Further Studies on February Shifts

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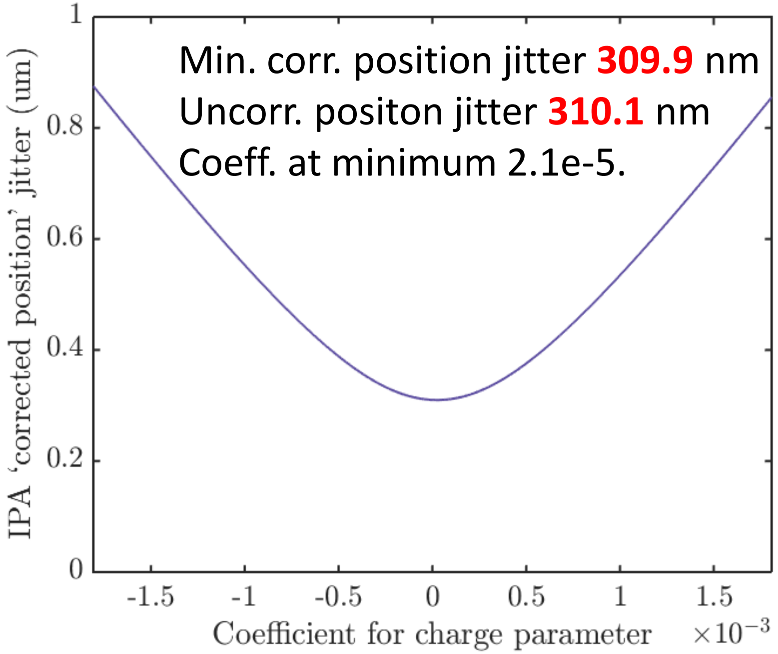
Friday, 23rd February 2018

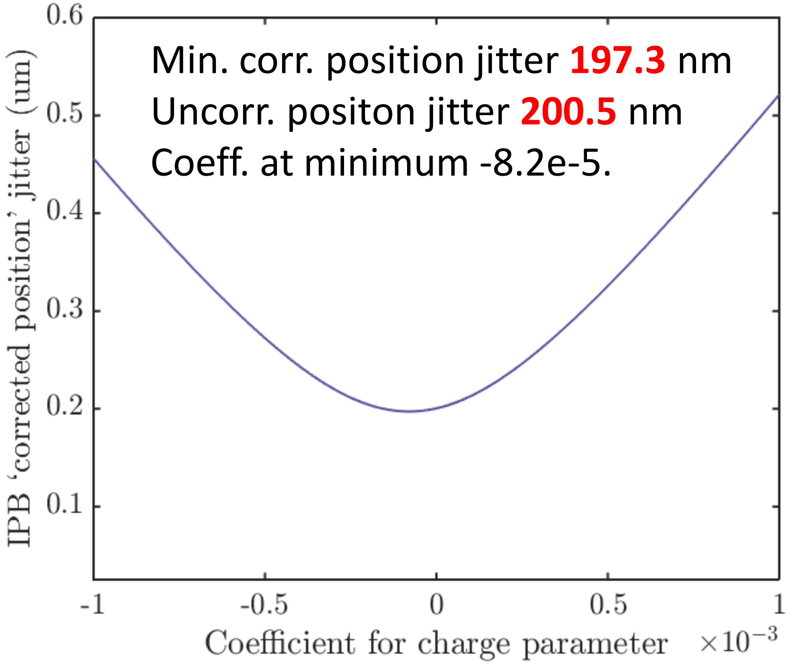
Outline

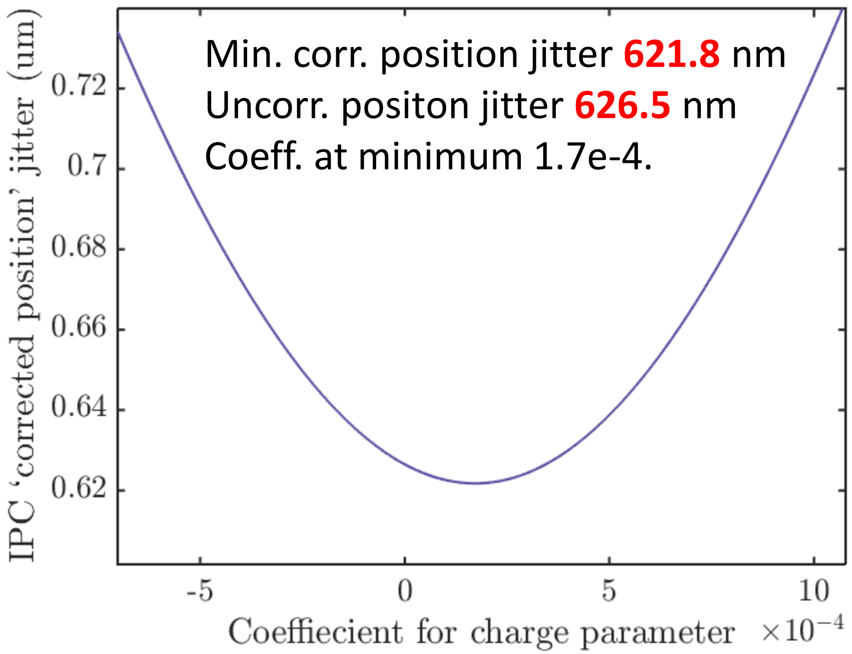
- Follow up from last weeks meeting:
  - Fitting position with charge and measure new corrected position jitter measurement.
  - Stability of phase (θ_{IQ}) and phase jitter.
  - Errors on calibration constant (k).
  - Resolution fitting - with and without including charge and considering other fitting parameters (for charge and attenuation scan).
  - Bunch positions measured across a charge scan.
  - Latency measurement.
- New items:
  - Strange features in the reference signal around edges of saturation.

Fitting position with charge

- Plots shown are for the data file for which fitting the charge made the biggest impact on resolution.
- (AQD0FFyScan11, jitRun11 (09/02/2018), high-beta optics, 10dB)
- Fitting the charge seems to mostly make a few nanometres difference to the jitter measurement. At most it makes ~ 5nm difference.
- Position-charge correlation typically no higher than +/- 20 %.
- **'charge corrected position' = position + coeff. * charge,** the coefficient is then scanned to find setting producing minimum jitter on charge corrected position.







Stability of Phase and Calibration Constant

- Repeat calibrations were performed (05/02/2018).
- ThetaIQ found by perpendicular fit, applied using method described in York et al. (American Journal of Physics **72**, 367 (2004)). Gives upper and lower uncertainty values.
- Calibration constant k found by weighted vertical least squares fit; with errors derived using method shown in: https://www.che.udel.edu/pdf/FittingData.pdf.

$$aERR = slope\_error\_of\_weighted\_line = \sqrt{\frac{\sum \frac{1}{e_i^2}}{(\sum \frac{x_i^2}{e_i^2})(\sum \frac{1}{e_i^2}) - (\sum \frac{x_i}{e_i^2})^2}}$$

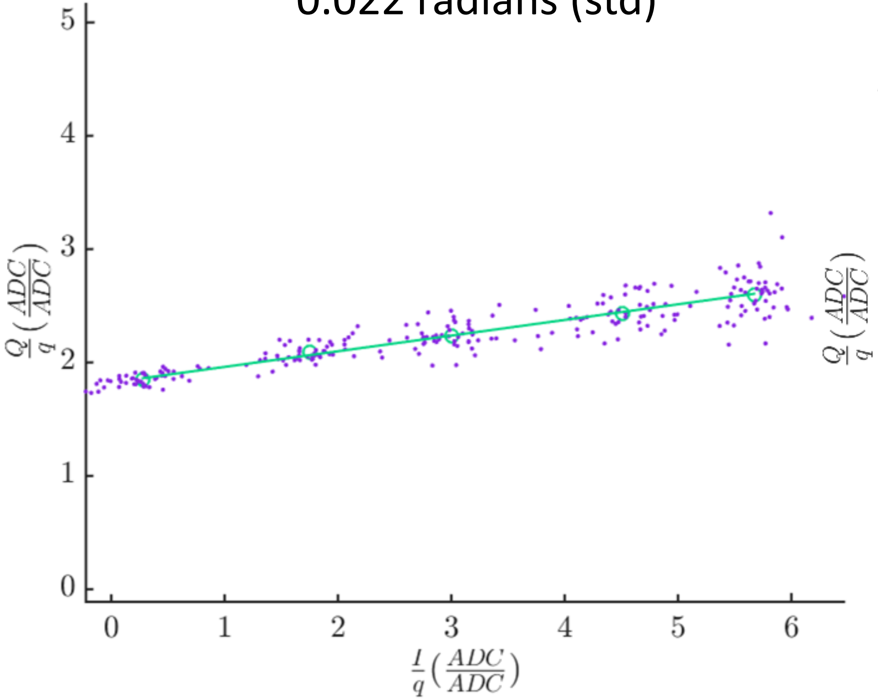
(X_i= points to fit to, e_i= their respective errors)

k (10 samples)	θ_{IQ}
-0.850 ± 0.008	0.136 ± 0.008
-0.836 ± 0.008	0.138 ± 0.009
-0.828 ± 0.009	0.139 ± 0.009
-0.841 ± 0.010	0.133 ± 0.008
-0.831 ± 0.009	0.100 ± 0.009
-0.829 ± 0.011	0.110 ± 0.009
-0.827 ± 0.013	0.125 ± 0.009
-0.836 ± 0.011	0.132 ± 0.008

