FONT Results 2010

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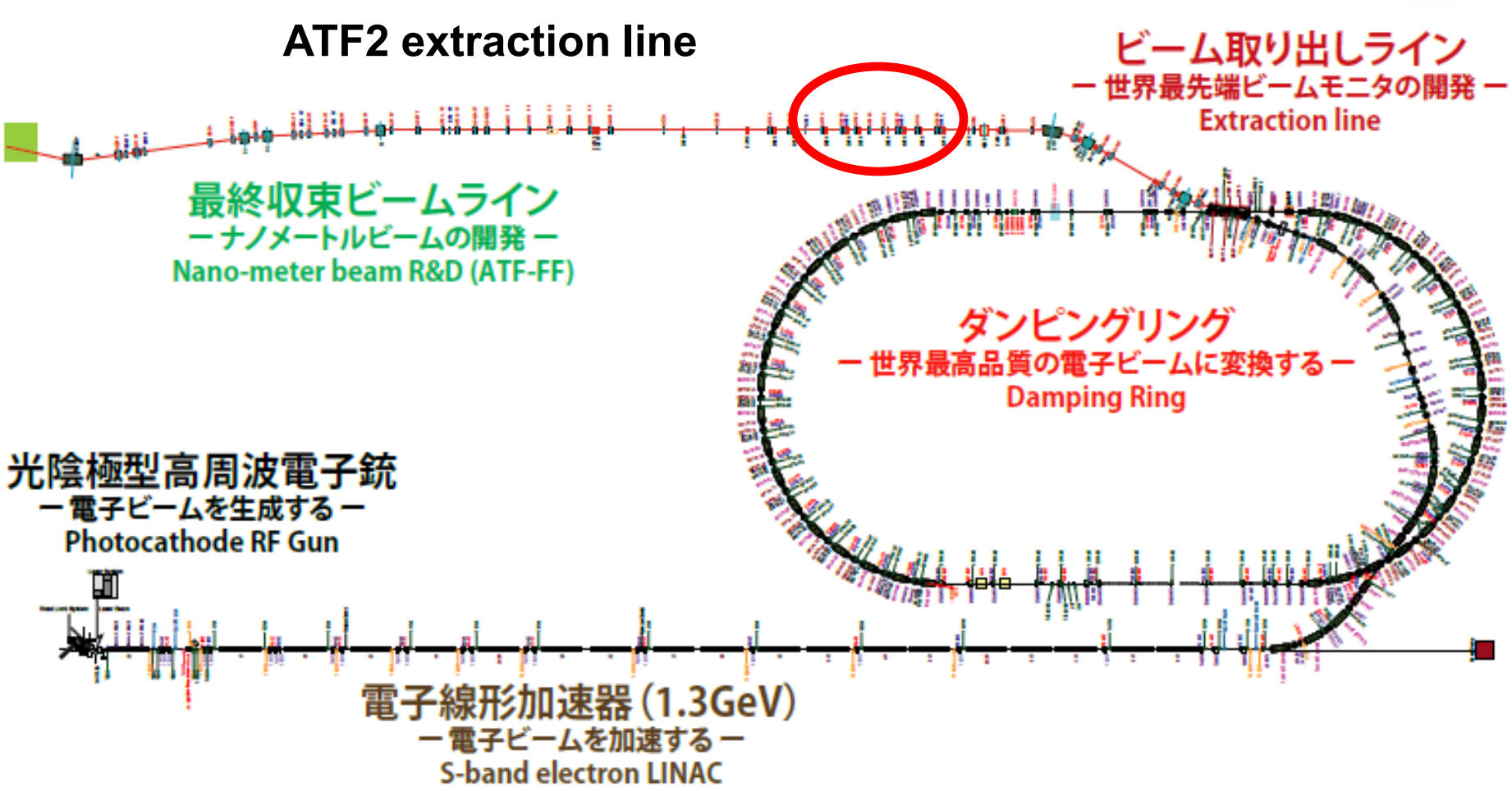
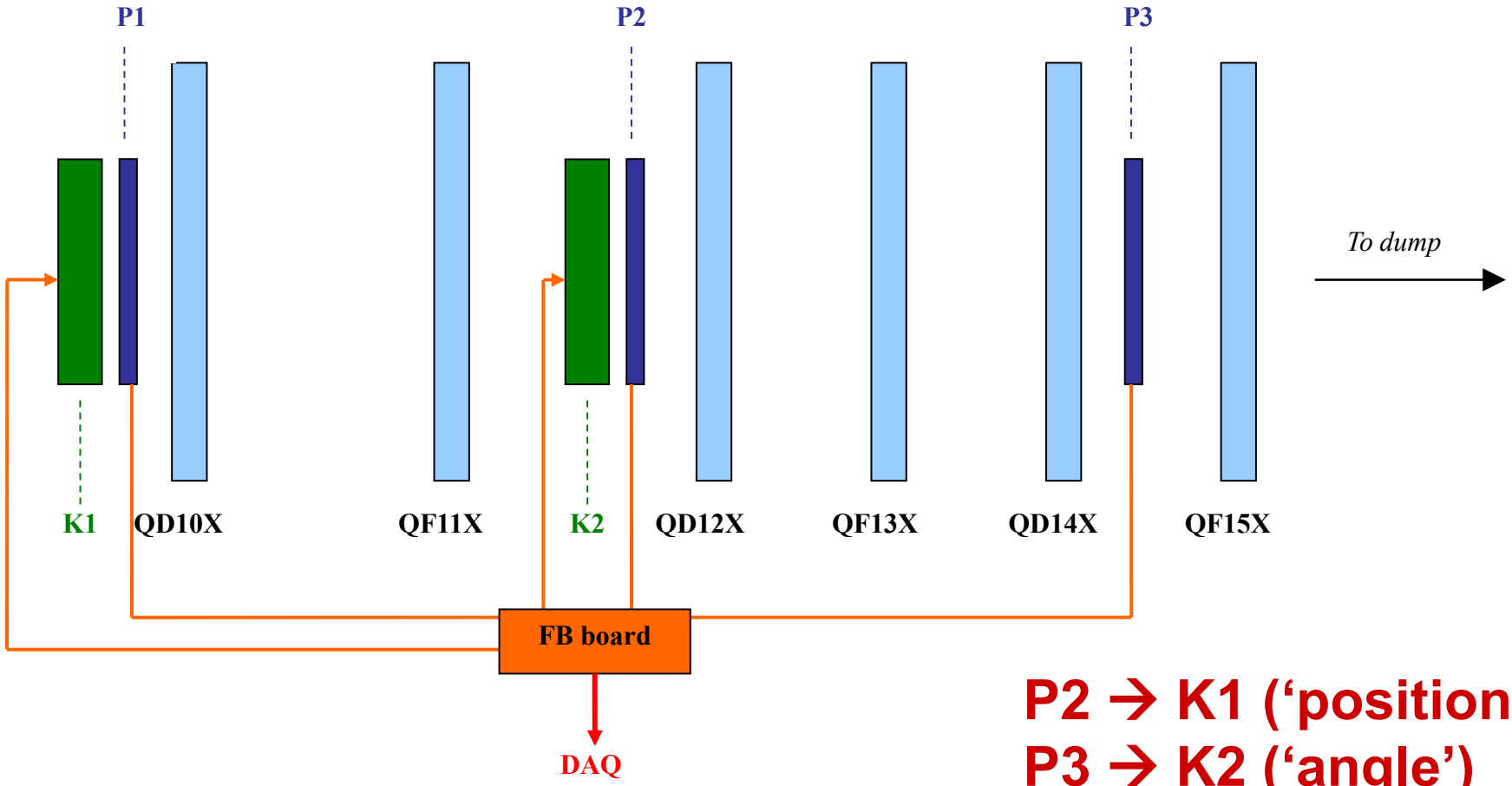
FONT5 location

