Cavity BPM Calibration Stability

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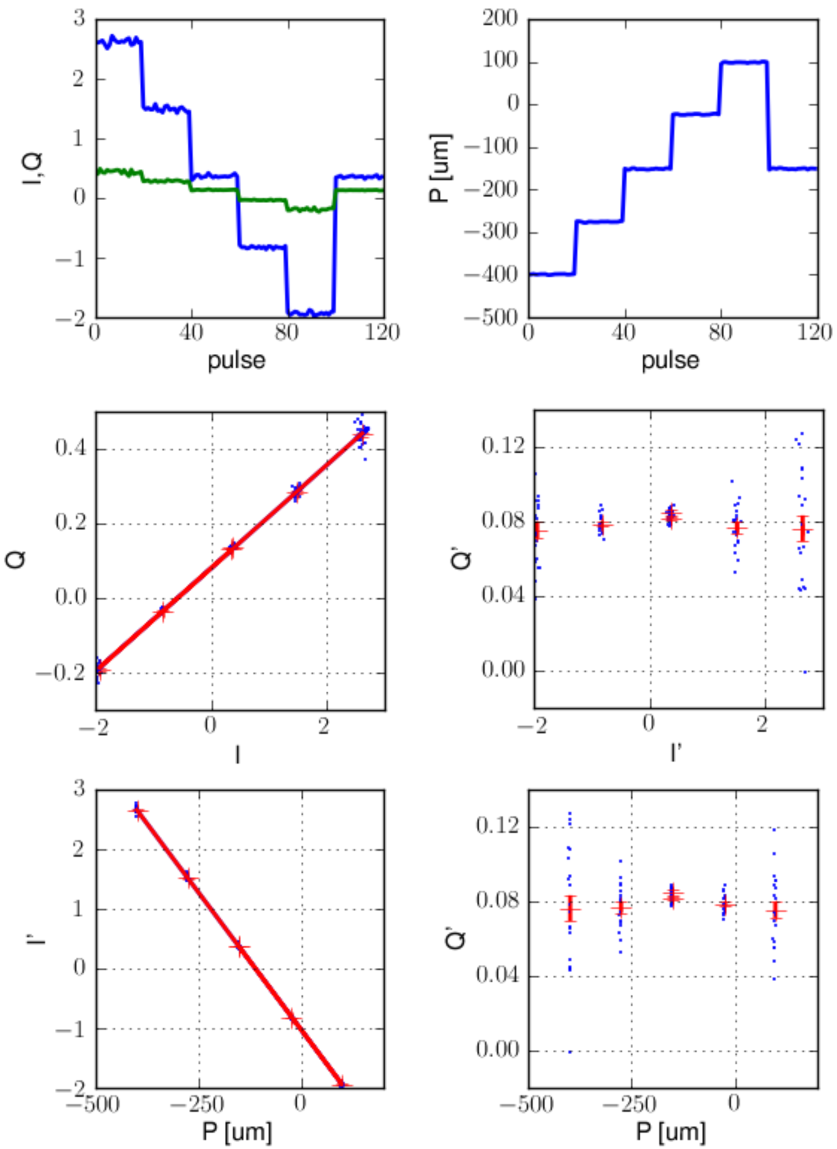
Calibration Procedure



1. Scan beam position in BPM using closed orbit bump or mover and record BPM I/Q signals

2. Fit Q against I in order to determine phase θ_{IQ} that corresponds to pure position information then rotate to I' and Q'

3. Fit I' against mover position to determine position scale

Last Year (IPAC'10)

Calibration scales were varying by ≈15%

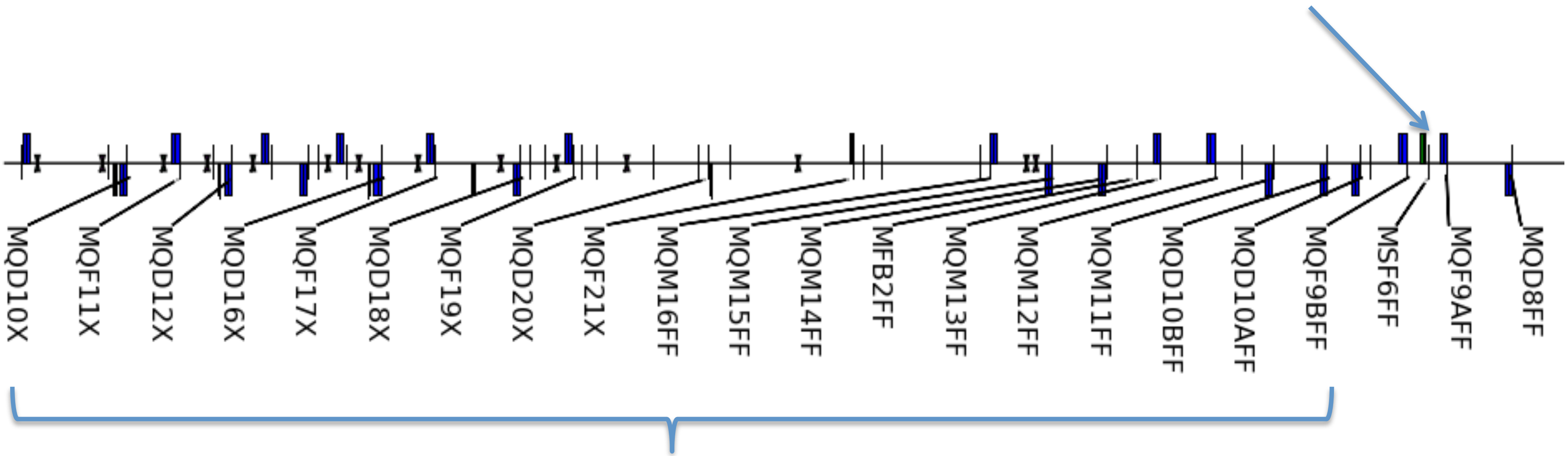
BPM	Week 1	Week 2	Week 3
MQD10X	1800.35	-	1883.3
MQD16FF	138.3	111.9	111.1
MQD10BFF	929.9	906.4	1254

