FONT5 @ ATF2: Status Update

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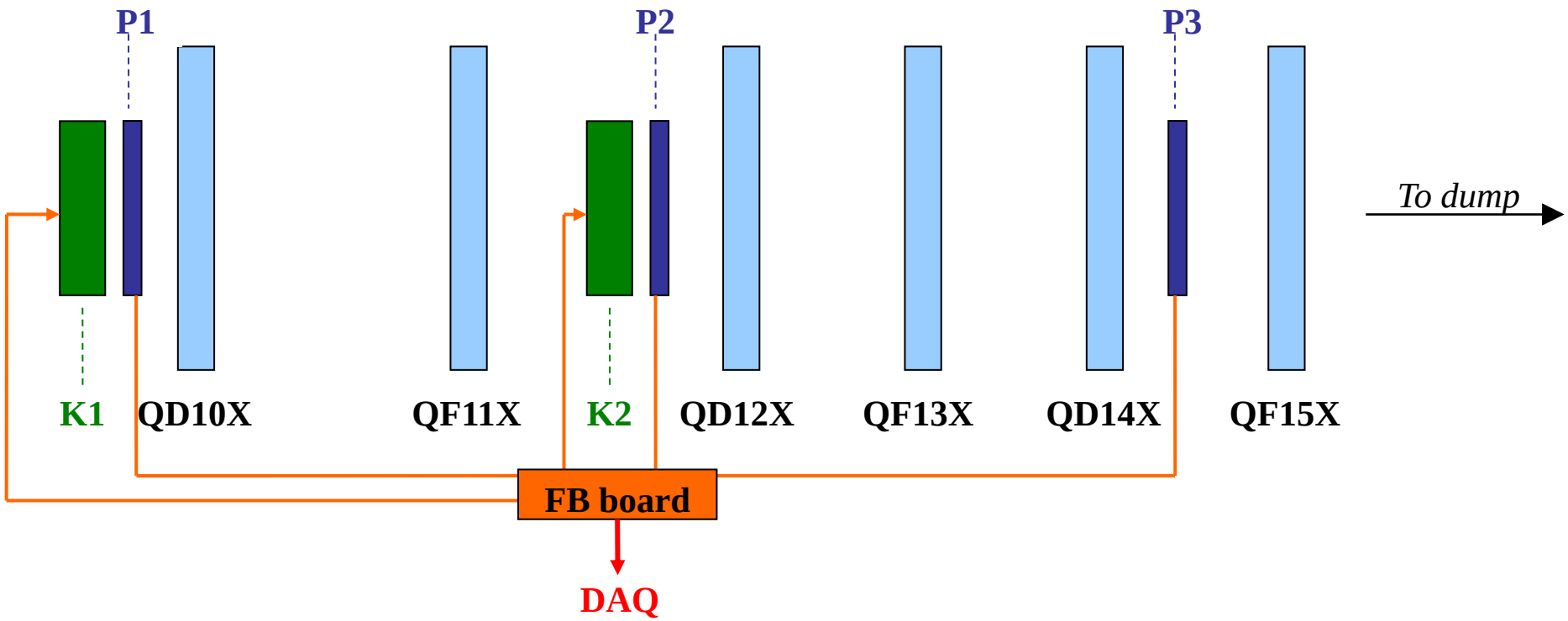
(on behalf of FONT group)

10th ATF Project Meeting

Abridged Summary – December 2009

- **Initial operation of first feedback loop (P2-K1)**
- **Large jitter and lack of correlation between bunches are major problems (sometimes jitter is small and well correlated!)**
- **Resolution consistently measured at around 3 microns**
- **A lot of progress made since then!**

Layout of FONT upstream feedback system



•Position and angle feedback: 3 stripline BPMs, 2 stripline kickers

• Ideal: Loop1 (P2-K1) corrects position (angle) at P2 (P3); Loop 2 corrects angle (position) at P2 (P3).

•As phase advance is not exactly $\pi/2$ between pairs of kickers/BPMs, both loops coupled

- kicker drive signals linear function of both P2 and P3 measurements.