Estimate of Phase Jitter

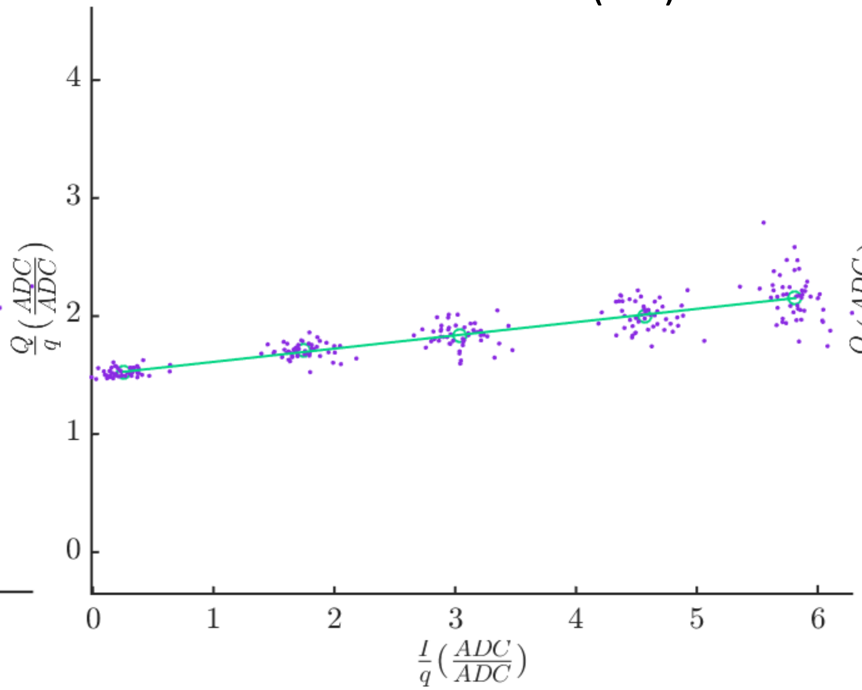
- Using standard deviation of θ_{IQ} for all triggers at each step, as measured from y intercept.
- Magnitude of phase jitter appears to be reasonably insensitive to changes in the charge.

Phase jitter:
0.022 radians (std)



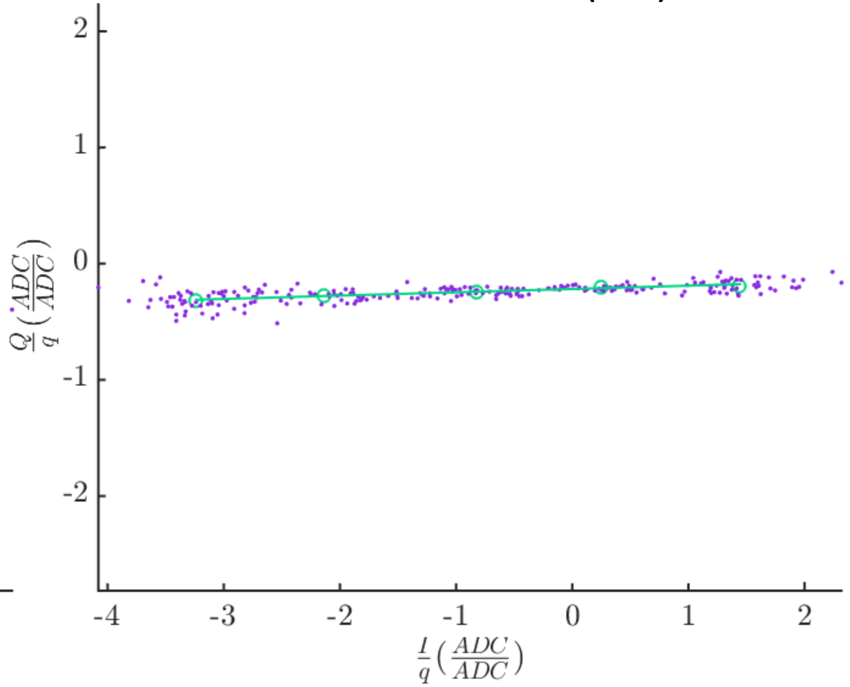
IPA

Phase jitter:
0.017 radians (std)



IPB

Phase jitter:
0.020 radians (std)



IPC

Latency Scan

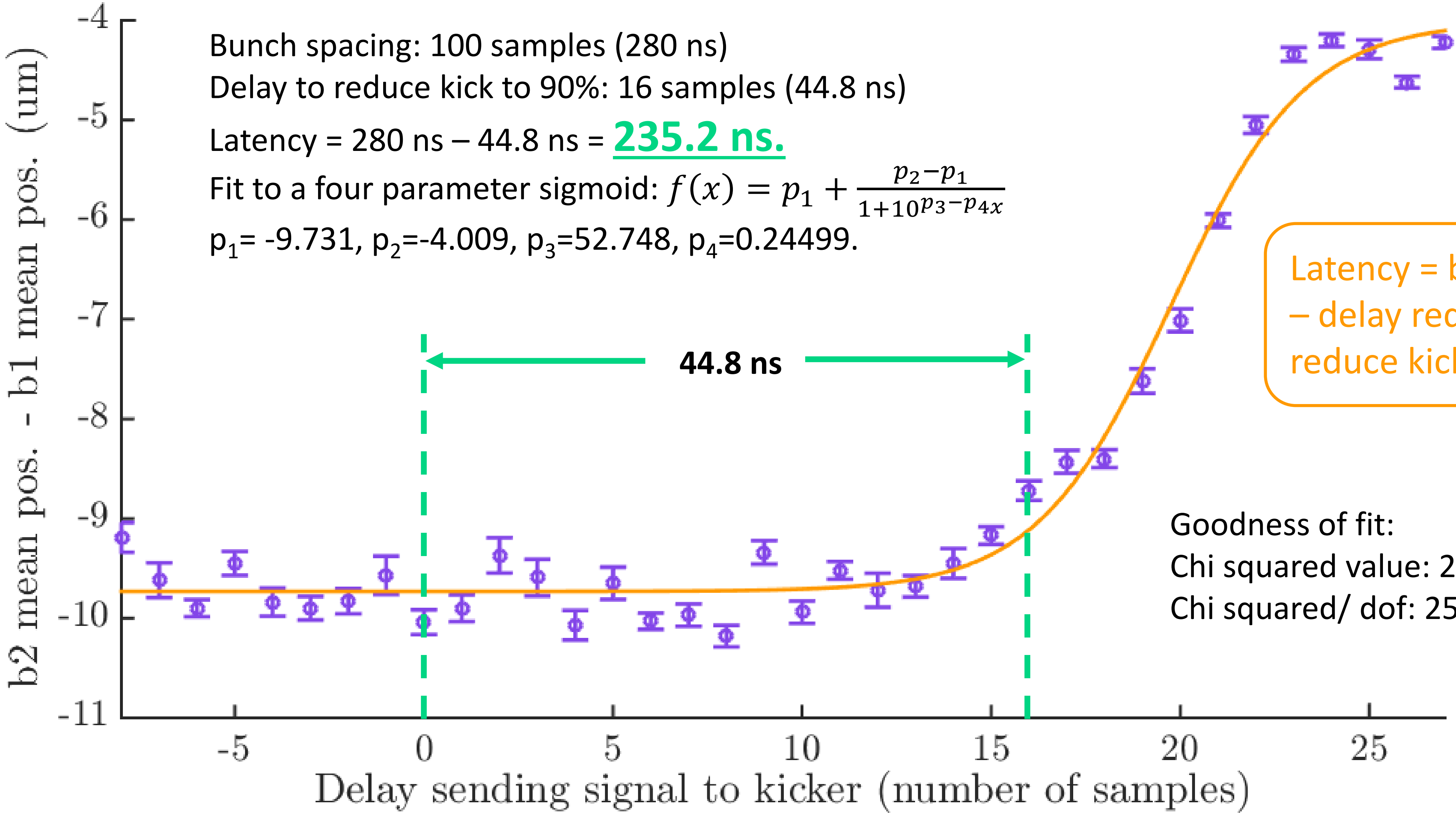
Bunch spacing: 100 samples (280 ns)

Delay to reduce kick to 90%: 16 samples (44.8 ns)

Latency = 280 ns – 44.8 ns = **235.2 ns.**

Fit to a four parameter sigmoid: $f(x) = p_1 + \frac{p_2 - p_1}{1+10^{p_3 - p_4 x}}$

p_1= -9.731, p_2=-4.009, p_3=52.748, p_4=0.24499.



