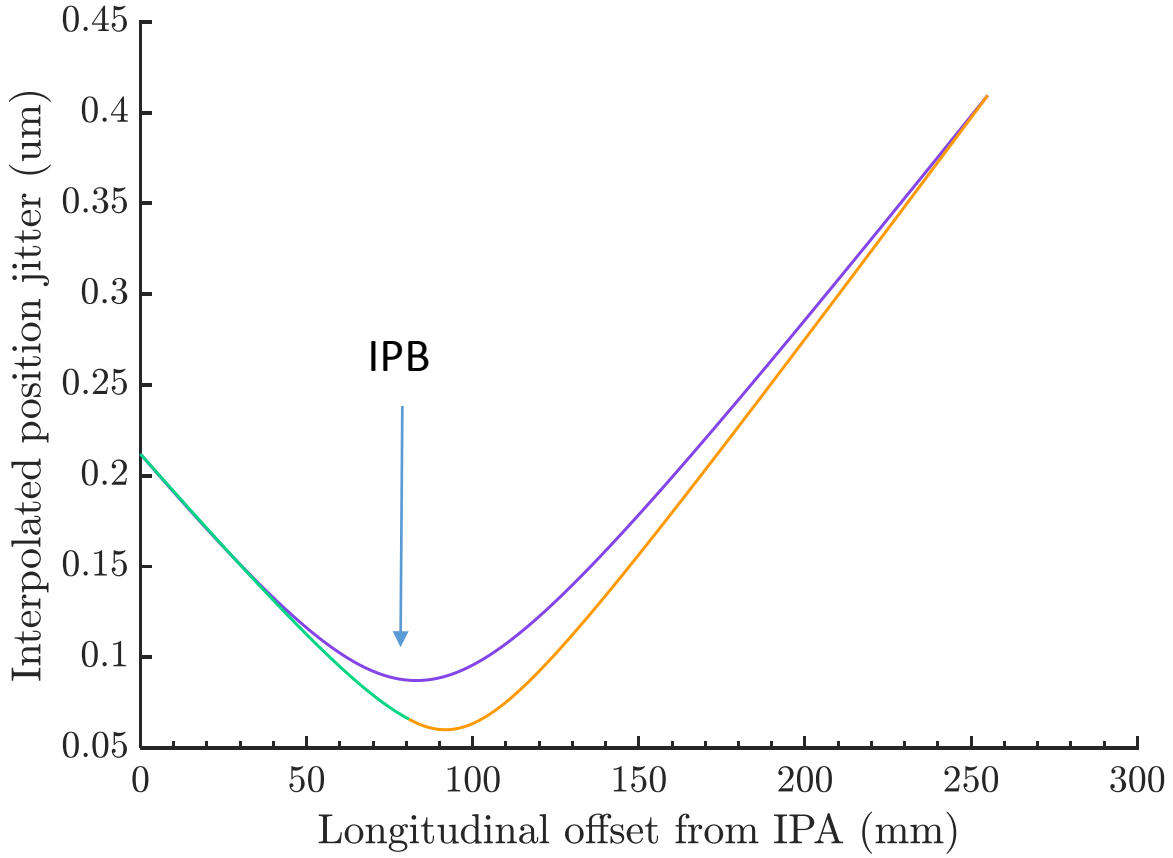
Study varying attenuation on input to limiter, with constant attenuation 40 dB on reference signal.