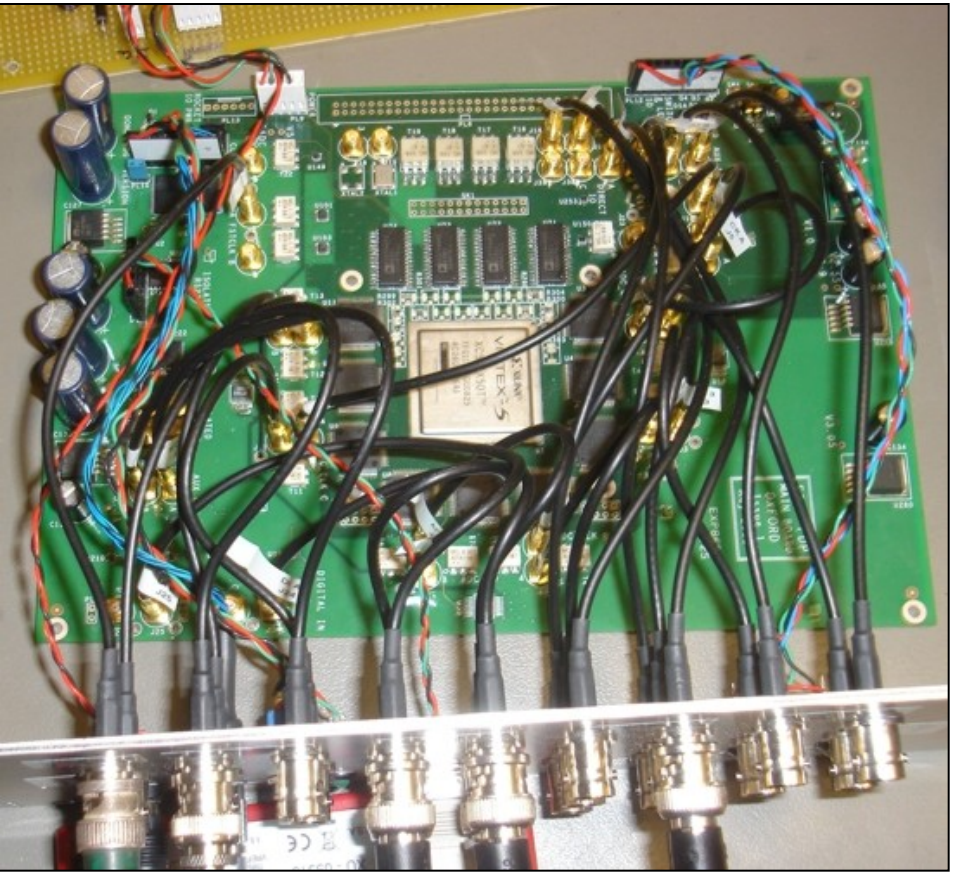


FONT5 setup



P2 → K1 ('position')
P3 → K2 ('angle')
P3 → K1
P2 → K2

FONT5 digital FB board



Xilinx Virtex5 FPGA

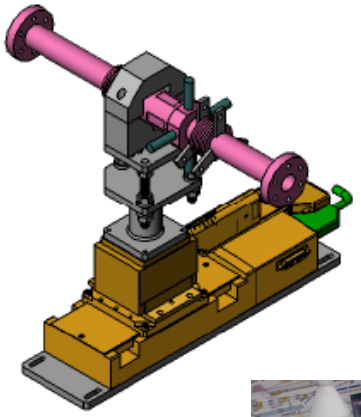
9 ADC input channels (TI ADS5474)

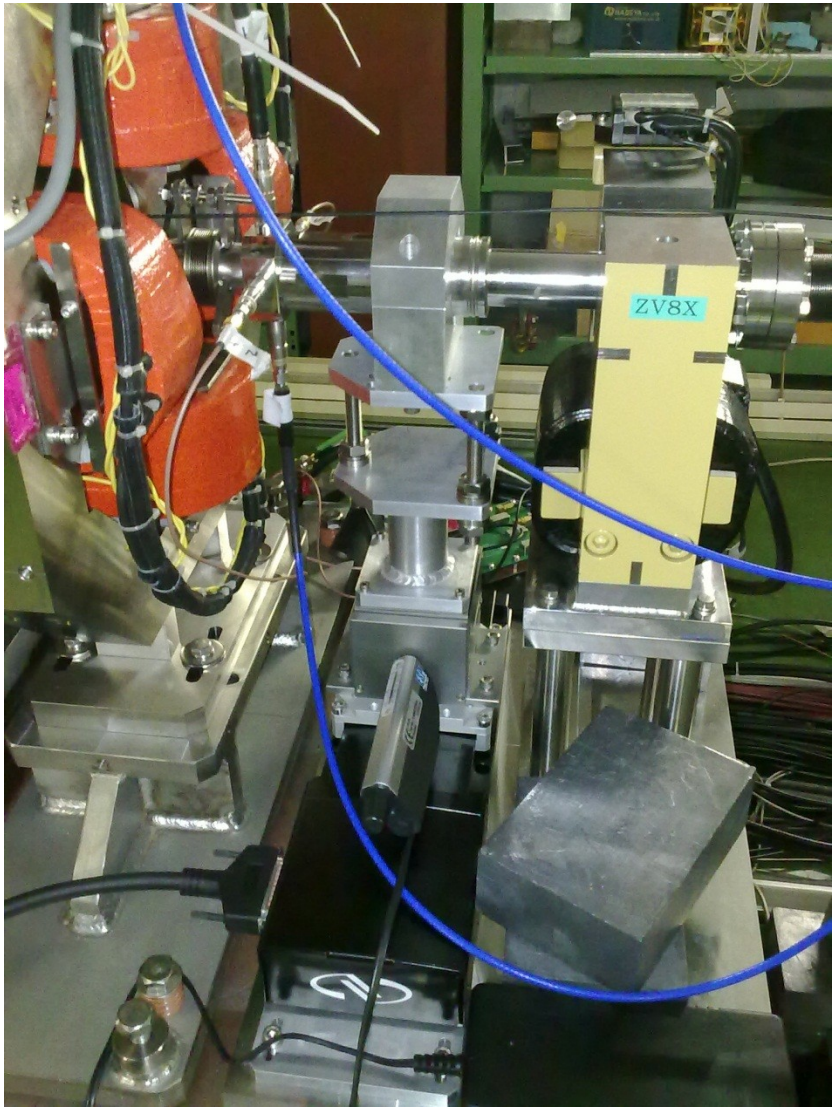
4 DAC output channels (AD9744)