Phases of BPM signals corresponding to position were varying by ~0.1 radian because of trigger timing variations

BPM	Week 1	Week 2	Week 3
MQD10X	-0.565	-	-0.676
MQD16FF	-0.814	-0.749	-0.801
MQD10BFF	-0.503	-0.427	-0.610

Jitter Subtraction

Usual beam position scan in BPM being calibrated



The uncalibrated signals from the BPMs upstream are used to remove the effect of the jitter from the signals in the BPM being calibrated, leaving just the variation due to the position scan

Three Methods

Conventional:

•Fits are made directly to the processed BPM signals with no jitter subtraction

Jitter Subtracted:

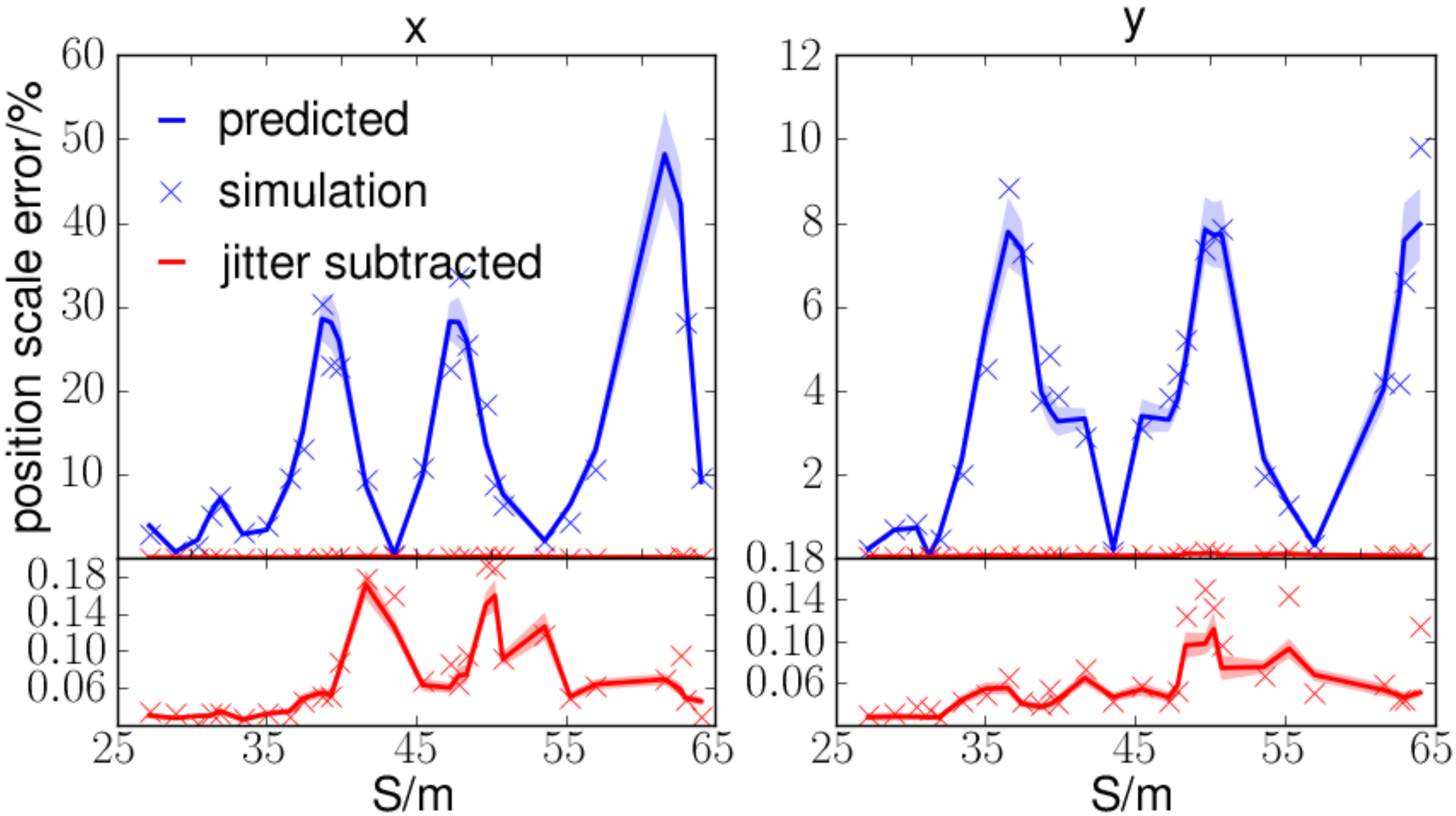
• 100 pulses of orbit data are recorded at the start of each calibration before the position scan
• The jitter can then be removed from the calibration data
• The same fitting is used to determine the calibration constants