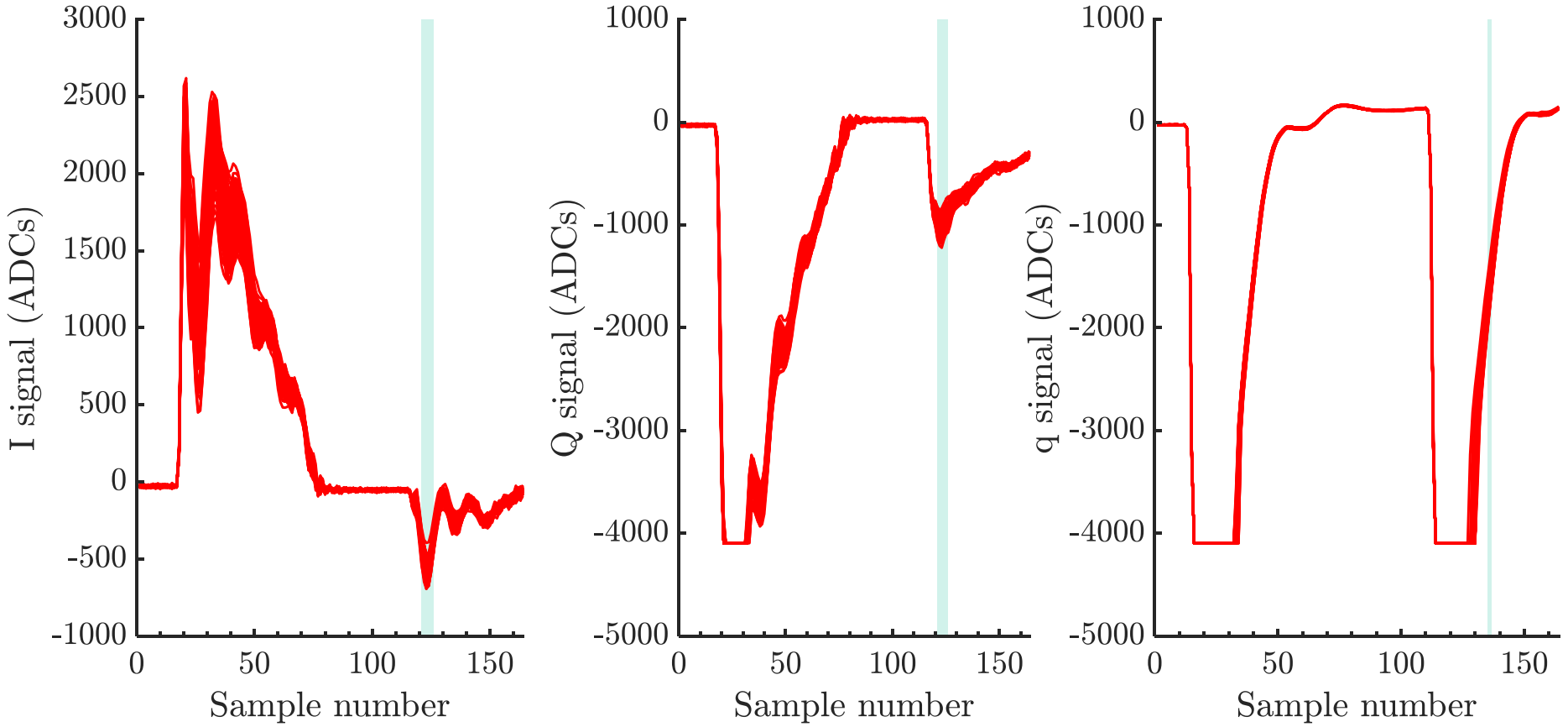
# High-beta Optics

# High-beta optics

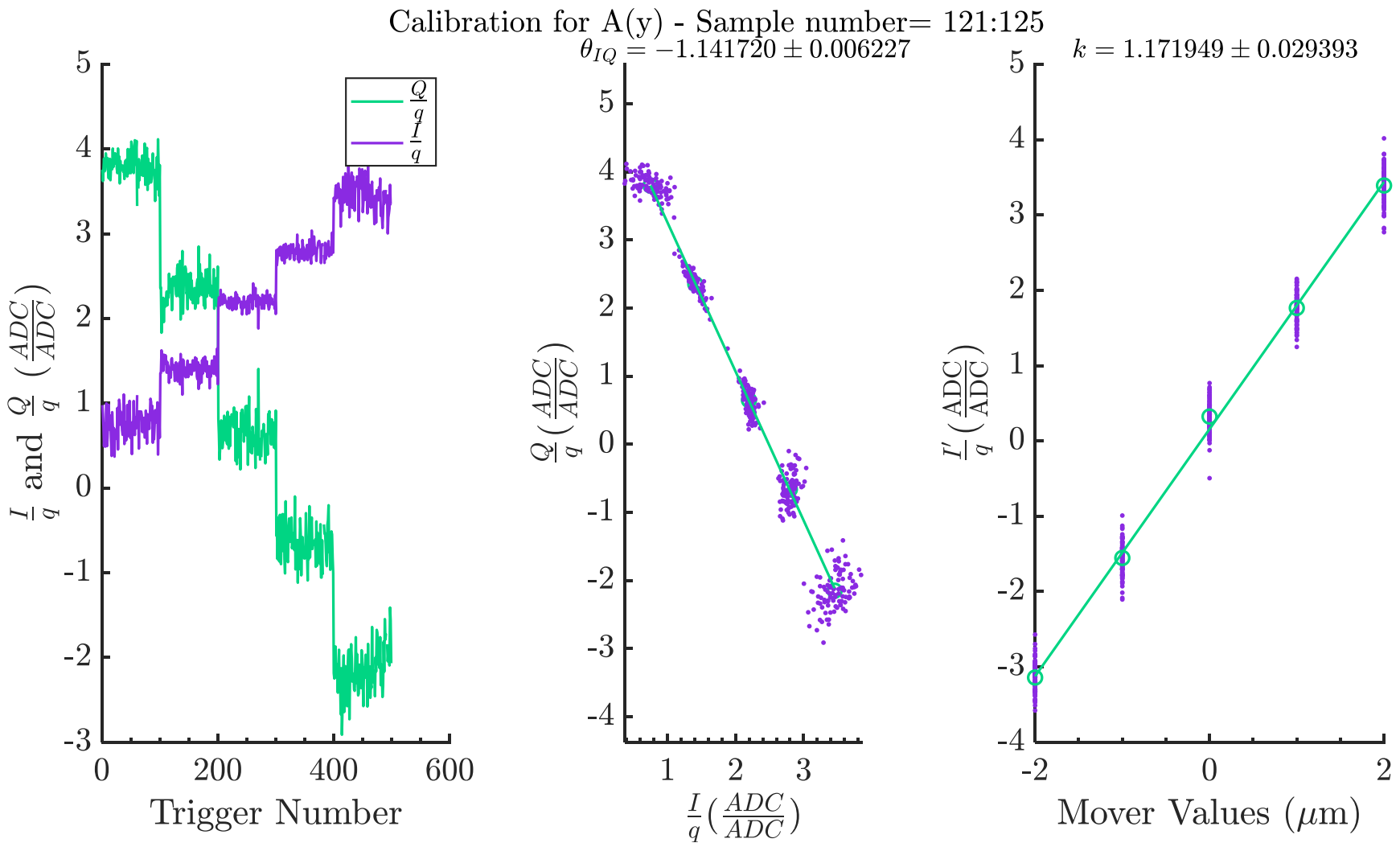
- Waist close to IPB.
  97 sample bunch spacing
- Charge bunch1: -2050
  Charge bunch2: -1942
- Mean positions at BPMs:  -233, 351, 786 nm.
  Std positions at BPMs:  212, 659, 410 nm.
- Minimum interpolated jitter 87.12 nm
- Minimum interpolated jitter 60.12 nm