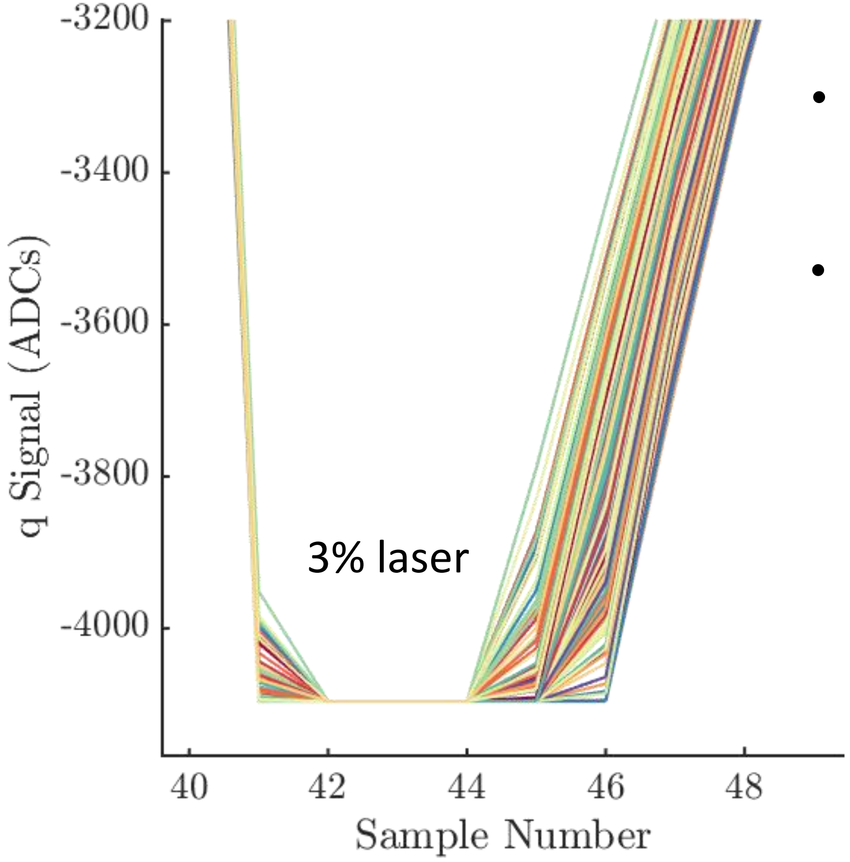
Latency = bunch spacing – delay required to reduce kick to 90% max.

Goodness of fit:

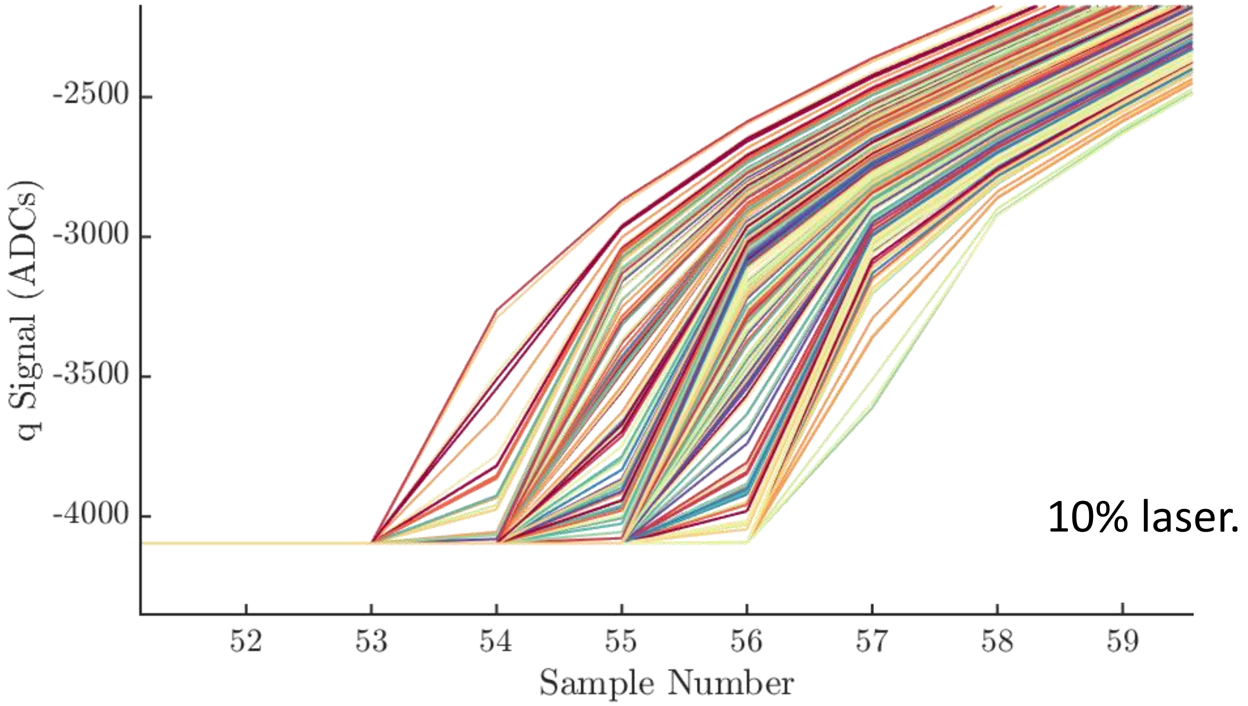
Chi squared value: 25.12

Chi squared/ dof: 25.12/32 = **0.785.**

Reference Signal



- Kinks in the reference signal around the peak do not fit the expected shape of a signal that is in digitiser saturation.
  - E.g would expect all triggers at sample 41 to be saturating. (In L.H.S plot)
- Some triggers seem to be saturating and others 1000 ADC away from saturating (e.g sample 55 in the plot below).