•P3 – K1 longest latency path is system

Plans for Early 2010

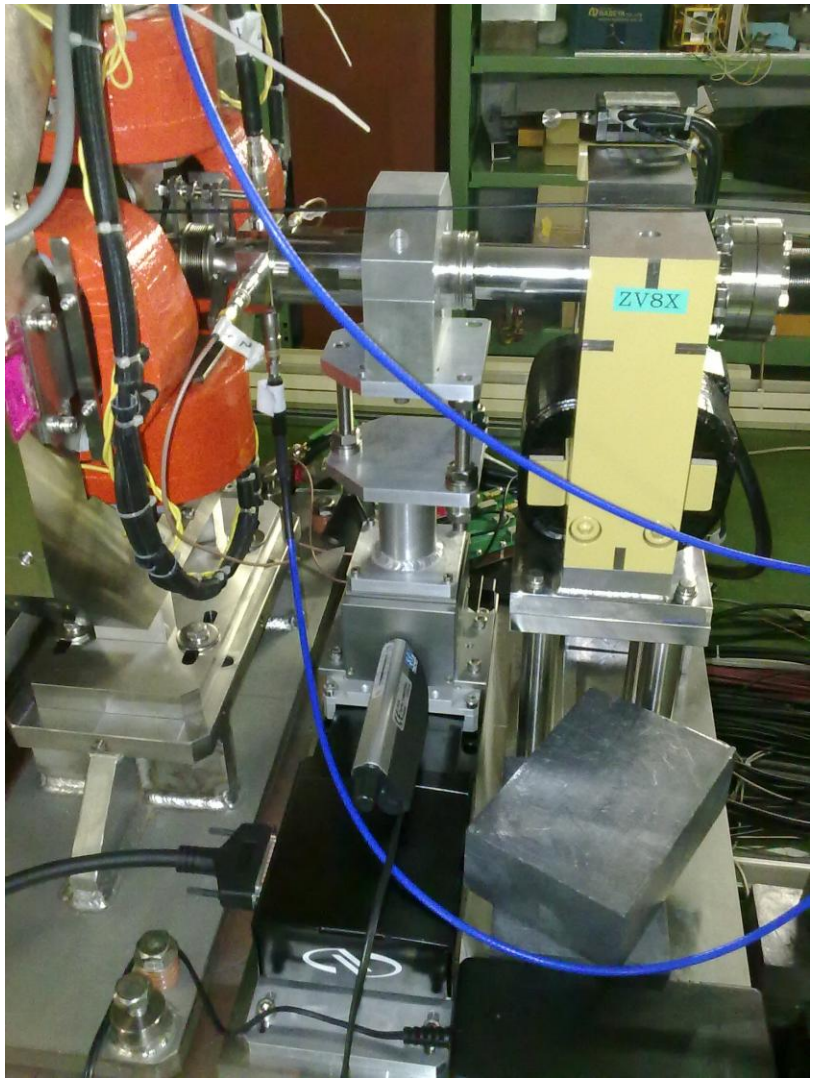
- Demonstrate good performance with feedback loop 1 (P2-K1)
- Demonstrate feedback with loop 2 (P3-K2)
- Investigate coupling between feedback loops and operate both loops uncoupled/coupled
- Understand source of instability (in DR?) affecting multi-bunch jitter
- Reduce noise / improve resolution (1 micron goal)

Shift Summary – Spring 2010

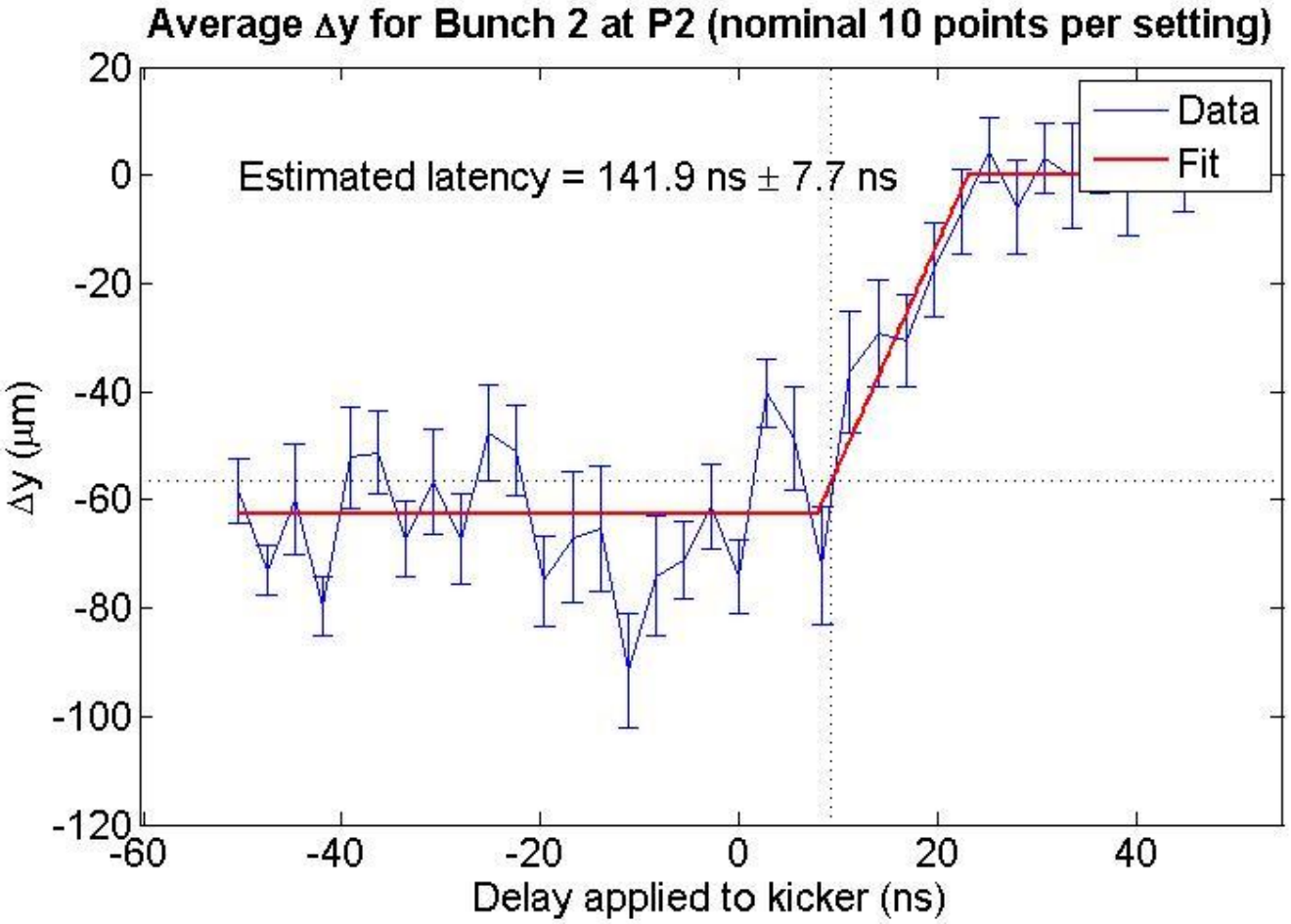
- 14 shifts in total Feb - June
- Feb 15 – 19: BC, RA, DB, GC
  - 2 shifts: Ran feedback loop1
- Feb 22 – 26: BC, RA, DB, GC
  - 2 shifts: Installed intermediate amps, ran feedback loop2
- Apr 5 – 9: BC, RA, DB
  - 2 shifts: Latency measurements P2-K1, P3-K2, and P3-K1. Loop 2 feedback studies.
- Apr 12 – 16: BC, RA, DB
  - 2 shifts (1 cancelled): Coupled/Uncoupled two loop feedback studies
- Apr 19 – 23: BC, RA, DB
  - 2 shifts: Interleaved coupled feedback studies (instrumented downstream stripline MQF15X for second shift)
- May 10 – 14: BC, RA, DB, JRL, CP
  - 3 shifts: Skew quad scans, corrector/mover calibrations; Interleaved coupled loop feedback; feedback gain scans; Ballistic feedback; LO phase variation studies
- May 17 – 21: BC, RA, DB, JRL
  - No shifts: ATF2 continuous tuning week
- May 31 – Jun 4: RA, DB, JRL, GC
  - 2 shifts: Instrumented X & Y processors for P1, P2, P3. Single bunch and 3-bunch resolution studies; coupling studies and skew quad scans.
- Jun 14 – 18: RA, DB
  - Fast kicker studies: first attempt to measure beam properties with long(er) bunchtrain