SVD Based Calibration:

• Signals from the BPM being calibrated are regressed against the upstream BPM signals as well as the mover/bump position
• The calibration constants are determined directly from the regression coefficients that correspond to the move/bump

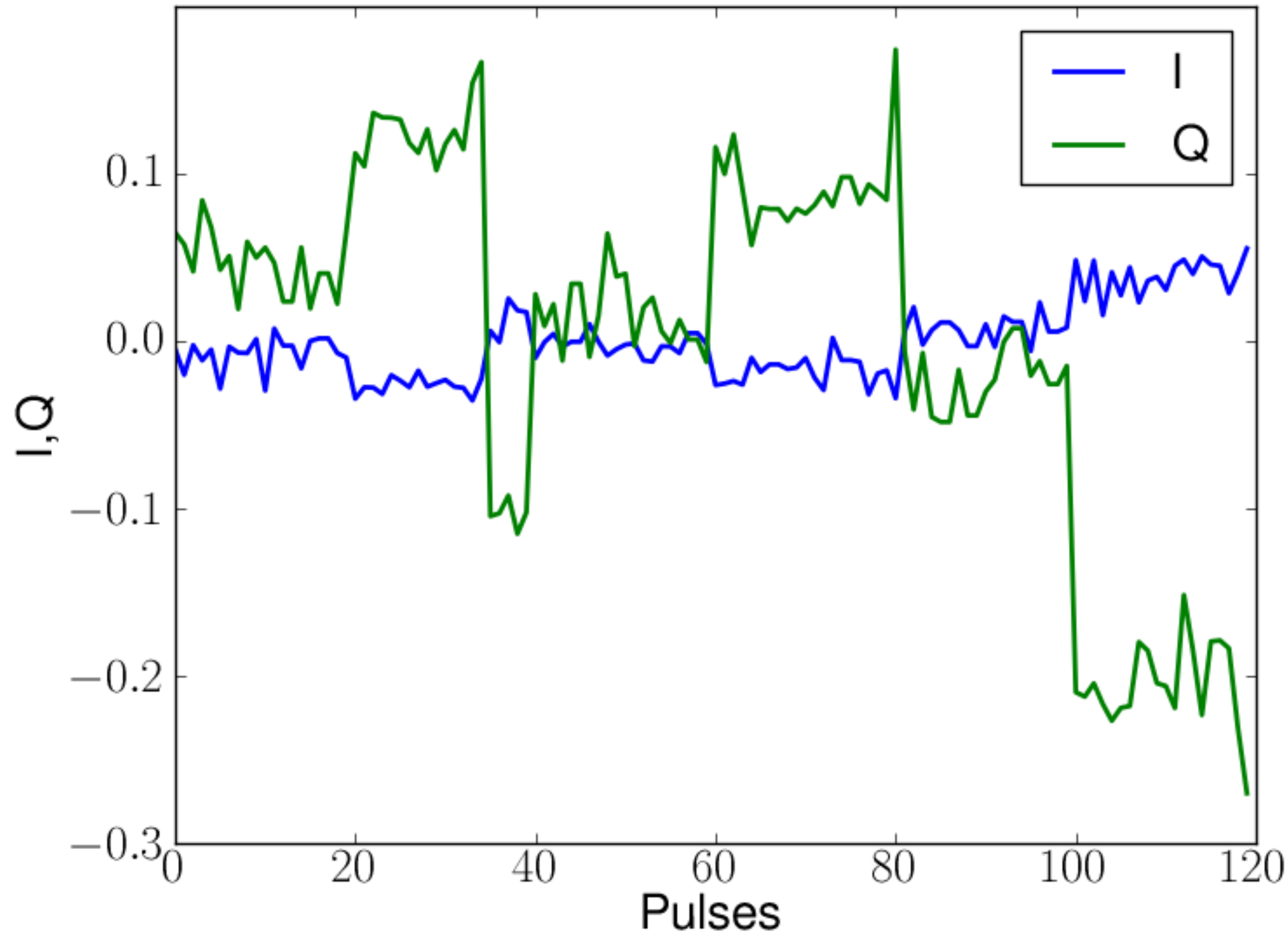
Simulation

Calibrations of BPMs on movers were simulated with and without jitter subtraction. The results are compared with the error expected from the amount of beam jitter.