Clocked at 357 MHz phase-locked to beam

4x faster than FONT4

Valencia FONT BPM movers





BPM Improvements

- **November/December 2010:**

  6 new BPM processors

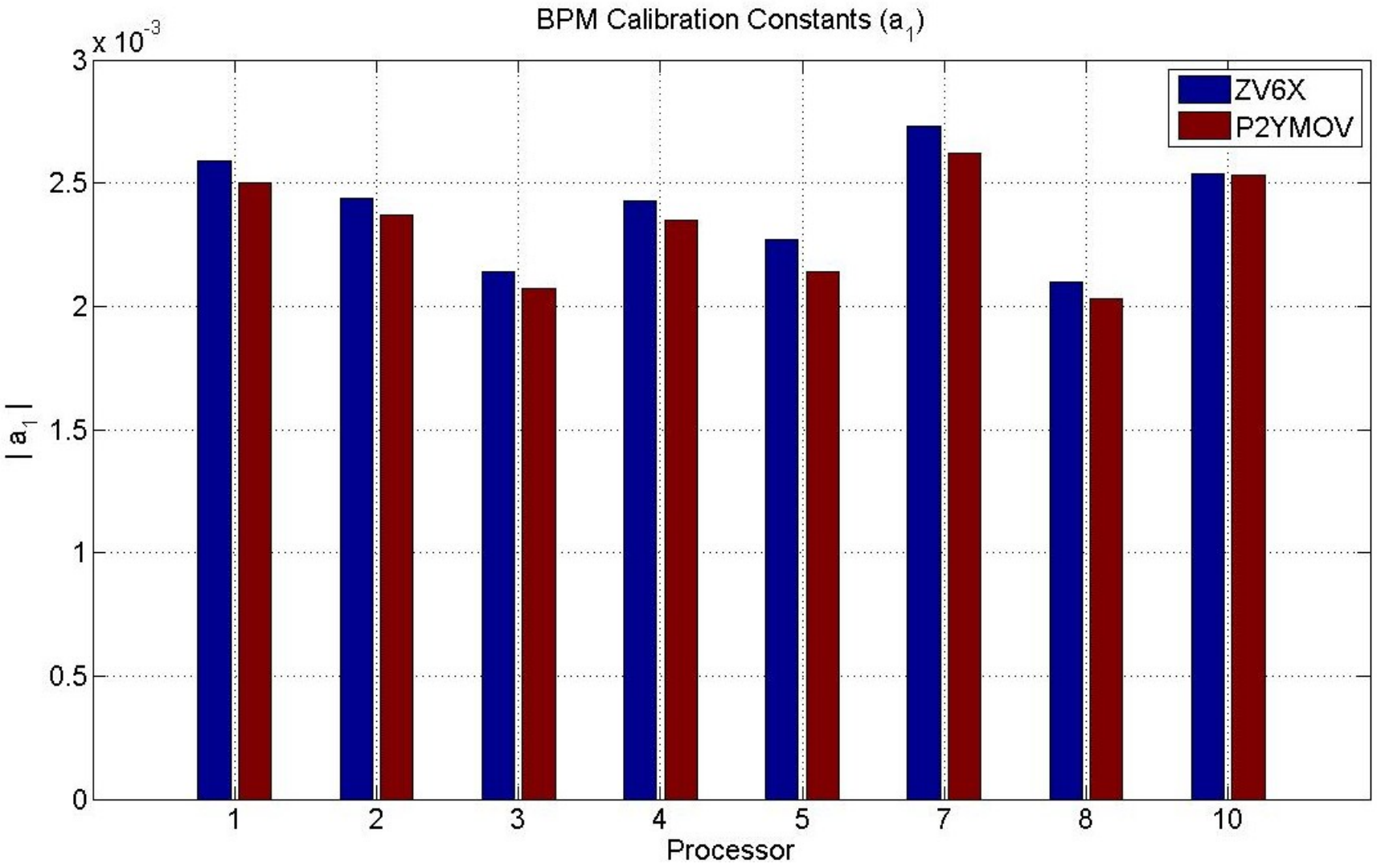
  10 BPM processors total:

  x1, y1; x2, y2; x3,y3; DR x,y + 2 spare

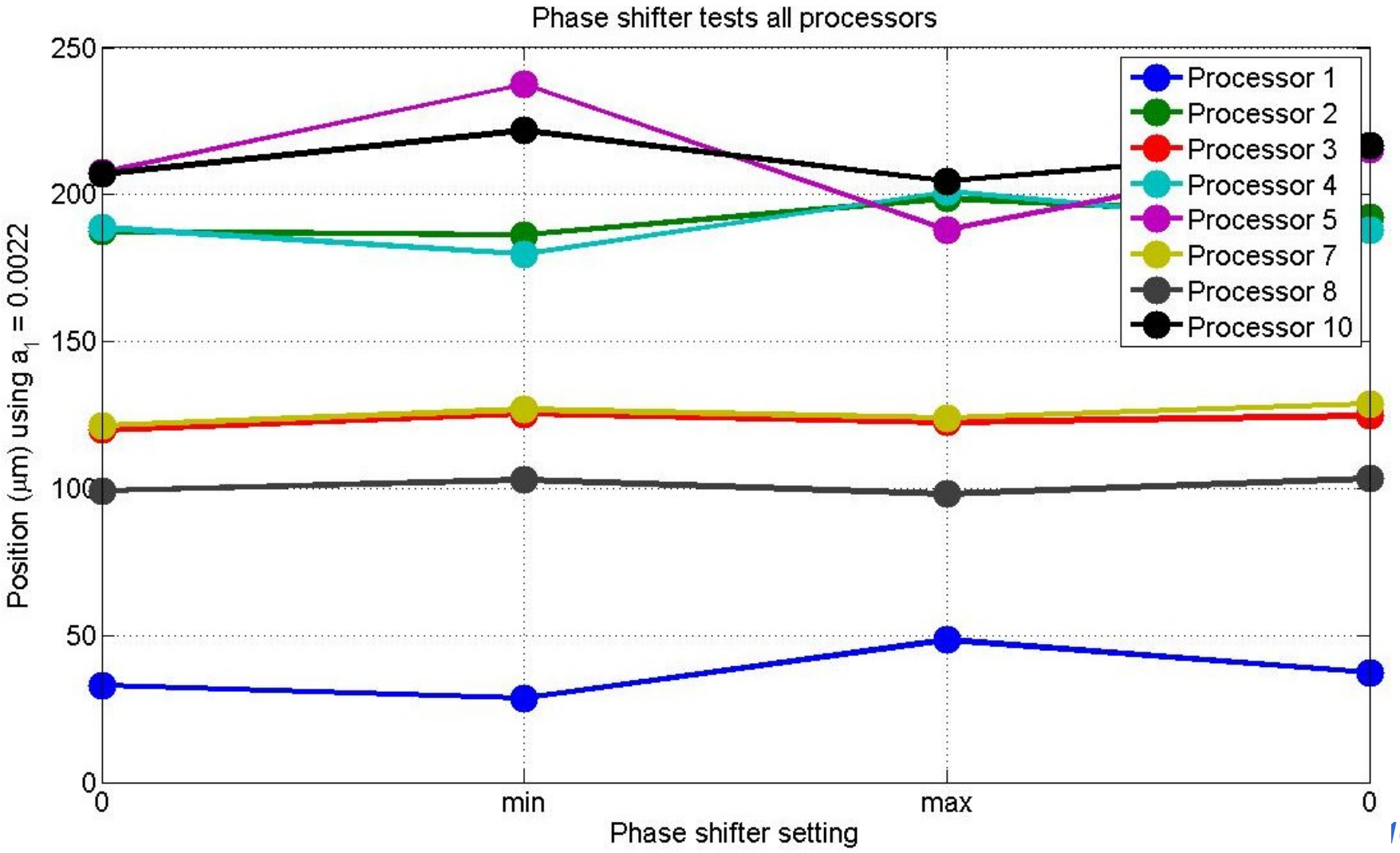
BPM Tests

- **Tests of BPM processors:**
  - **basic signal checks**
  - **calibrations**
  - **resolution measurements**
  - **sensitivity to LO phase**