Hardware Changes

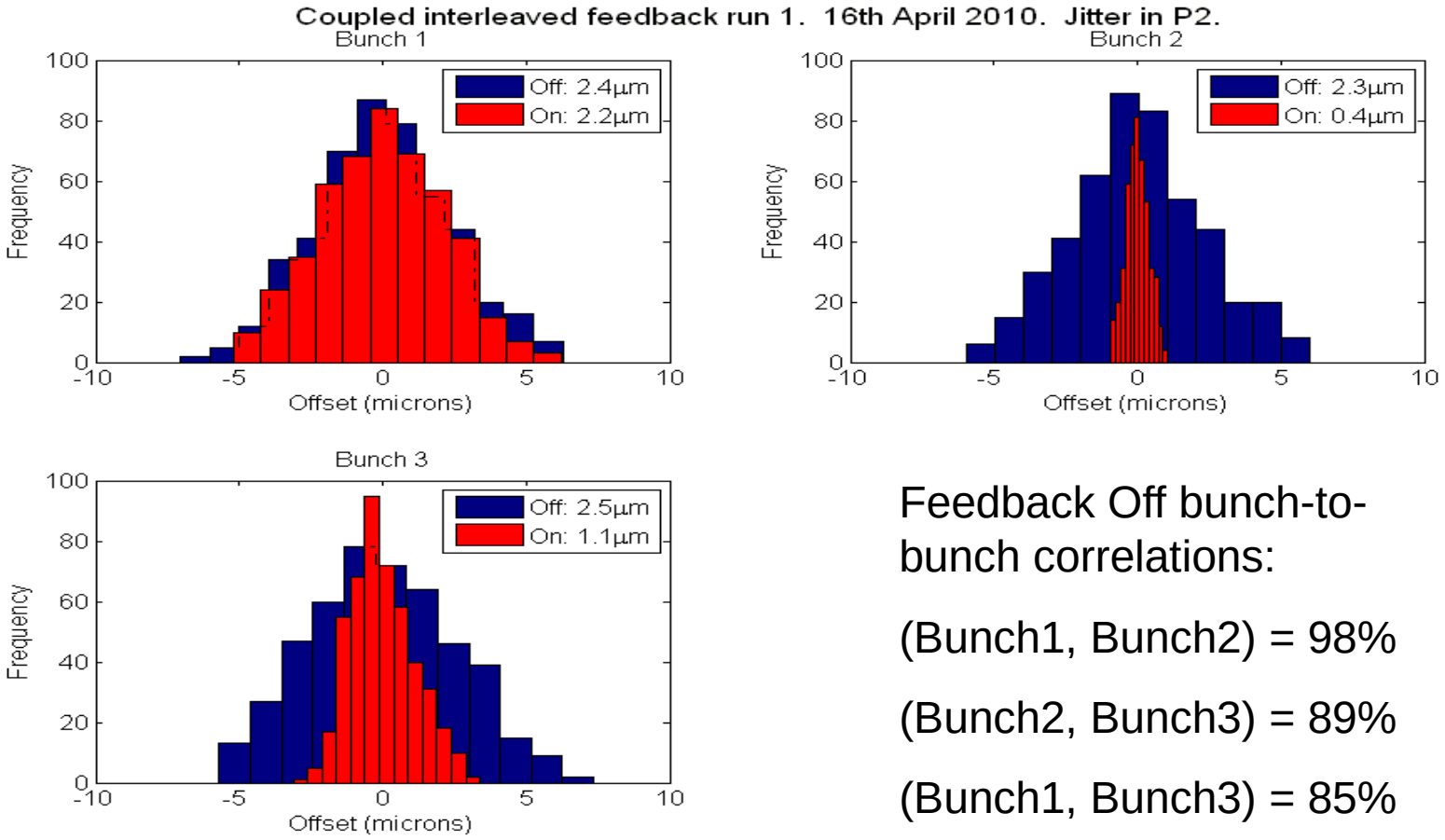
- No major changes to hardware in feedback loop:
  - New connectors for kickers made, amplifiers for loop 2 installed; low noise amplifiers added before digital board to increase sensitivity; various changes to cables; shielding etc; swapping of processors/BPMs
- BPM mover systems from Valencia group installed at P1, P2 and P3 beginning of April.
  - Travel: +/- 2 mm in Y; +/- 2.5 mm in X
  - Zero the signal in BPMs without moving the beam
  - Currently operational and being used!