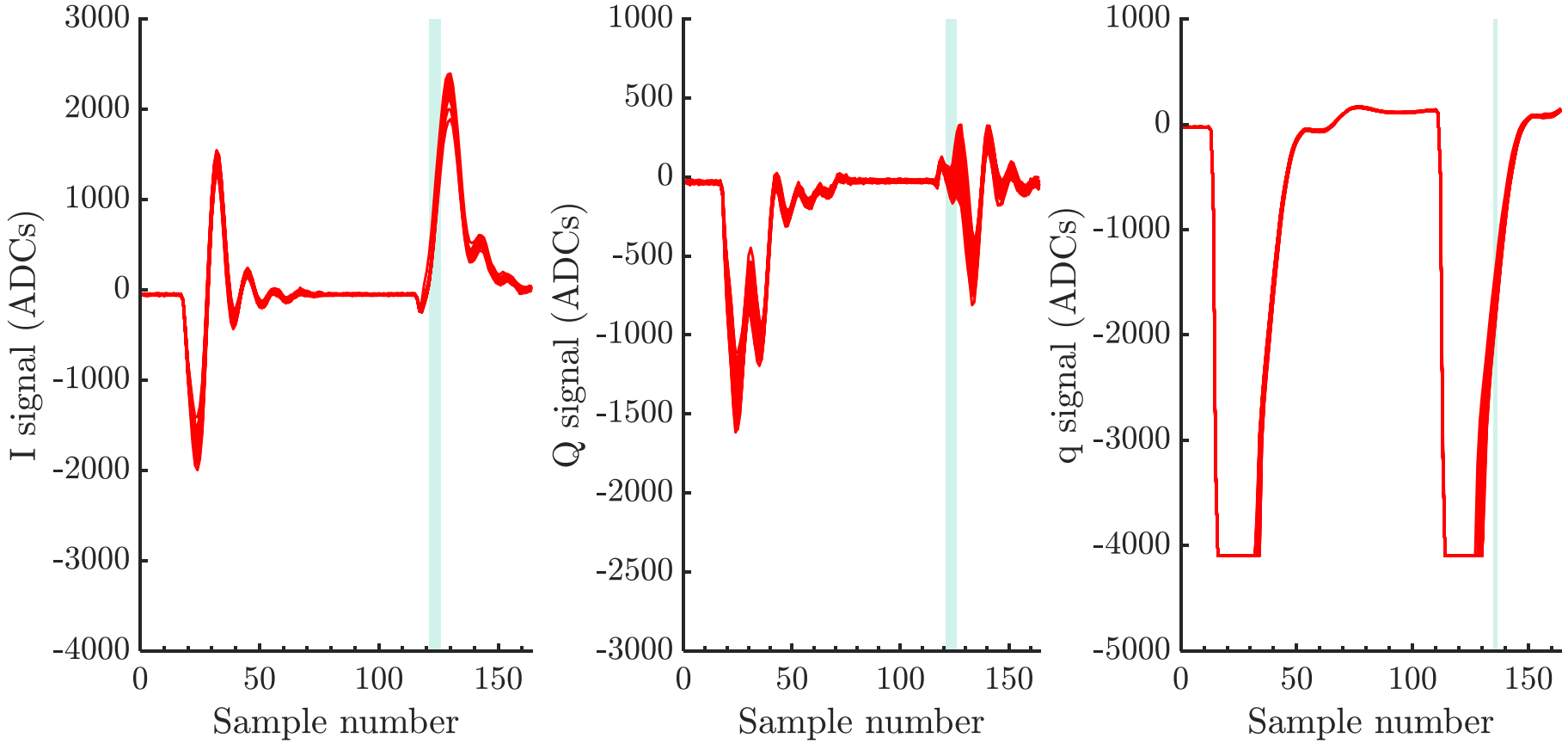
# IPA


I signal (ADCs)
Sample number
Q signal (ADCs)
Sample number
q signal (ADCs)
Sample number