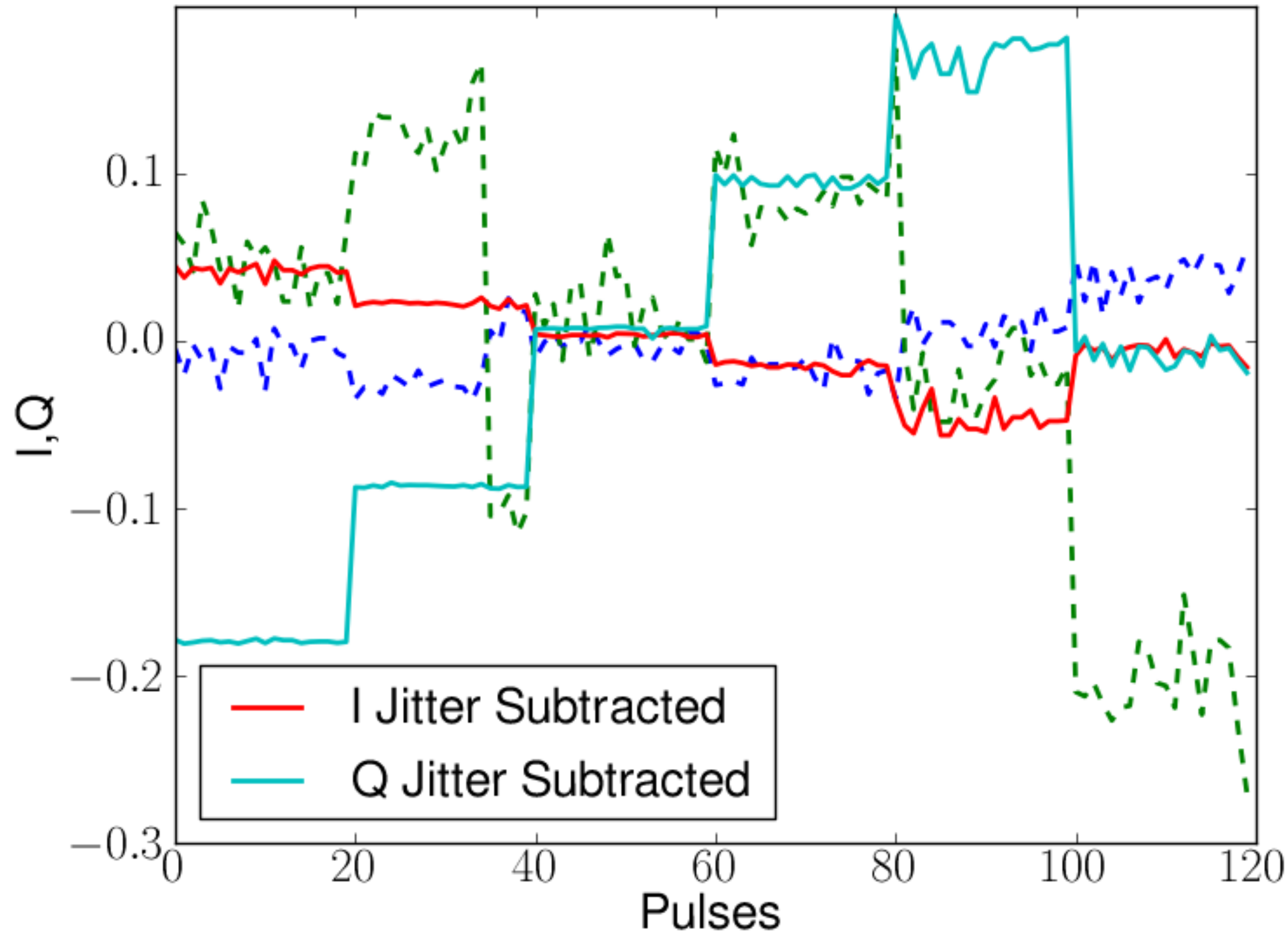
Bad Calibration

During a parasitic calibration, the beam motion is sometimes greater than the size of a calibration step