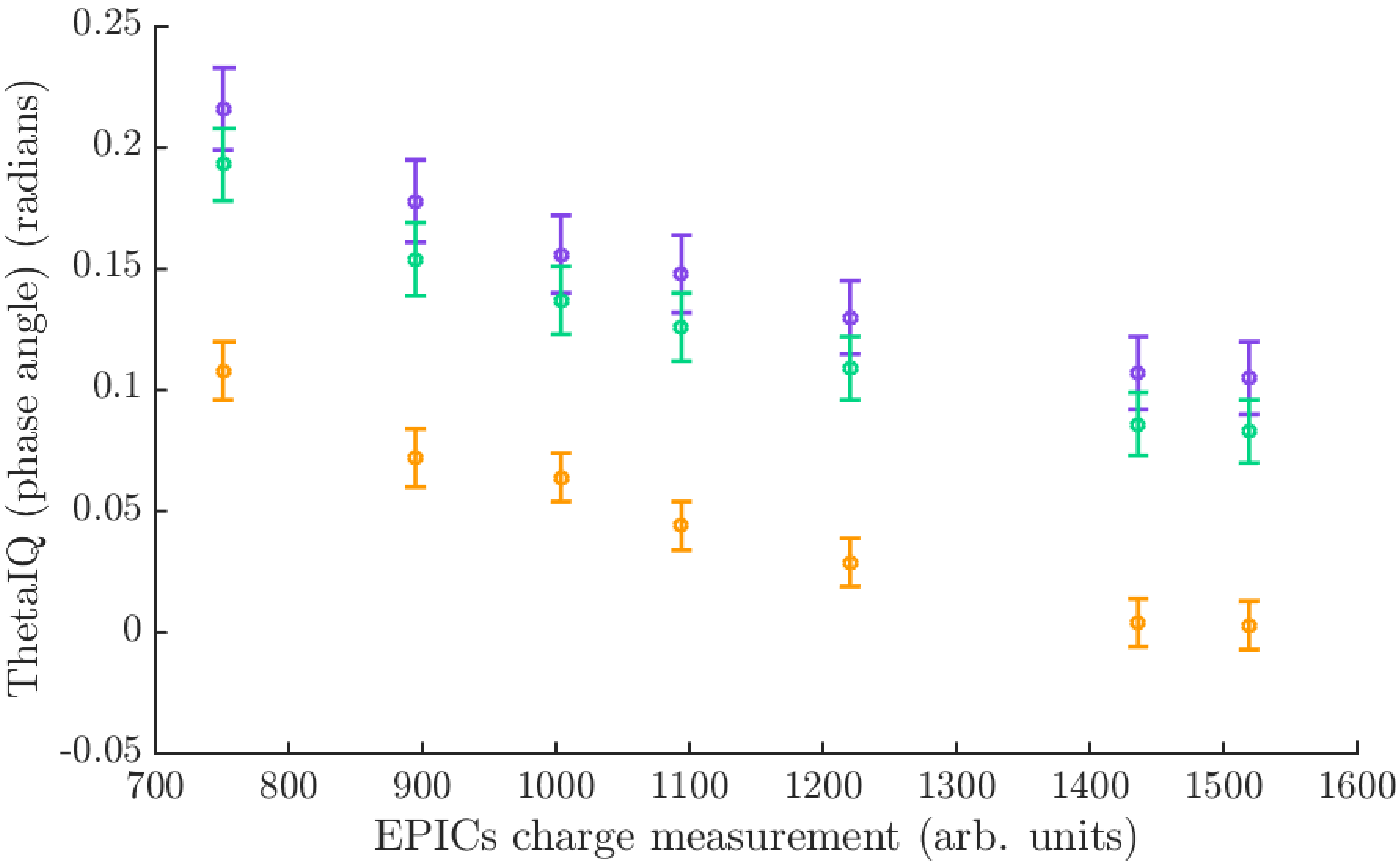


Charge Scan

09/02/2018, high-beta optics

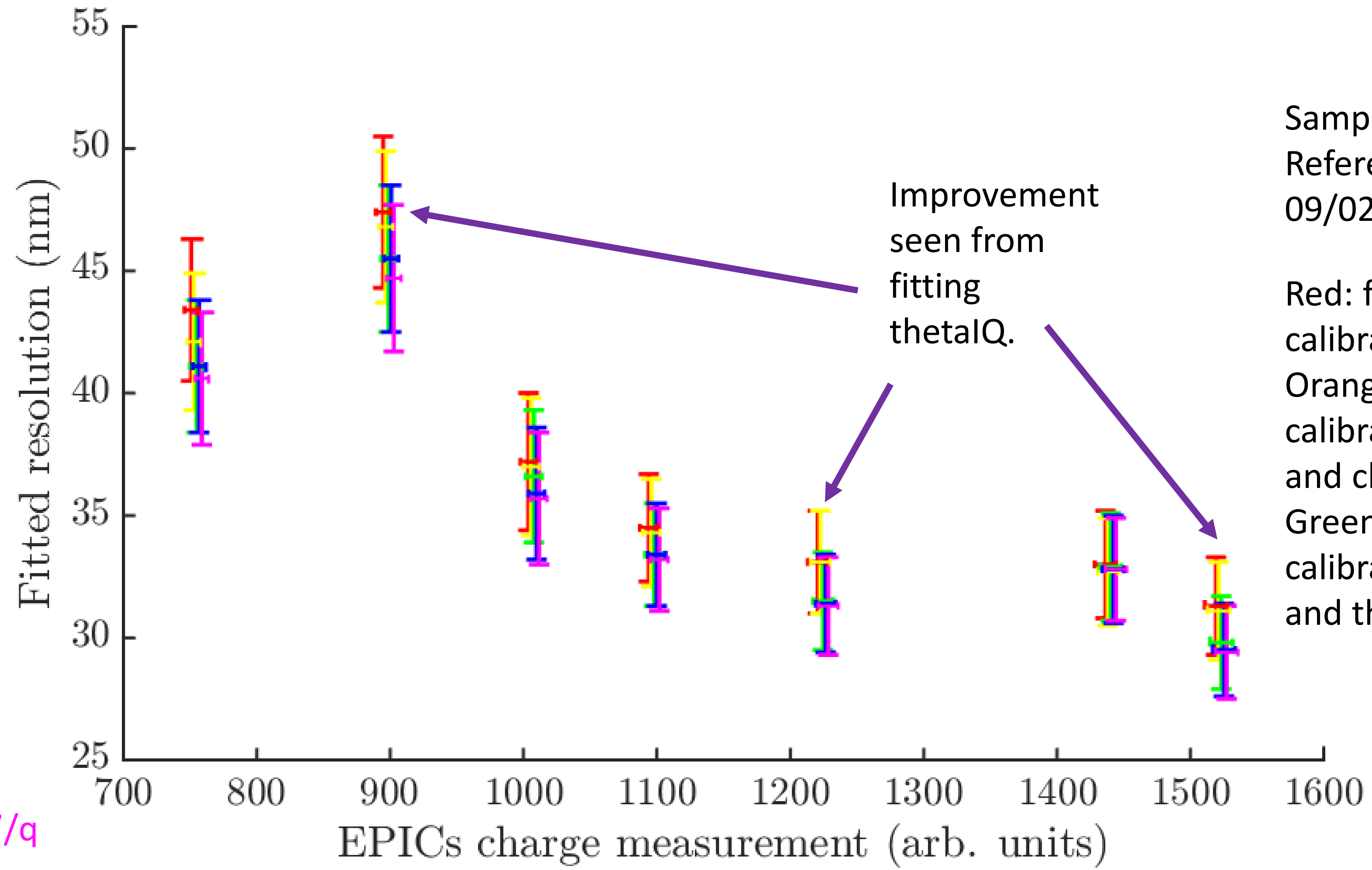
10dB

θ_{IQ} vs. charge



- Dipole and reference samples are unchanged throughout scan.
- ThetaIQ is fit through a perpendicular least squares fit.
- Shift 09/02/2018, 10 dB, high-beta optics.
- Q/q and I/q both show charge dependence.

Charge Scan Resolution IPA



Samples: 50: 57
Reference 57
09/02/2018

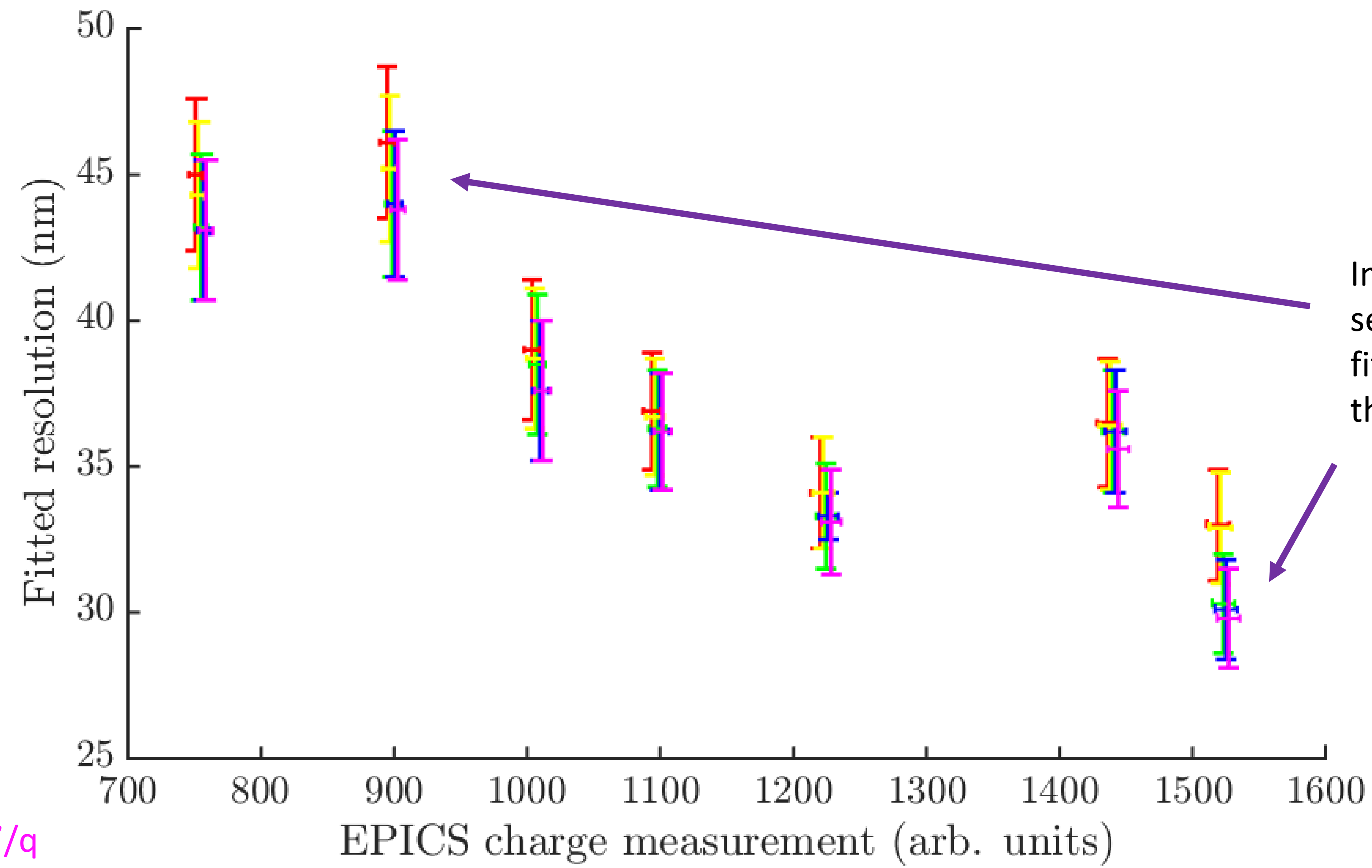
Red: fitting out calibration constant.
Orange: fitting out calibration constant and charge.
Green: fitting out calibration constant and theta.