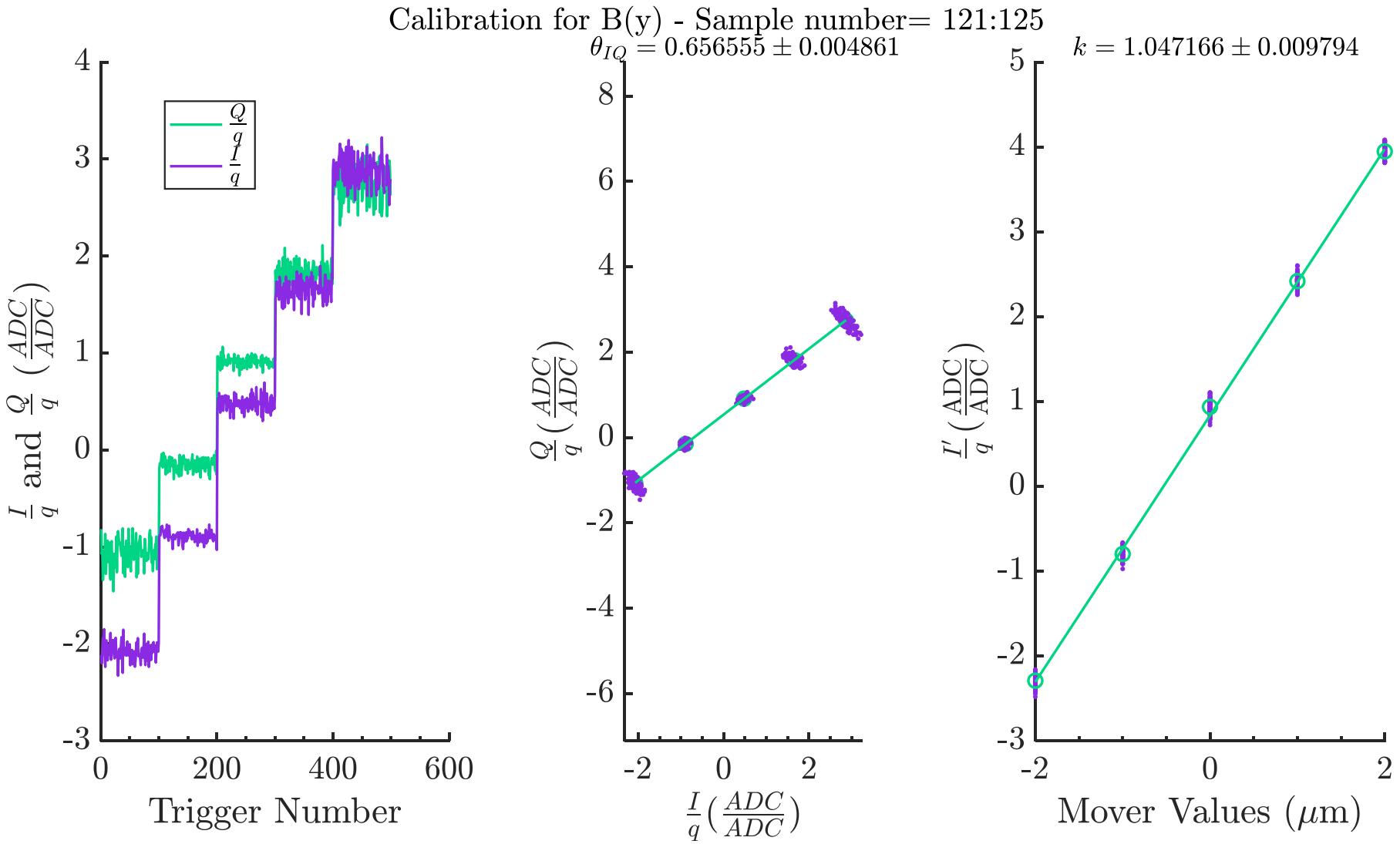
# IPA


Calibration for A(y) - Sample number= 121:125
$\theta_{IQ} = -1.141720 \pm 0.006227$
$k = 1.171949 \pm 0.029393$
$\frac{I}{q}$ and $\frac{Q}{q}$ $(\frac{ADC}{ADC})$
Trigger Number
$\frac{Q}{q}(\frac{ADC}{ADC})$
$\frac{I}{q}(\frac{ADC}{ADC})$
$\frac{I'}{q}(\frac{ADC}{ADC})$
Mover Values ($\mu$m)