Latency estimate (worst case P3 – K1)



Feedback Performance on Jitter @ P2: Coupled Interleaved Run (16 April)



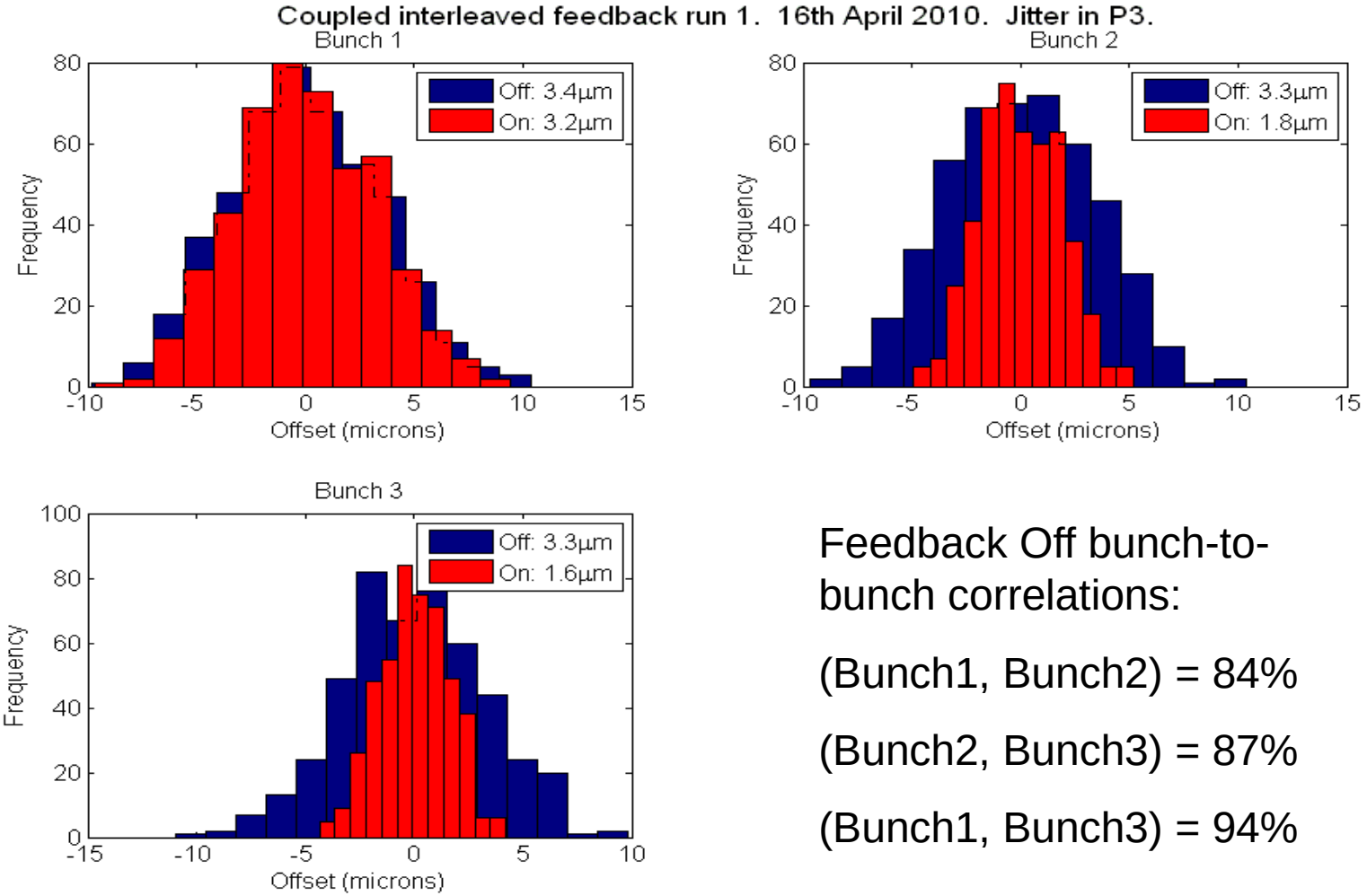
Feedback Off bunch-to-bunch correlations:

(Bunch1, Bunch2) = 98%

(Bunch2, Bunch3) = 89%

(Bunch1, Bunch3) = 85%

Feedback Performance on Jitter @ P3: Coupled Interleaved Run (16 April)



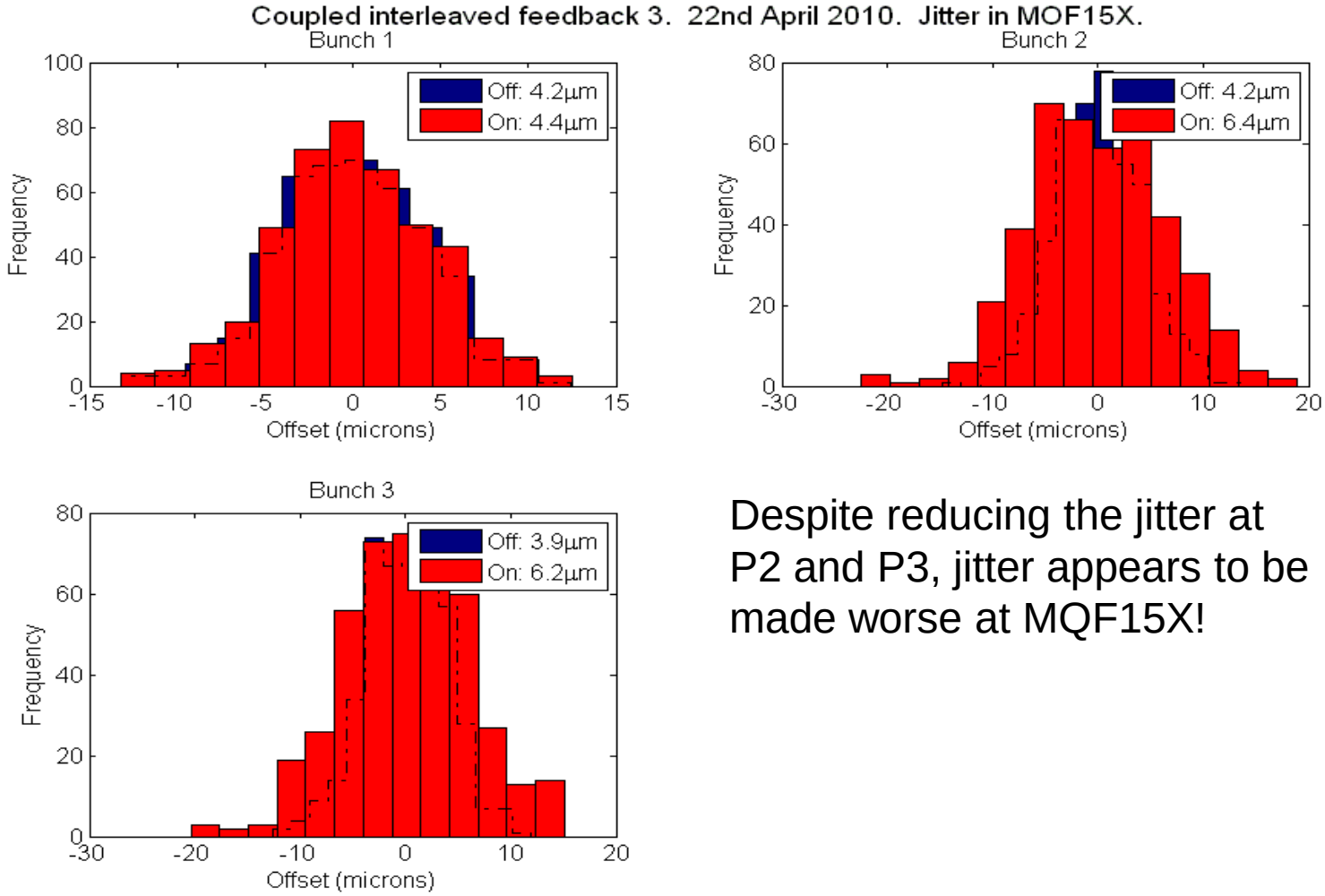
Feedback Off bunch-to-bunch correlations:

(Bunch1, Bunch2) = 84%

(Bunch2, Bunch3) = 87%

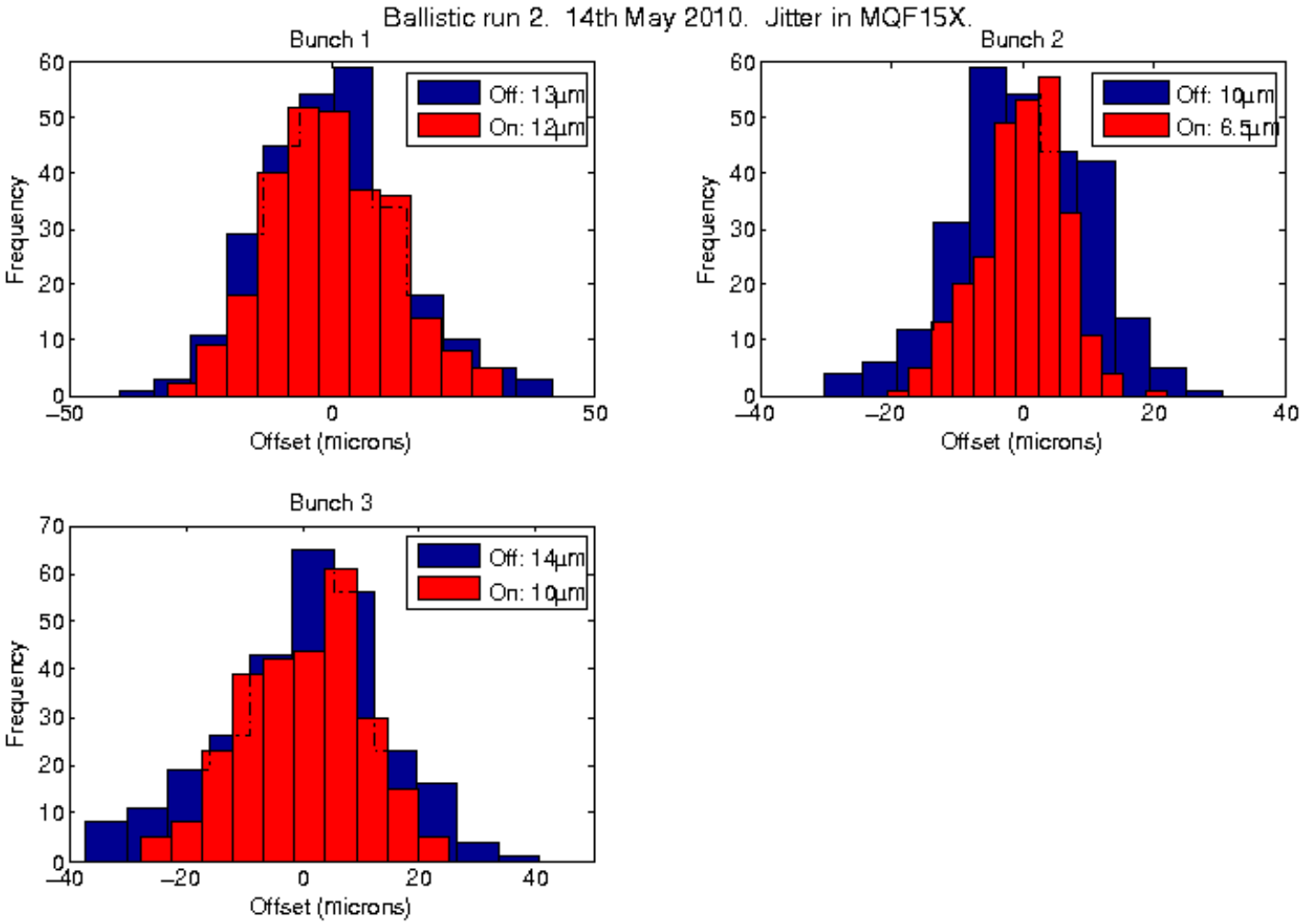
(Bunch1, Bunch3) = 94%

Feedback Performance on Jitter @ MQF15X: Coupled Interleaved Run (22 April)