Fit to:
Position,
Position and 1/q
I/q and Q/q
I’/q, Q’/q, 1/q
I’/q, Q’/q, 1/q, self Q’/q

Charge Scan Resolution IPB

Red: fitting out calibration constant.
Orange: fitting out calibration constant and charge.
Green: fitting out calibration constant and theta.

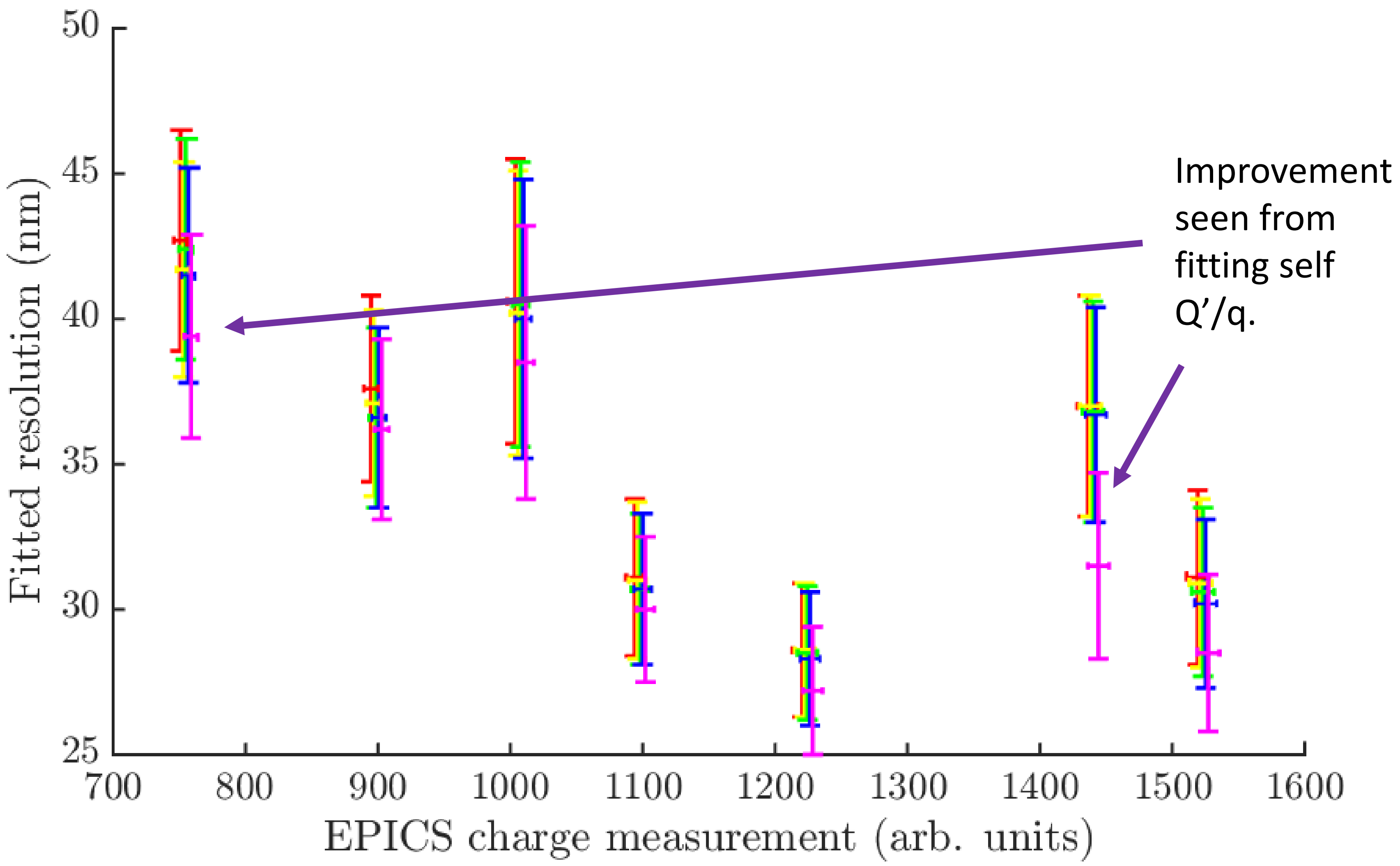
Fit to:
Position,
Position and 1/q
I/q and Q/q
I'/q, Q'/q, 1/q
I'/q, Q'/q, 1/q, self Q'/q



Improvement seen from fitting thetaIQ.

Charge Scan Resolution IPC

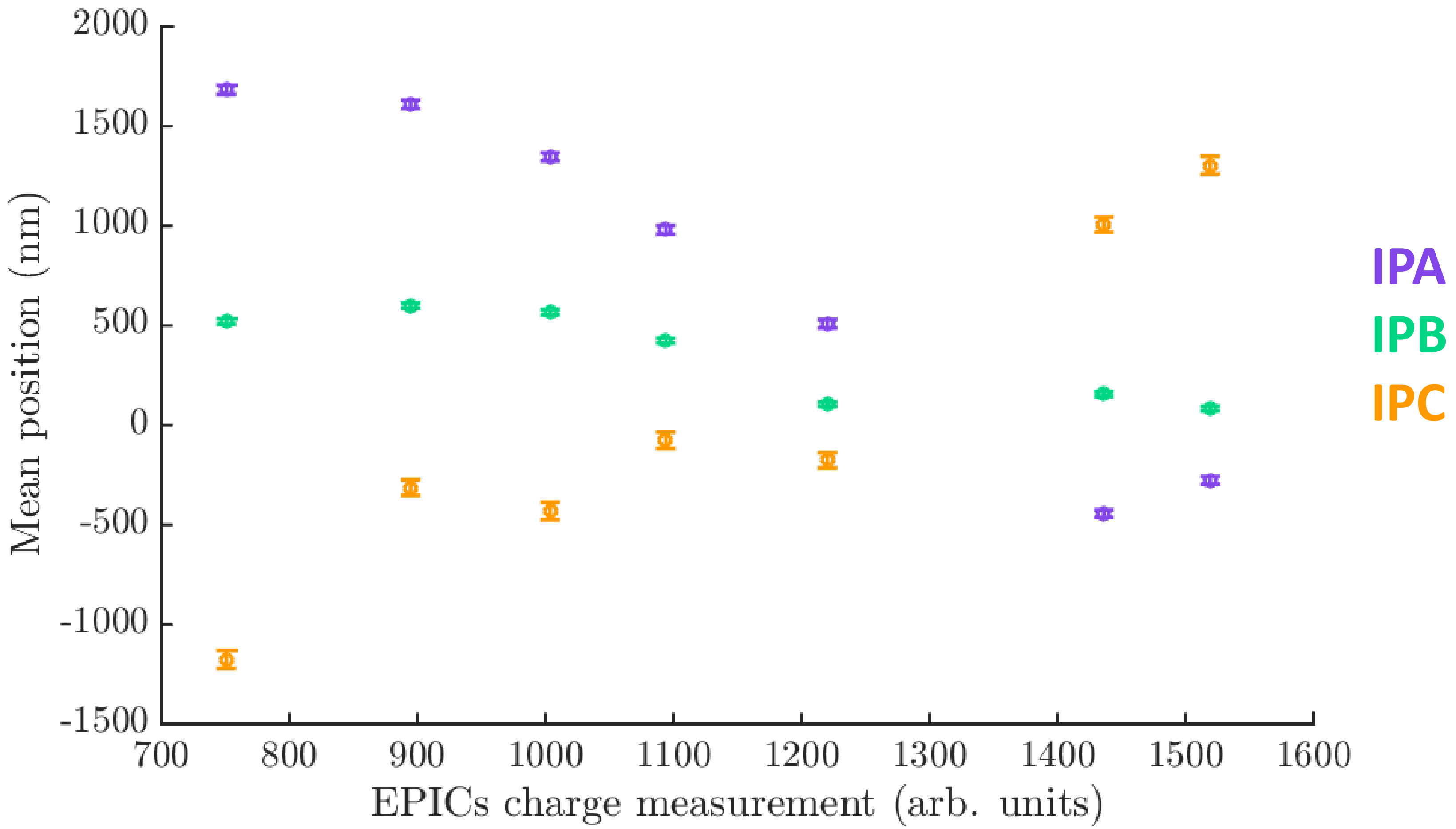
Red: fitting out calibration constant.
Orange: fitting out calibration constant and charge.
Green: fitting out calibration constant and theta.