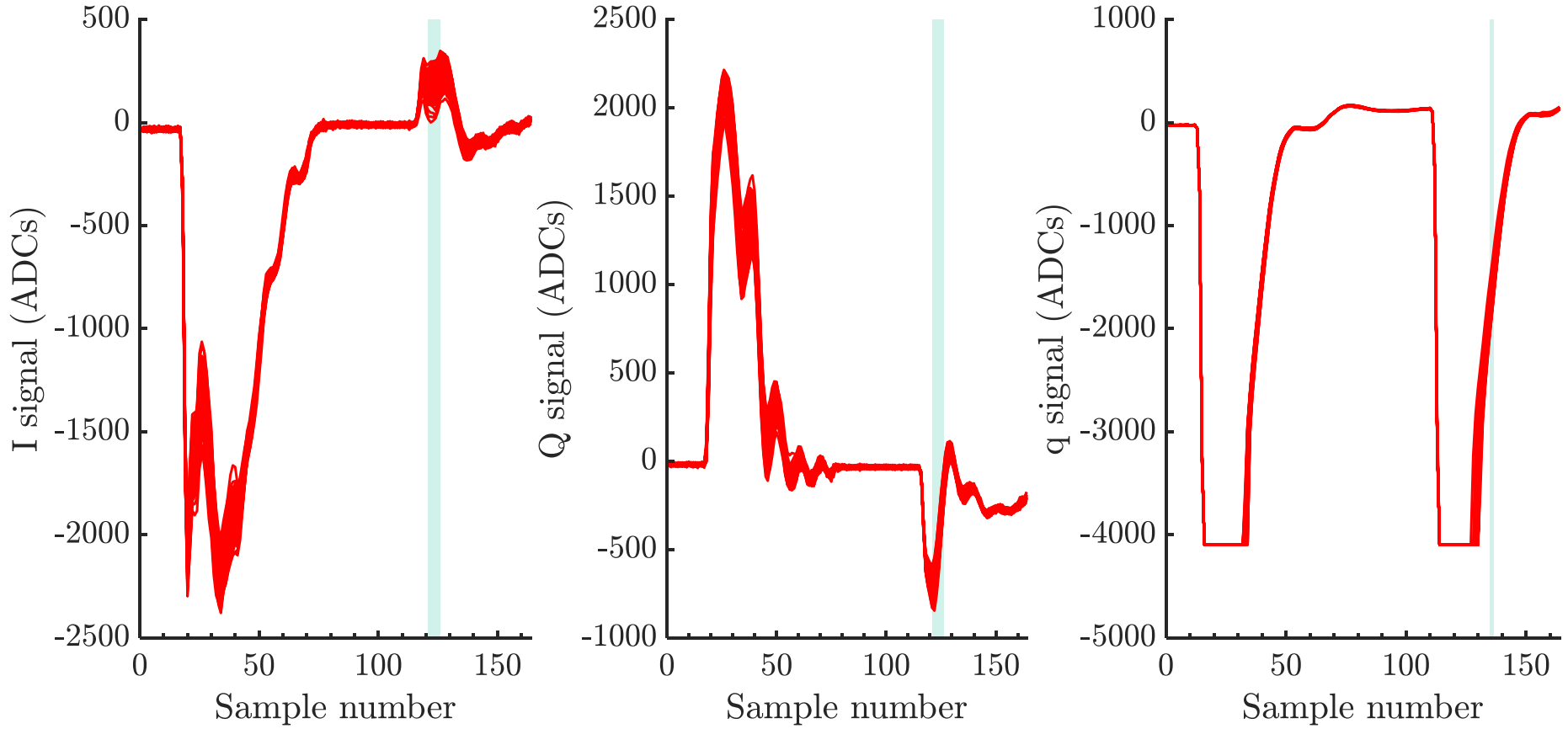
# IPB


I signal (ADCs)
Q signal (ADCs)
q signal (ADCs)
Sample number
Sample number
Sample number