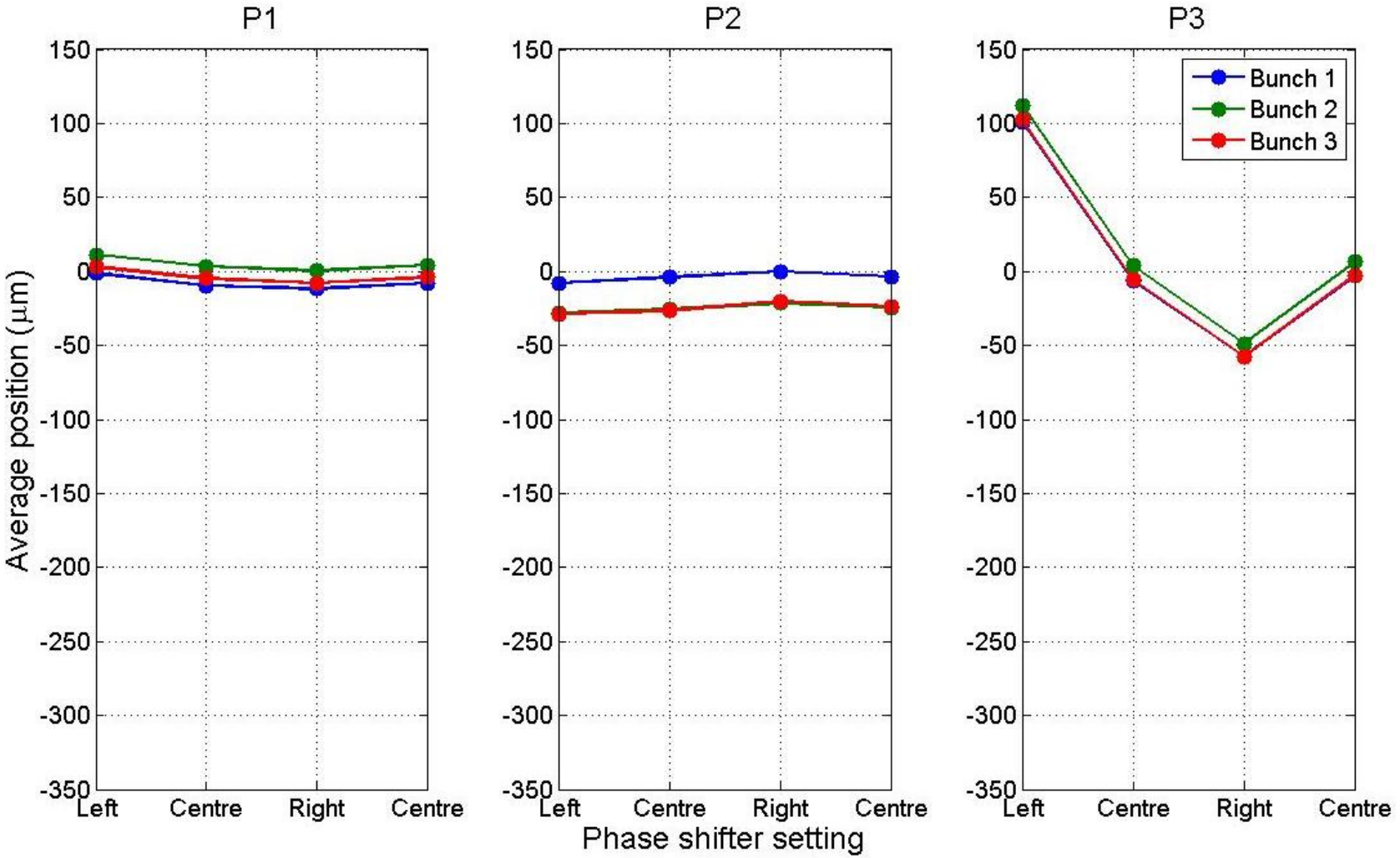


Despite reducing the jitter at P2 and P3, jitter appears to be made worse at MQF15X!

MQF15X - Ballistic



LO phase variation investigations: +/- 9 degrees of 714 MHz (14 May)



BPM resolution/LO phasing effects

- Intermediate amplifiers (17 dB) added in Feb to boost signal levels at ADCs in hope of increasing s/n.
- FB results indicate resolution must be < 0.4 um (stabilising system output at 1 BPM)
- Using 3-BPM method to estimate resolution with P1, P2, P3 shows resolution to be around 2-3 um , but indicates sub-micron resolution with P2,P3, MQF15X
- Know that phase variation in LO affects different processors in different ways, and current hypothesis is that phase variation introduces correlated noise between P2 and MQF15X which might result in ‘artificially good’ resolution with respect to the rest of the machine.