Calibration results: mover + corrector scans



BPM sensitivity to LO phase



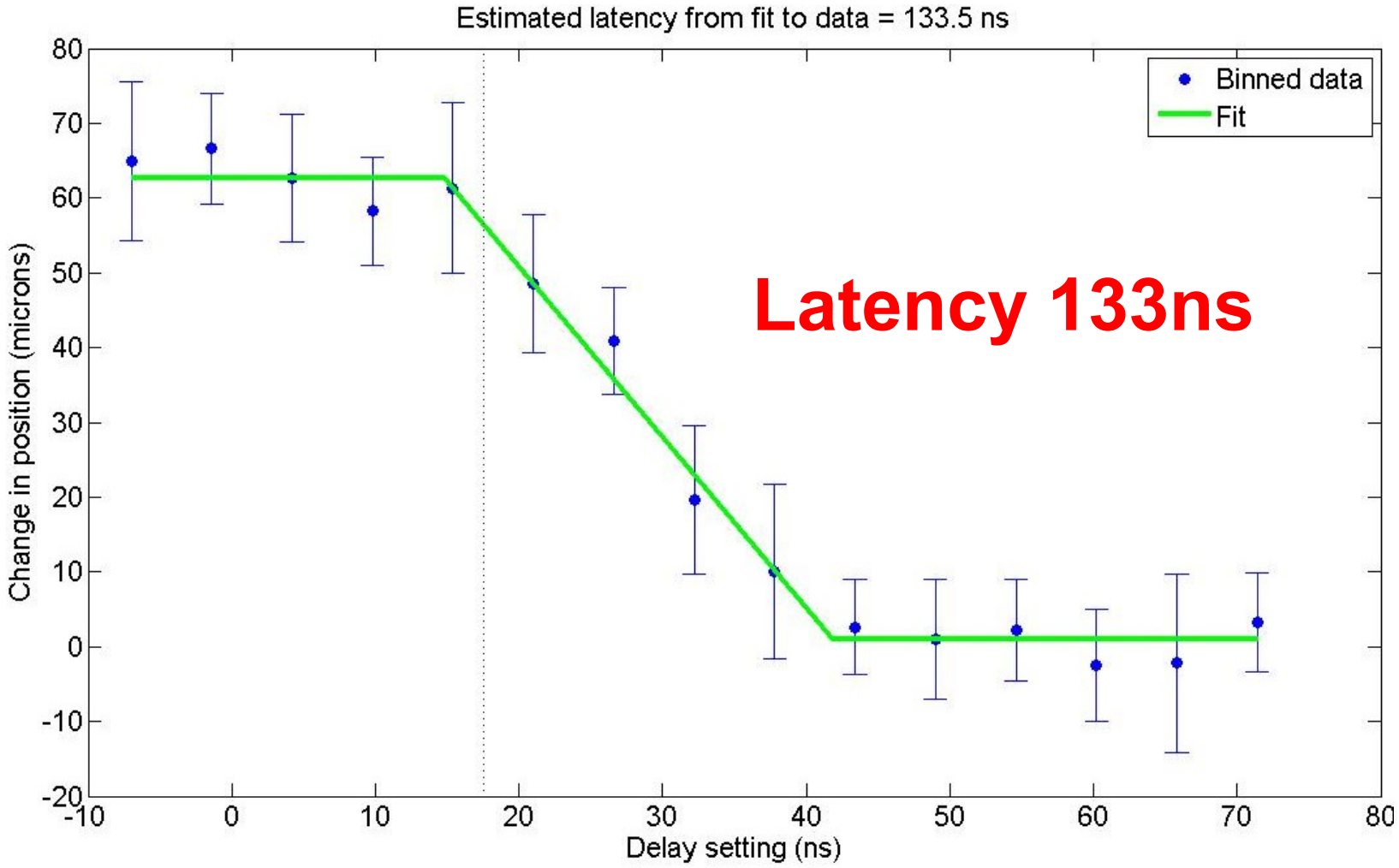
BPM work in progress

- **Further matching of stripline – BPM cables**
- **Matching of sum – difference signal path lengths**

Outline of FB results

- Latency
- Basic loop performance
- Banana correction
- Beam quality + kicker timing studies
- Coupled-loop FB results
- Next steps