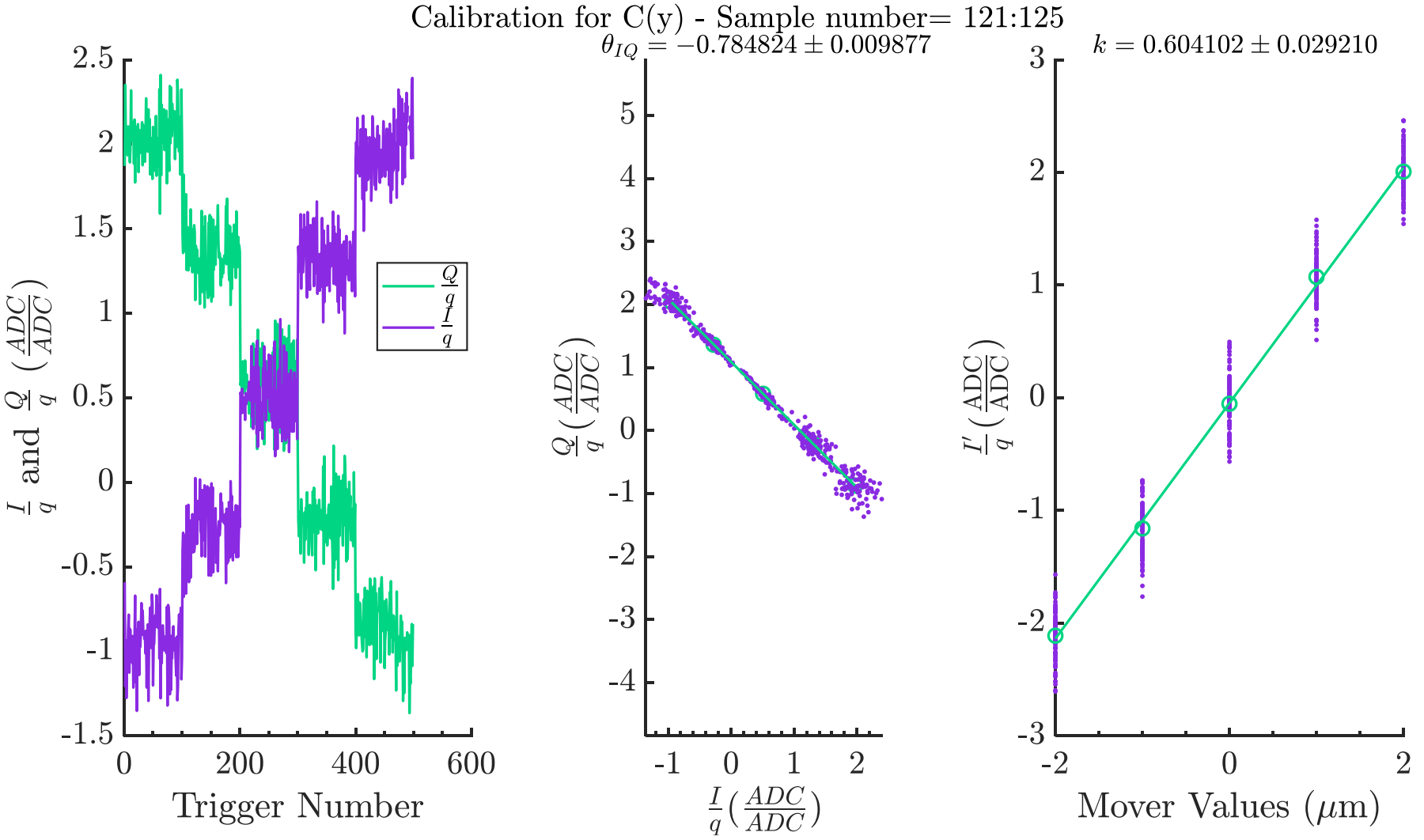
# IPB


Calibration for B(y) - Sample number= 121:125
$\theta_{IQ} = 0.656555 \pm 0.004861$
$k = 1.047166 \pm 0.009794$
$\frac{Q}{q}$
$\frac{I}{q}$
$\frac{I}{q}$ and $\frac{Q}{q}$ $(\frac{ADC}{ADC})$
Trigger Number
$\frac{Q}{q}(\frac{ADC}{ADC})$
$\frac{I}{q}(\frac{ADC}{ADC})$
$\frac{I'}{q}(\frac{ADC}{ADC})$
Mover Values ($\mu$m)