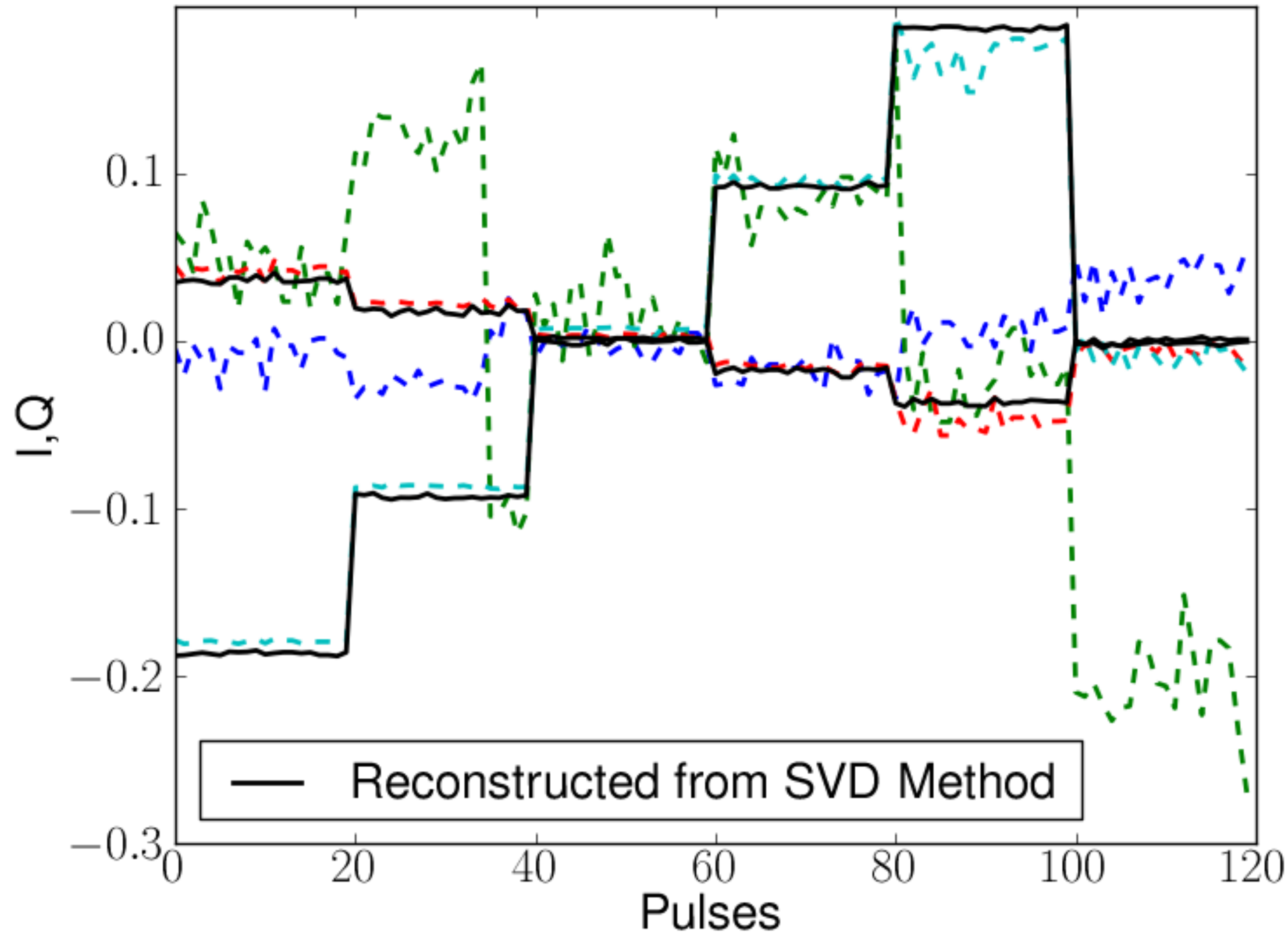
With Jitter Subtraction

Jitter subtraction removes these big beam moves as well as the smaller jitter so that the calibration steps are easily resolved