Latency: P2 → K1 loop



Latency estimate

- Time of flight kicker – BPM: 12ns
- Signal return time BPM – kicker: 32ns

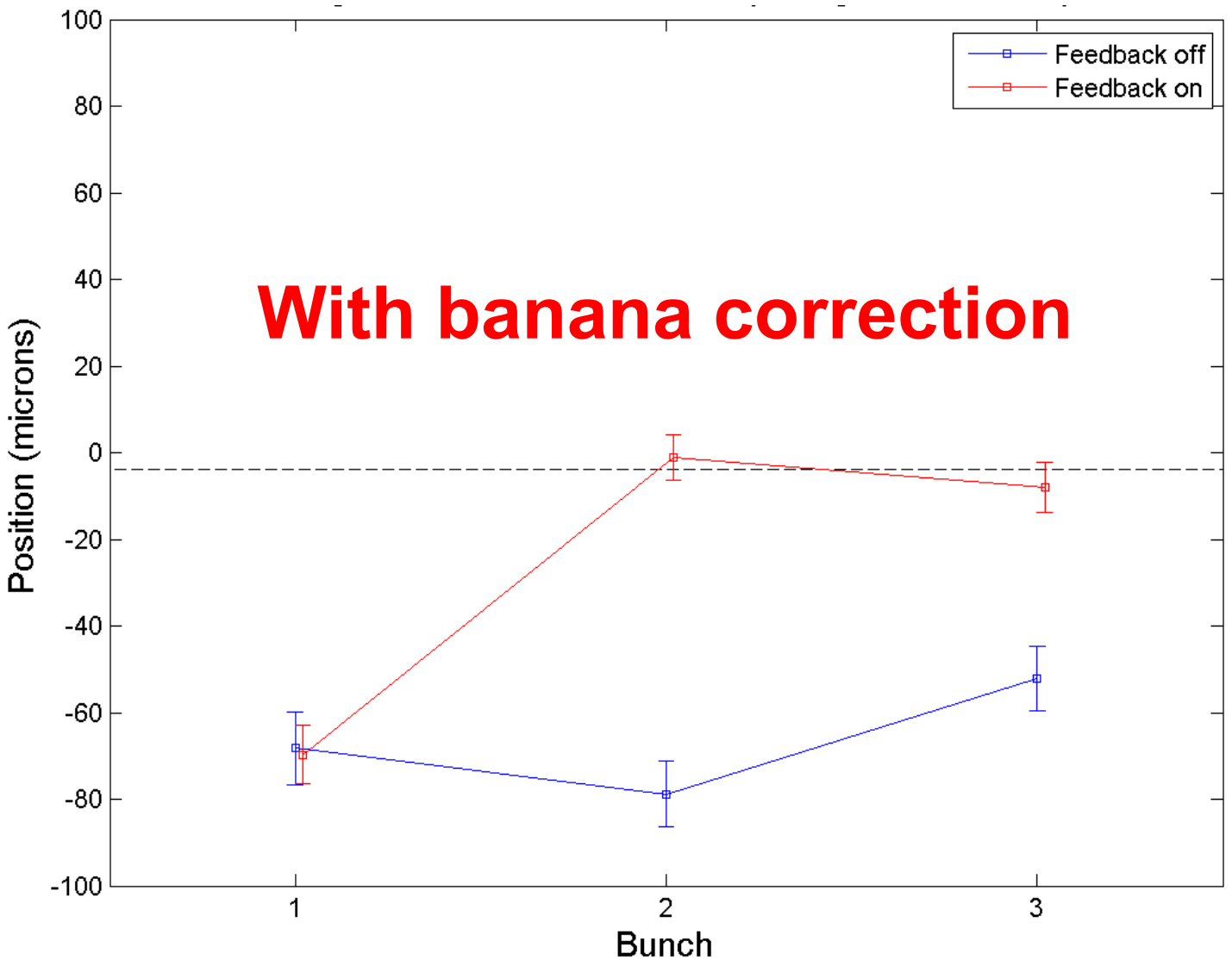
  Irreducible latency: 44ns

- BPM processor: 10ns
- ADC/DAC (4.5 357 MHz cycles) 14ns
- Signal processing (8 357 MHz cycles) 22ns
- FPGA i/o 3ns
- Amplifier 35ns
- Kicker fill time 3ns