Fit to:
Position,
Position and 1/q
I/q and Q/q
I'/q, Q'/q, 1/q
I'/q, Q'/q, 1/q, self Q'/q

Mean Positions for Charge Scan

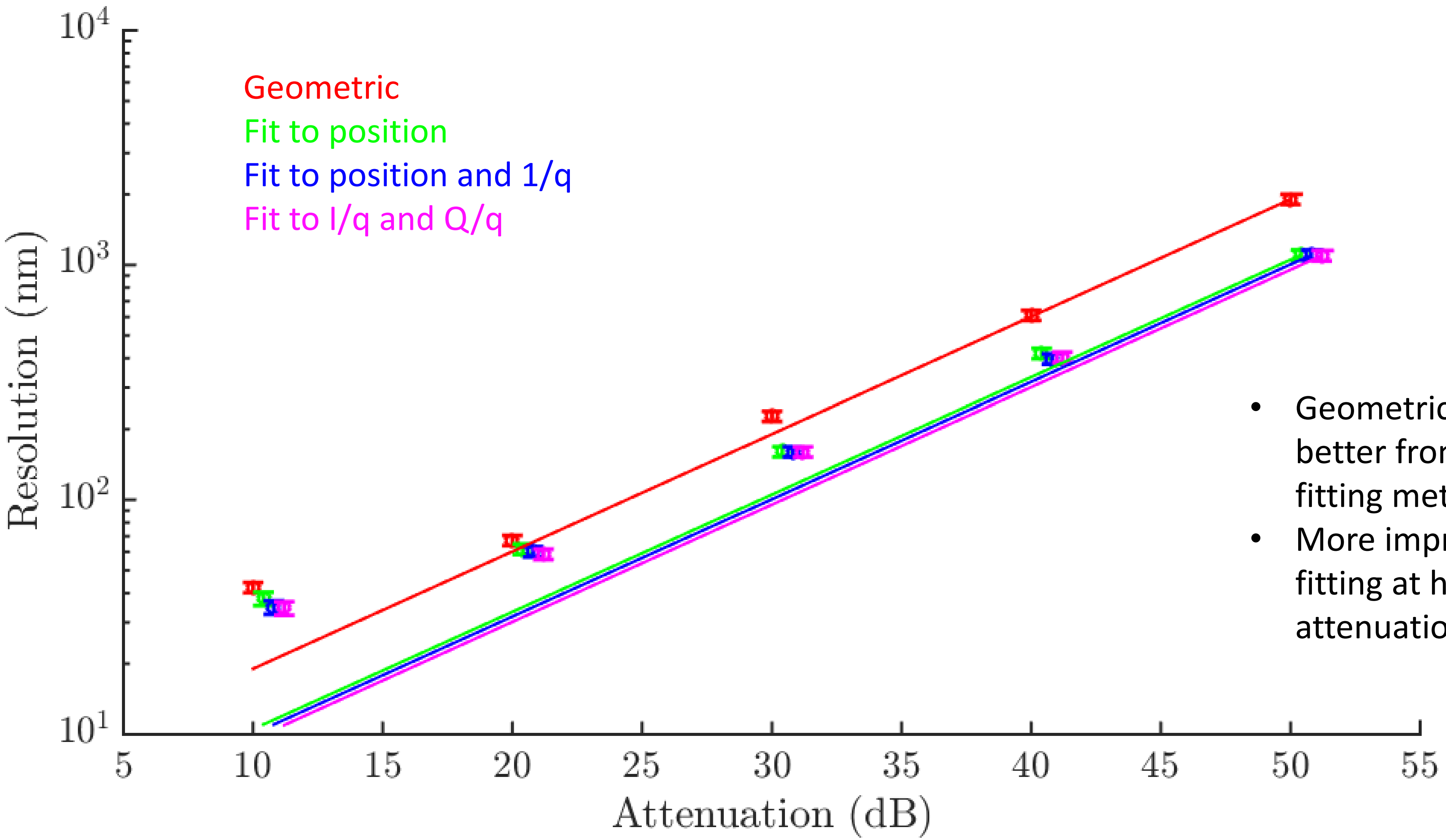
- Beam waist between IPA and IPB, close to IPB (high-beta optics).
- Significant change in mean position seen at IPA, IPB and IPC throughout charge scan.
- IPA and IPC, further from the beam waist, show the beam position crossing the electrical centre.