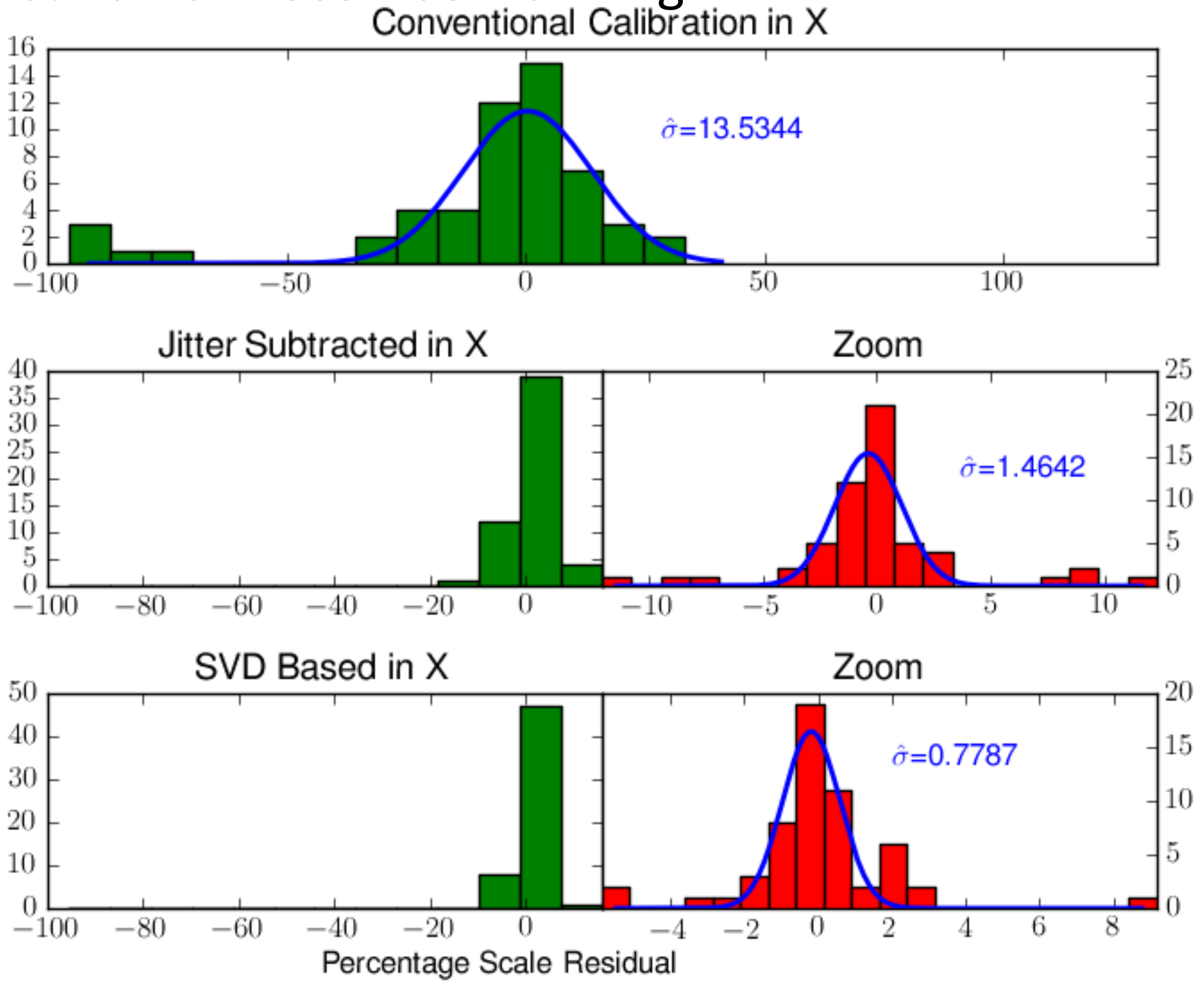
Reconstructed from SVD Method

The SVD based method is even less sensitive to the beam motion and removes even more



Calibration Scales (Dec 2011)

Repeat calibrations of nearly all the BPMs on movers were taken in the first half of December running