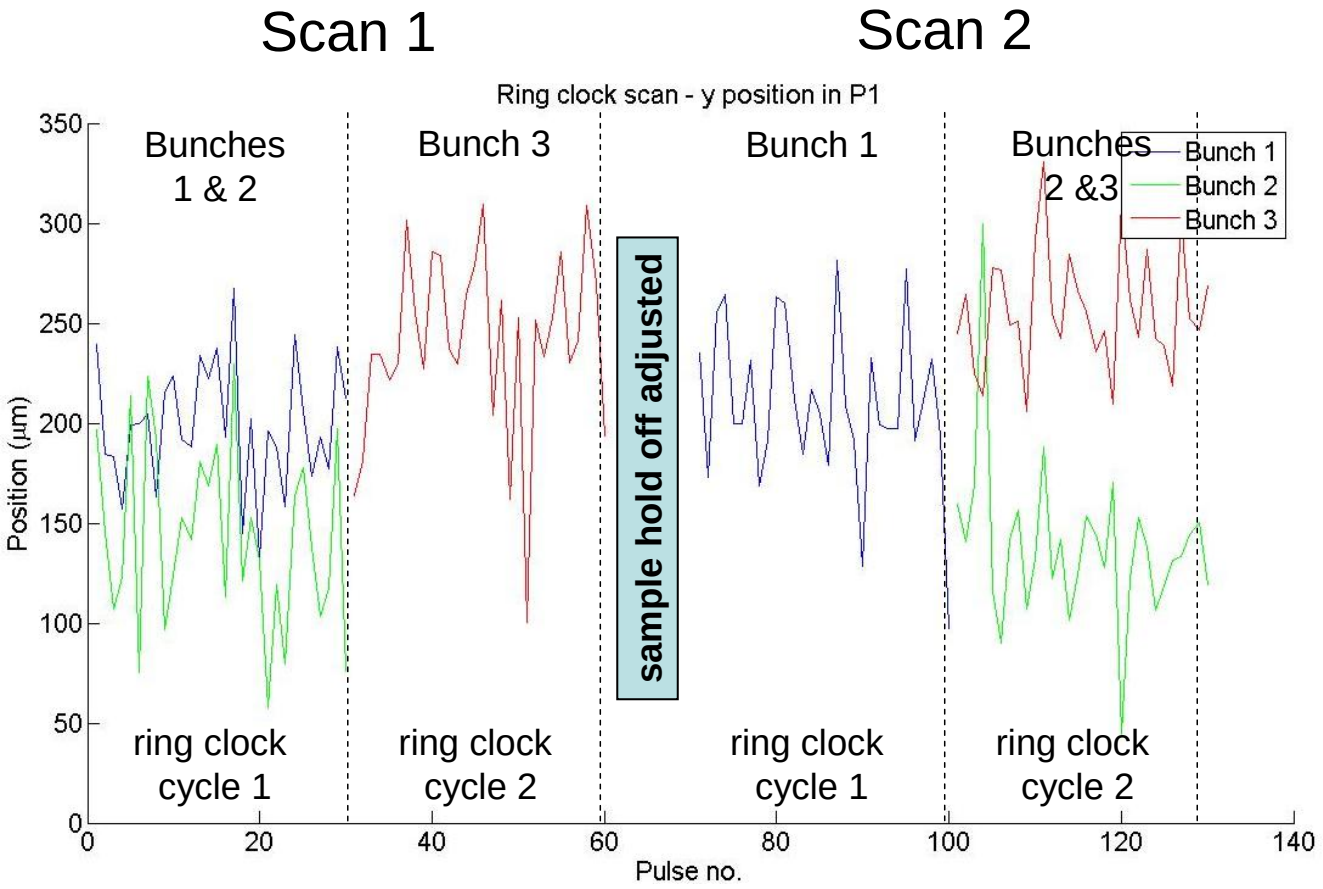
Beam Jitter Conditions / Multi-bunch effects

- Generally believed that large, uncorrelated bunch-to-bunch jitters observed in 2009 and Feb 2010 due to oscillations in DR (some evidence from XSR monitor)
- Earlier in Spring were planning to instrument stripline in DR for bunch-bunch resolution of jitter in DR
- Later in Spring observed excellent beam conditions in EXT (e.g. 16 April) : 2-3 um jitter in FONT region and >95% correlations
  - Believe we are benefitting from ATF2 emittance tuning efforts in DR and EXT.
- On some shifts, initial beam conditions bad but could revert to a previous setfile from a ‘good’ day, on other days could not do this (e.g. 2 – 3 June)

Jitter with Fast Ext Kicker

- Tested new firmware (and new DAQ software) to allow recording of 30-60 bunch train with 300 ns bunch spacing. (Old DAQ returns 1 ring clock period per trigger – 165 samples @ 2.8 ns).
- Unfortunately, unable to get UART/DAQ combination to work.

Fall back solution – modified old DAQ to scan through ring clock cycles to measure successive combinations of bunches (i.e. 1&2, 2 &3, etc)



Fast Extraction Kicker: Jitter & Bunch-to-bunch Correlations

	P1	P2	P3
Bunch 1	**36.4 μm**	**46.7 μm**	**53.2 μm**
Bunch 2	**43.4 μm**	**50.2 μm**	**61.5 μm**
Bunch 3	**39.7 μm**	**45.4 μm**	**52.3 μm**

	P1	P2	P3
Bunch 1 – Bunch 2	**45%**	**36%**	**45%**
Bunch 2 – Bunch 3	**-35%**	**-32%**	**-36%**

Not discouraging! Not enough data to make any concrete conclusions, but observed jitter and bunch-to-bunch correlations NOT inconsistent with those seen with double kicker system on a bad day (i.e. in absence of DR and EXT tuning).

Future Plans for upstream feedback system

- Get modified firmware/DAQ software for long bunch-train working on the bench in Oxford during summer
- Continue/finish FB studies with 3 bunches (depends somewhat on plans with fast extraction kicker)
- Understand how to ‘tune out’ multi-bunch oscillations
  - Instrumenting stripline in DR would give useful diagnostic
- Eliminate/minimise processor sensitivity to LO phase – better matching of stripline inputs; new processor design with better inherent s/n, latency, dynamic range.