Attenuation Scan

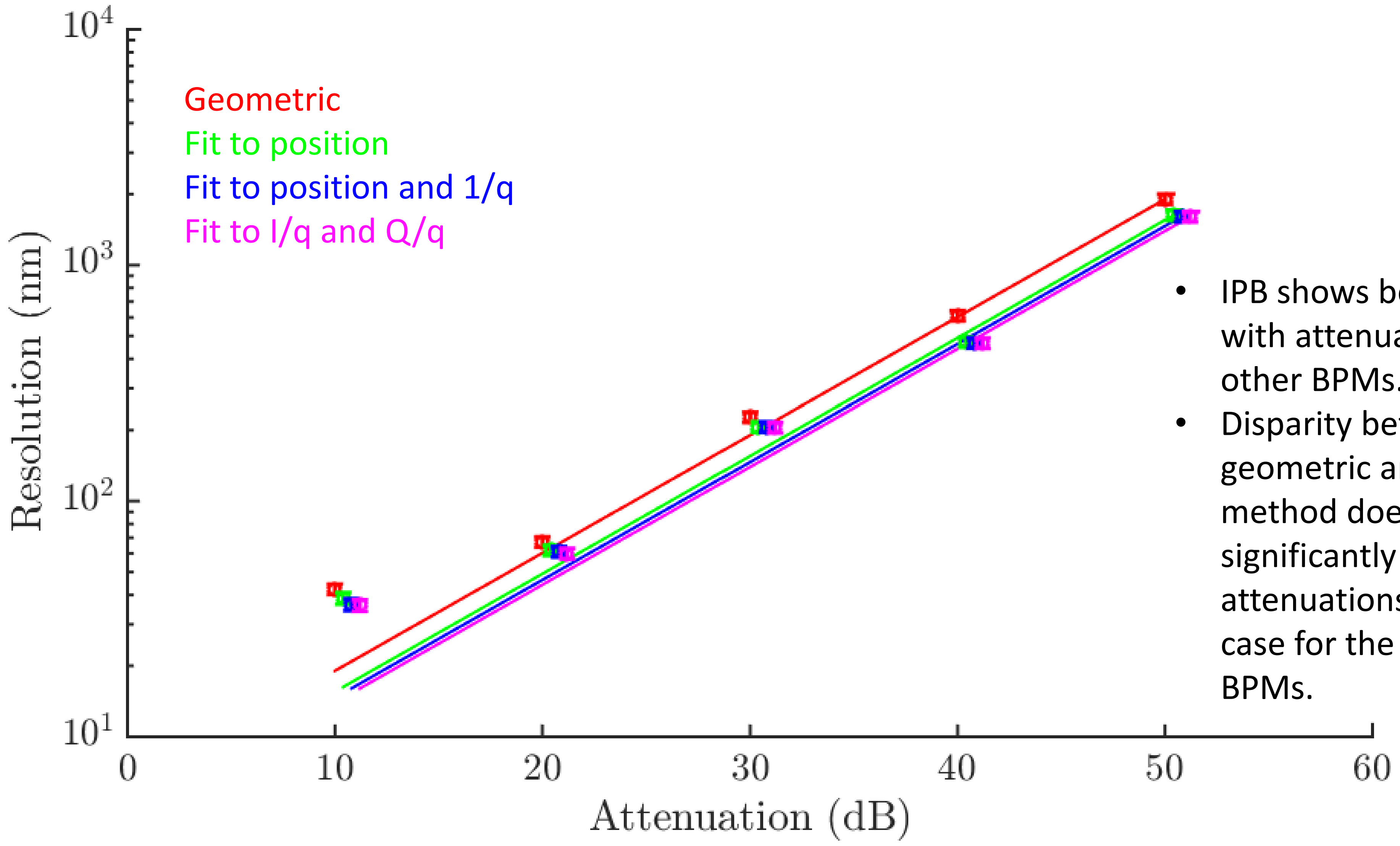
09/02/2018, high-beta optics
10dB

IPA Attenuation Scan



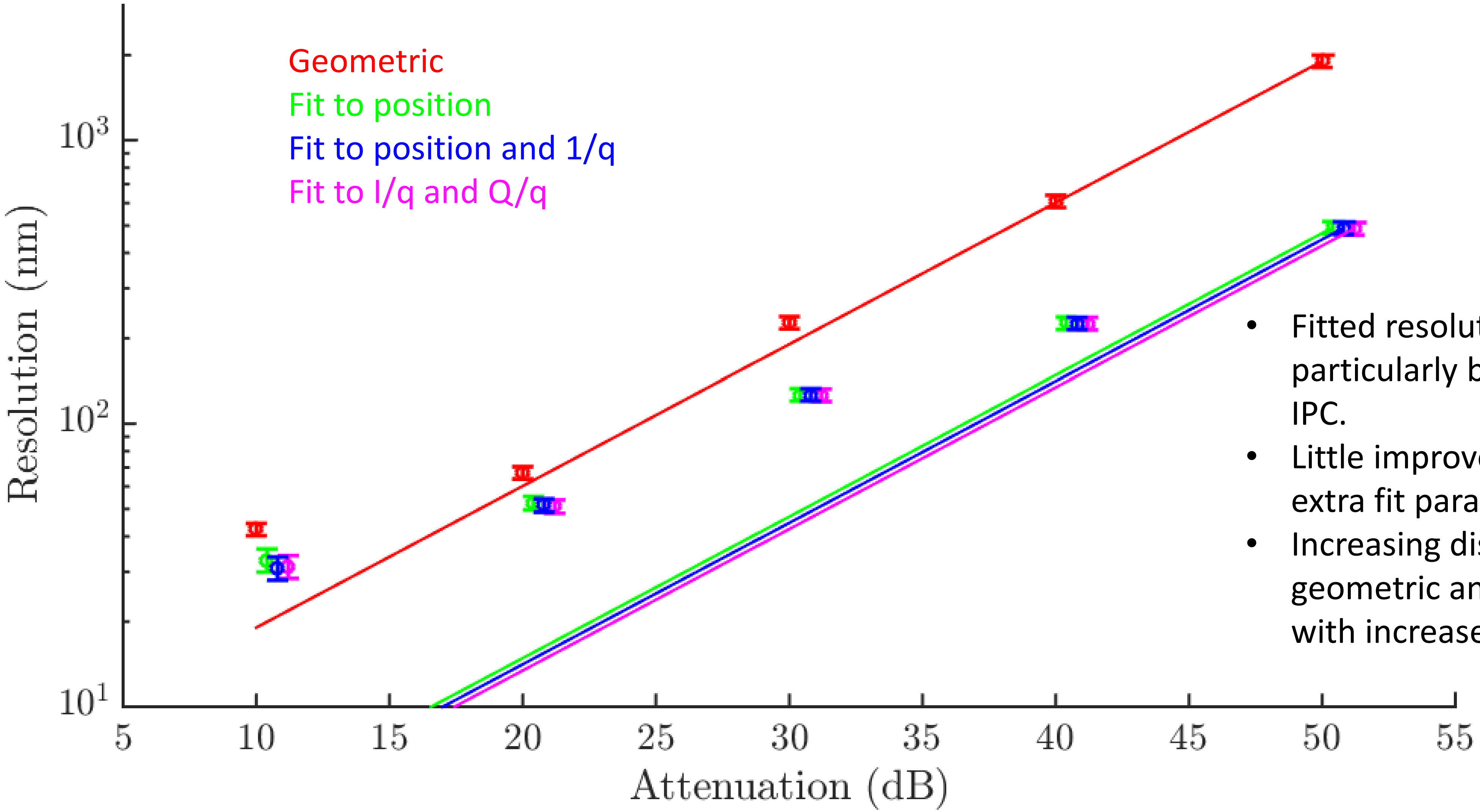
- Geometric method scaled better from 50 dB than fitting method.
- More improvement from fitting at higher attenuations.

IPB Attenuation Scan



- IPB shows better scaling with attenuation than the other BPMs.
- Disparity between geometric and fitting method does not increase significantly at higher attenuations, as was the case for the other two BPMs.