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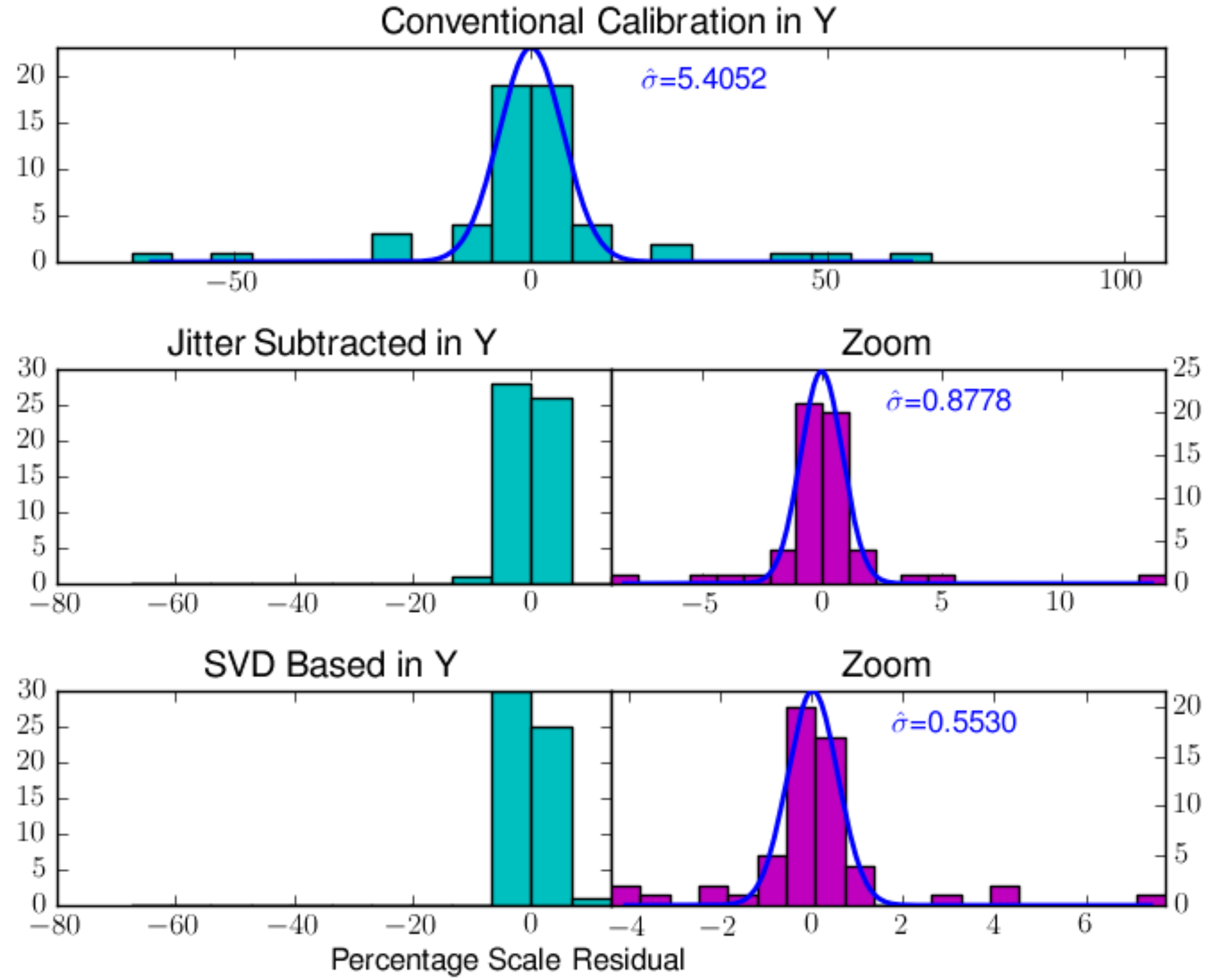
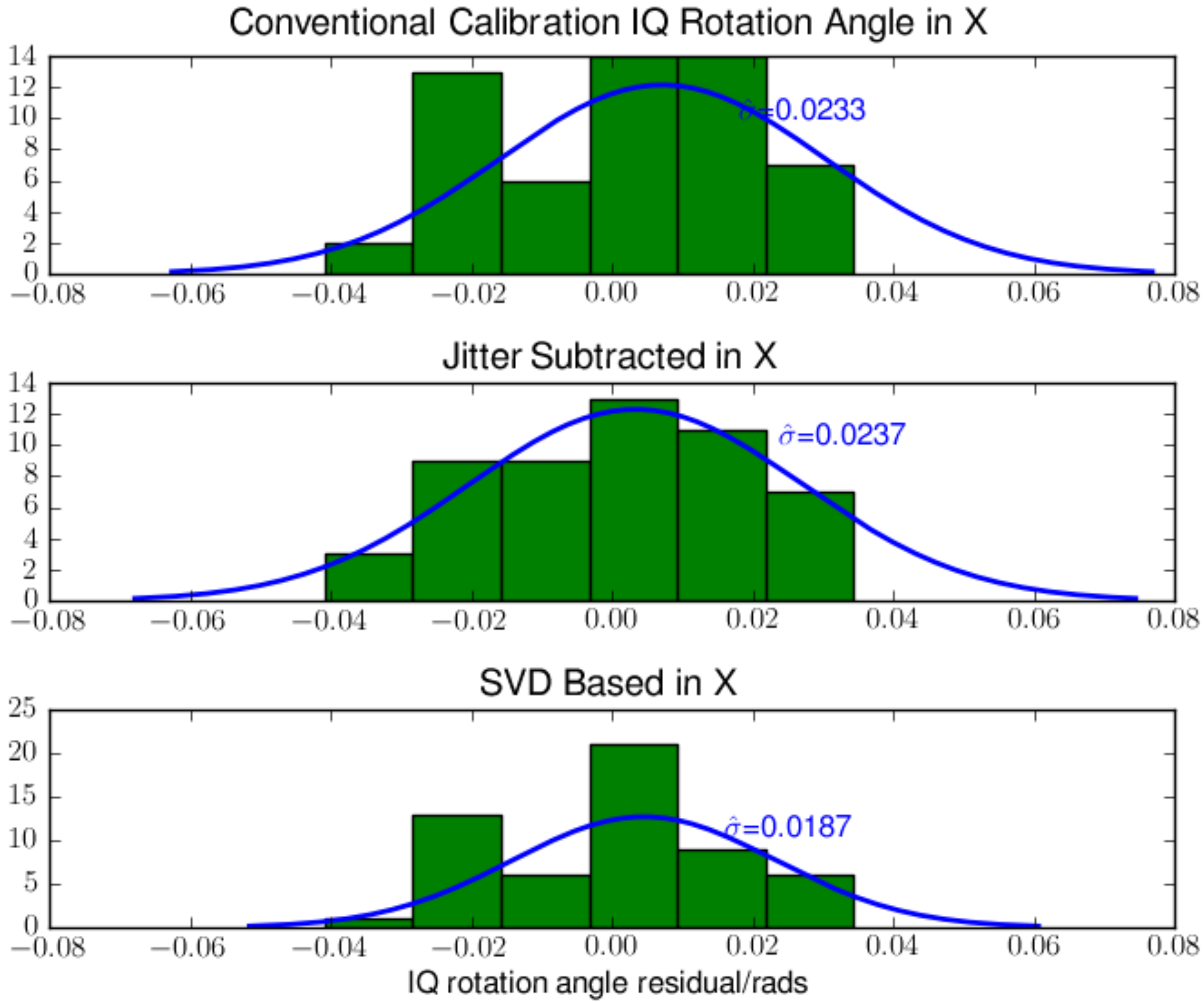


I/Q Phase (Dec 2011)