# IPC

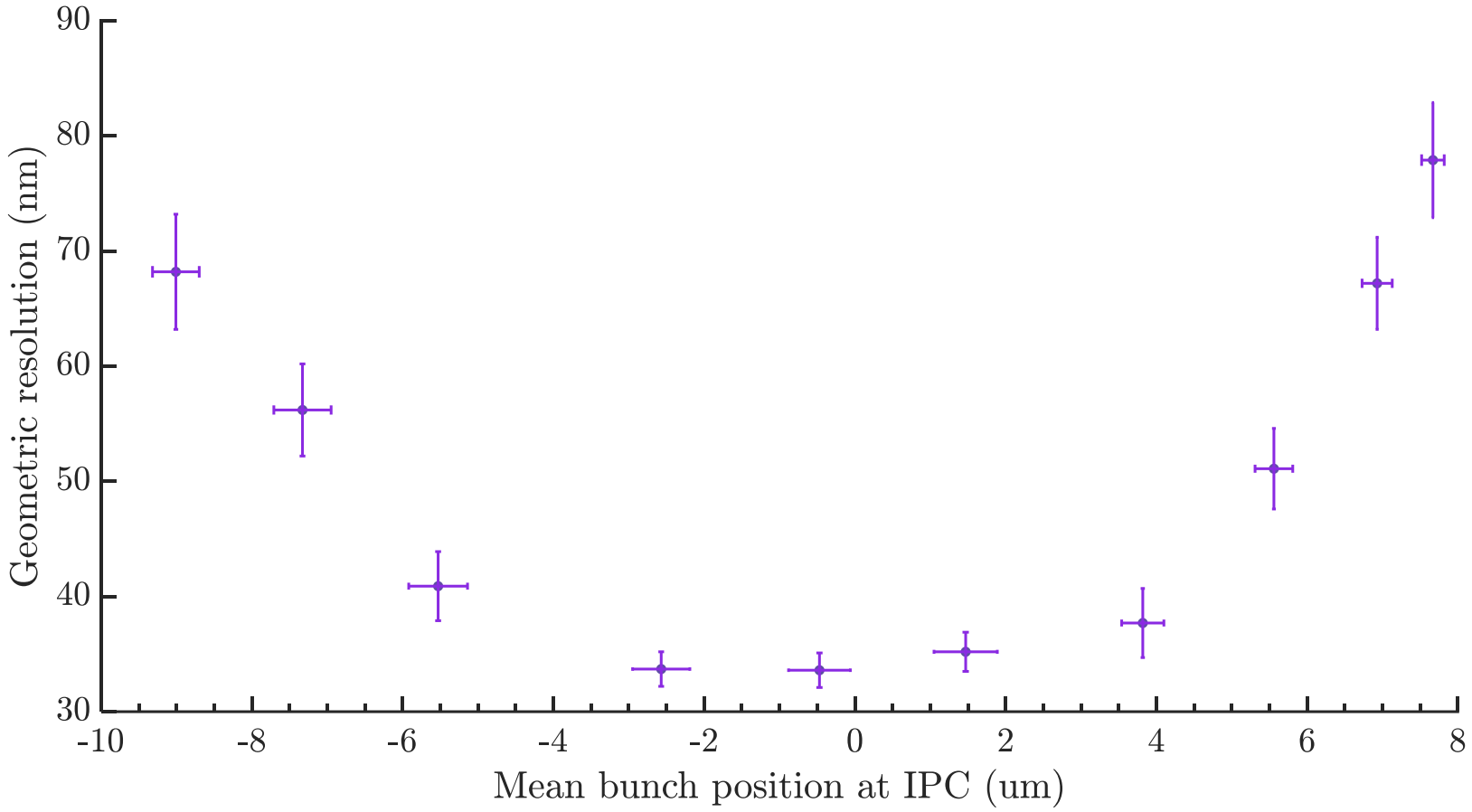

I signal (ADCs)
Q signal (ADCs)
q signal (ADCs)
Sample number
Sample number
Sample number

# IPC


Calibration for C(y) - Sample number= 121:125
$\theta_{IQ} = -0.784824 \pm 0.009877$
$k = 0.604102 \pm 0.029210$
$\frac{I}{q}$ and $\frac{Q}{q}$ $(\frac{ADC}{ADC})$
Trigger Number
$\frac{Q}{q}$
$\frac{I}{q}$
$\frac{Q}{q}(\frac{ADC}{ADC})$
$\frac{I}{q}(\frac{ADC}{ADC})$
$\frac{I'}{q}(\frac{ADC}{ADC})$
Mover Values ($\mu$m)

# Geometric resolution Vs. IPC position

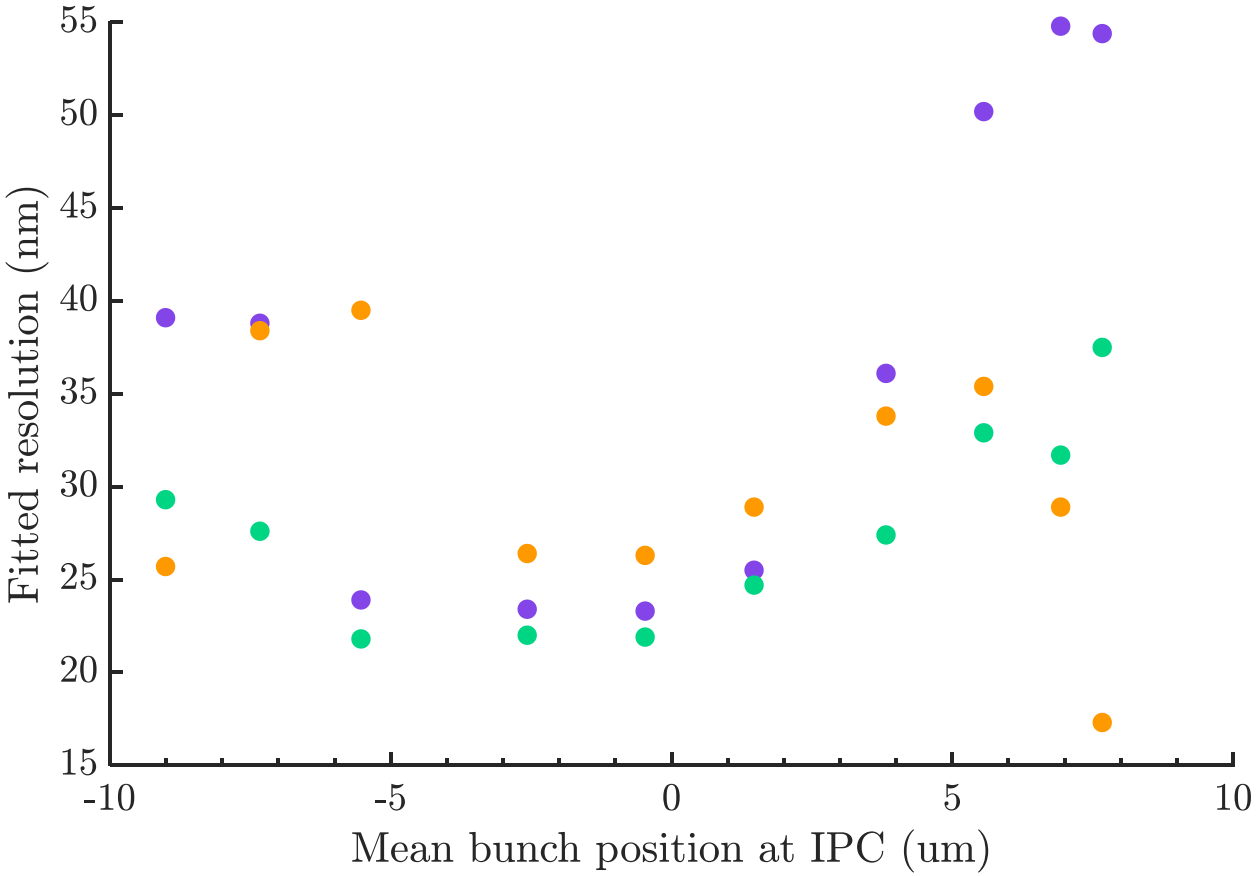
*x*-errorbars show bunch position jitter.