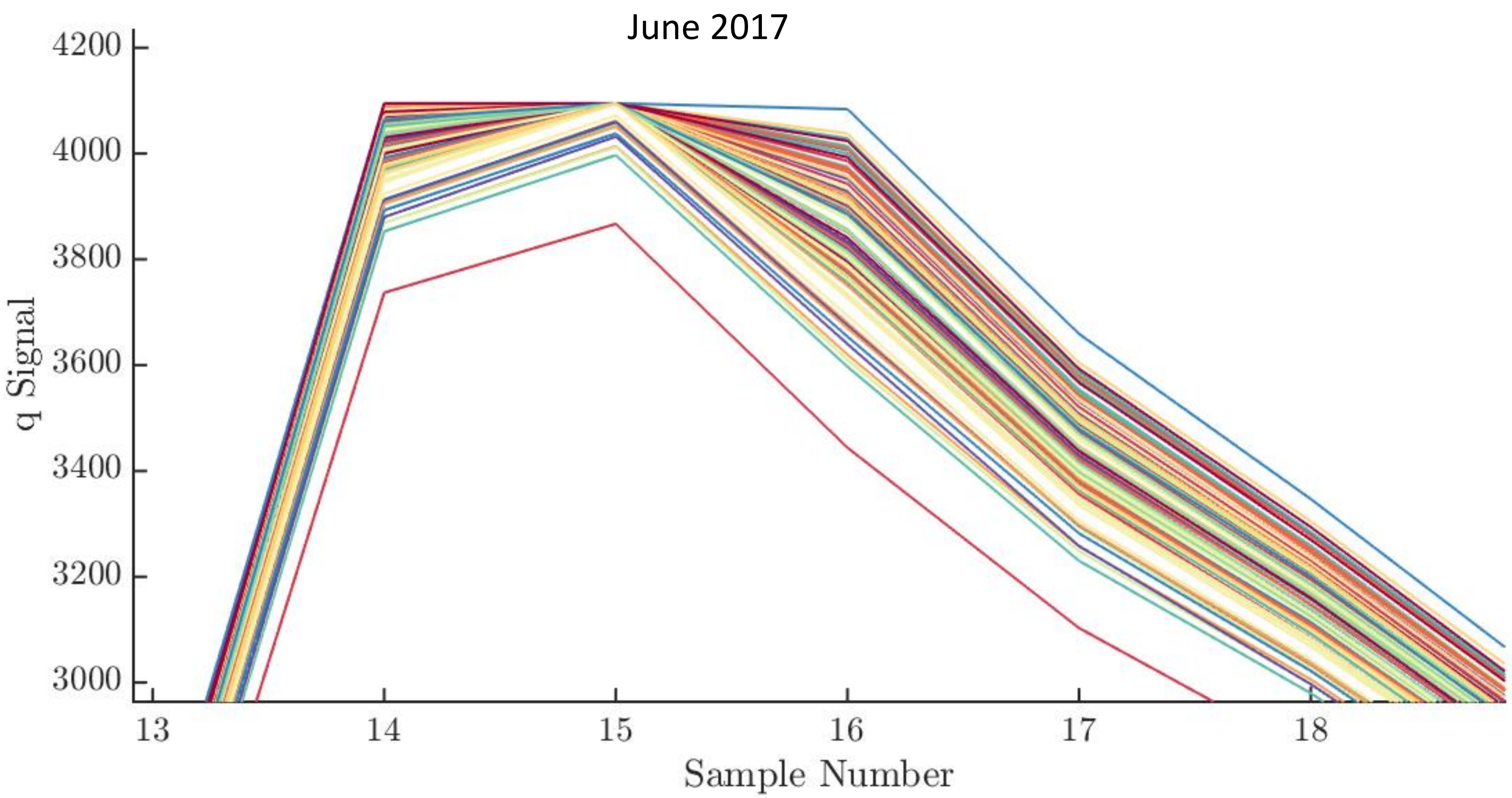
IPC Attenuation Scan



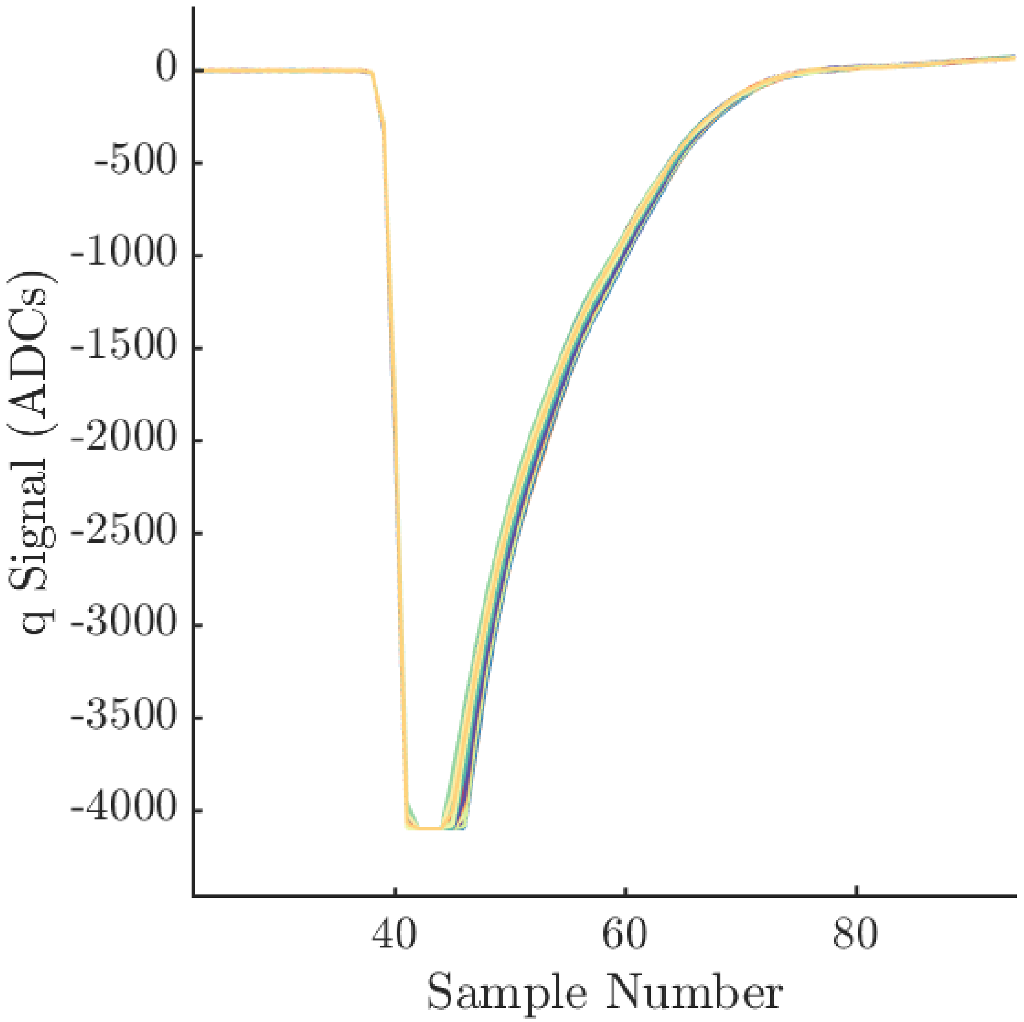
- Fitted resolutions scale particularly badly from 50 dB for IPC.
- Little improvement from adding extra fit parameters.
- Increasing disparity between geometric and fitted resolutions with increased attenuation.

Thank you

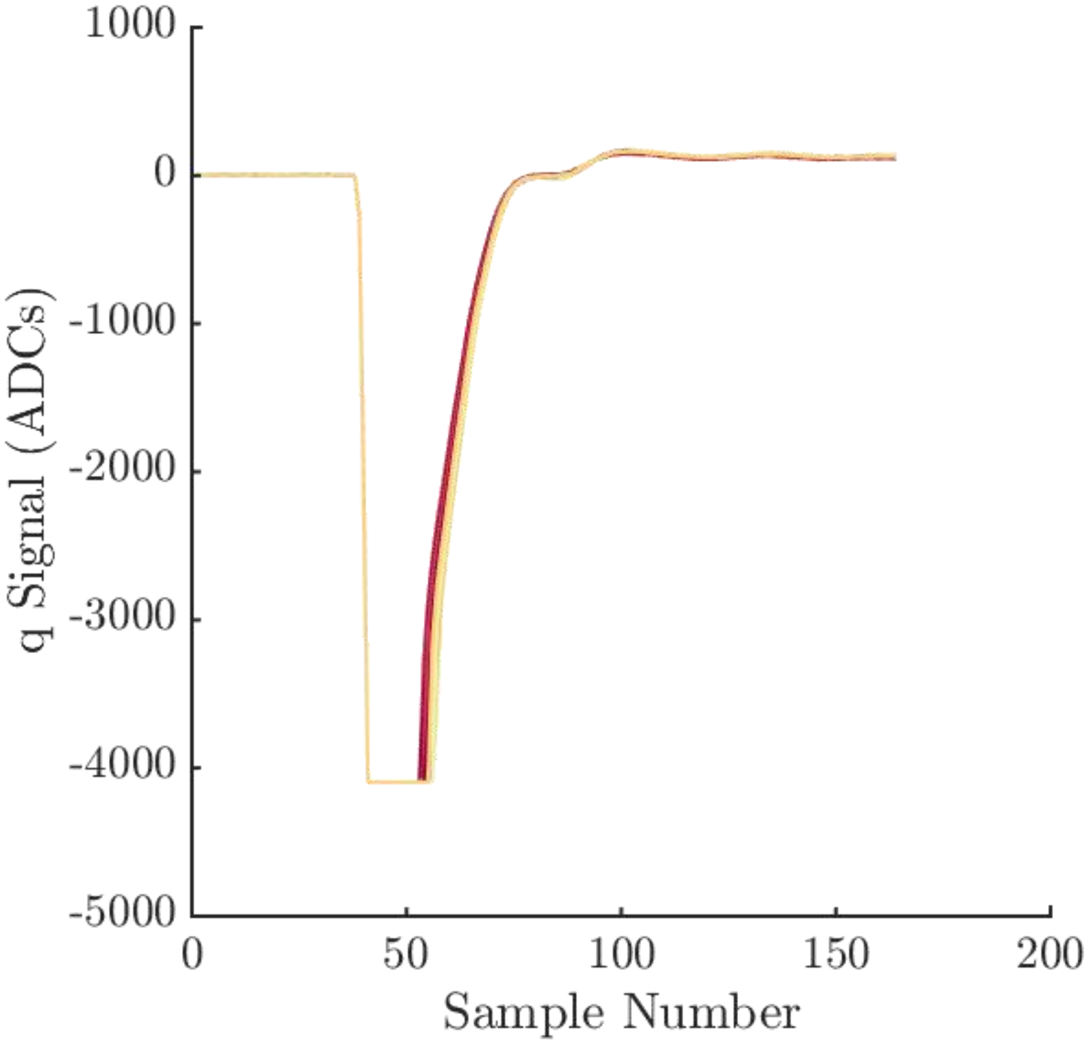
June 2017


June 2017
q Signal
4200
4000
3800
3600
3400
3200
3000
13
14
15
16
17
18
Sample Number

Feb 2018



0
-500
-1000
-1500
-2000
-2500
-3000
-3500
-4000
40
60
80
Sample Number
q Signal (ADCs)



1000
0
-1000
-2000
-3000
-4000
-5000
0
50
100
150
200
Sample Number
q Signal (ADCs)