Trigger timing effect corrected, so BPM phase is much more stable during normal operation



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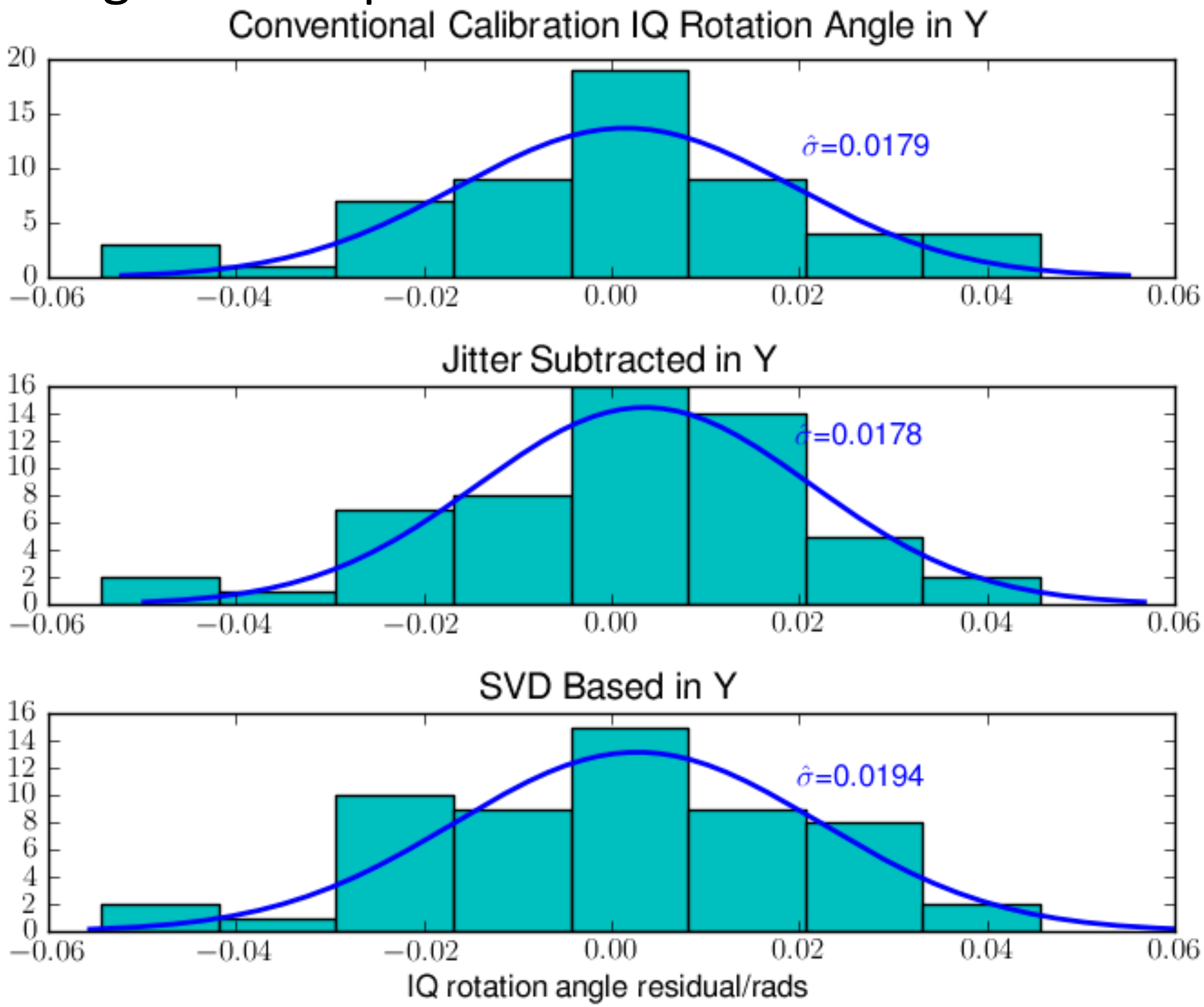

Summary

	σ of Fitted Gaussian Peak		
Parameter	**Conventional**	**Jitter Subtracted**	**SVD Based**
Scale X/%	13.53	1.46	0.78
Scale Y/%	5.41	0.88	0.55
Angle X/rads	0.0233	0.0237	0.0187
Angle Y/rads	0.0179	0.0178	0.0194

Errors are still larger than from idealised simulation that includes no large beam moves and no variation in BPM response

Bump Calibrations

Readings from stripline BPMs were used to subtract the jitter from the upstream BPMs calibrated using closed orbit bumps. This was tested on MQF11X in y.

	Standard Deviation (STD) in Scale		STD in Phase
Method	µm	%	rads
Conventional	119.6	8.68	0.00298
Jitter Subtracted	118.8	8.36	0.00223
SVD Based	100.9	7.19	0.00251

Conclusion

- Calibration scales are now stable to within 1% in most of the beamline
- BPM phase is now stable to below 0.02 radians
- Calibration is now much more robust
- Jitter subtracted bump calibration needs further testing