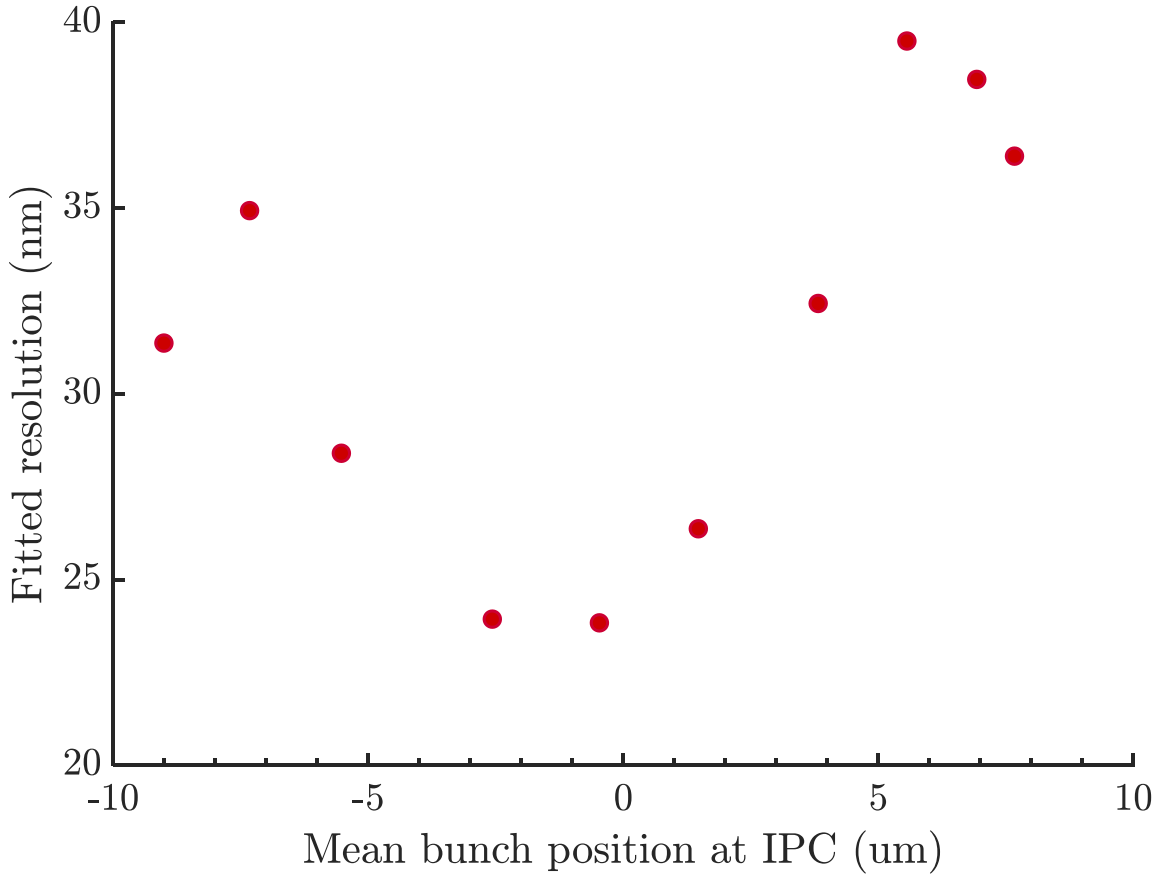

| IPC position offset (um) | Geometric resolution (nm) |
|---|---|
| 7.67 | 77.9 |
| 6.93 | 67.2 |
| 5.56 | 51.1 |
| 3.82 | 37.7 |
| 1.47 | 35.2 |
| -0.47 | 33.6 |
| -2.57 | 33.7 |
| -5.53 | 40.9 |
| -7.33 | 56.2 |
| -9.01 | 68.2 |

# Fitted resolution vs. IPC position

IPA, IPB, IPC fitted resolutions (fitting for just position)




Mean of the IPA, IPB, IPC fitted resolutions.



# Conclusion

- Calibrations were performed in nominal optics, as a function of BPM position, BPM tilt, and waist position.
- IP BPM mover diagnostics, it was clearly demonstrated that changes can be seen in the IPB signals just by moving the IPC mover.
- Limiter phase jitter was studied as a function of input signal level
- Resolution was studied as a function of IPC position, in a scan of +/- 10 um.