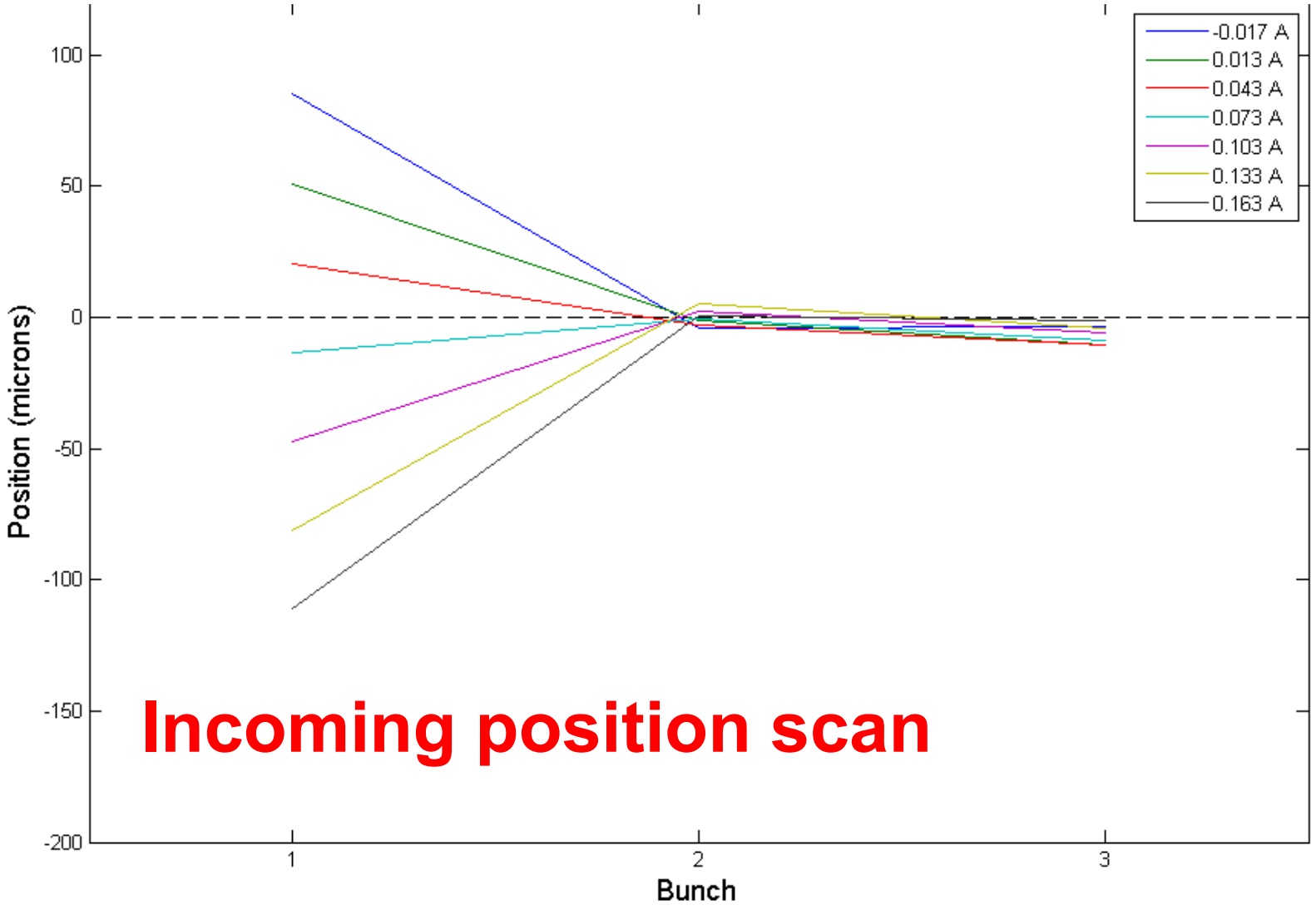
  Electronics latency: 87ns

- Total latency budget: 131ns

P2 → K1 loop performance

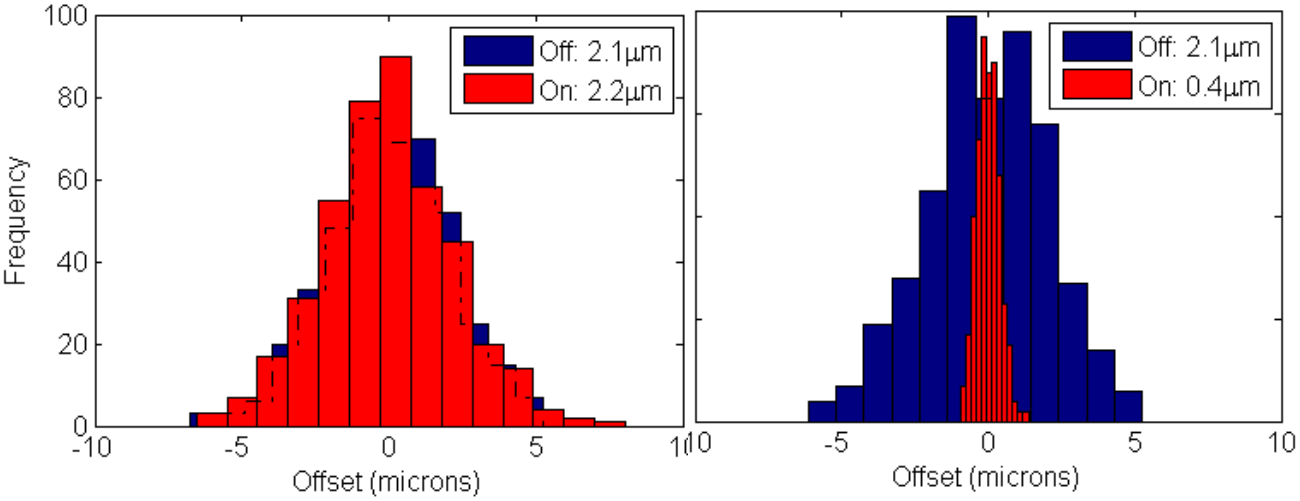


P2 → K1 loop performance



P2 → K1 loop jitter reduction

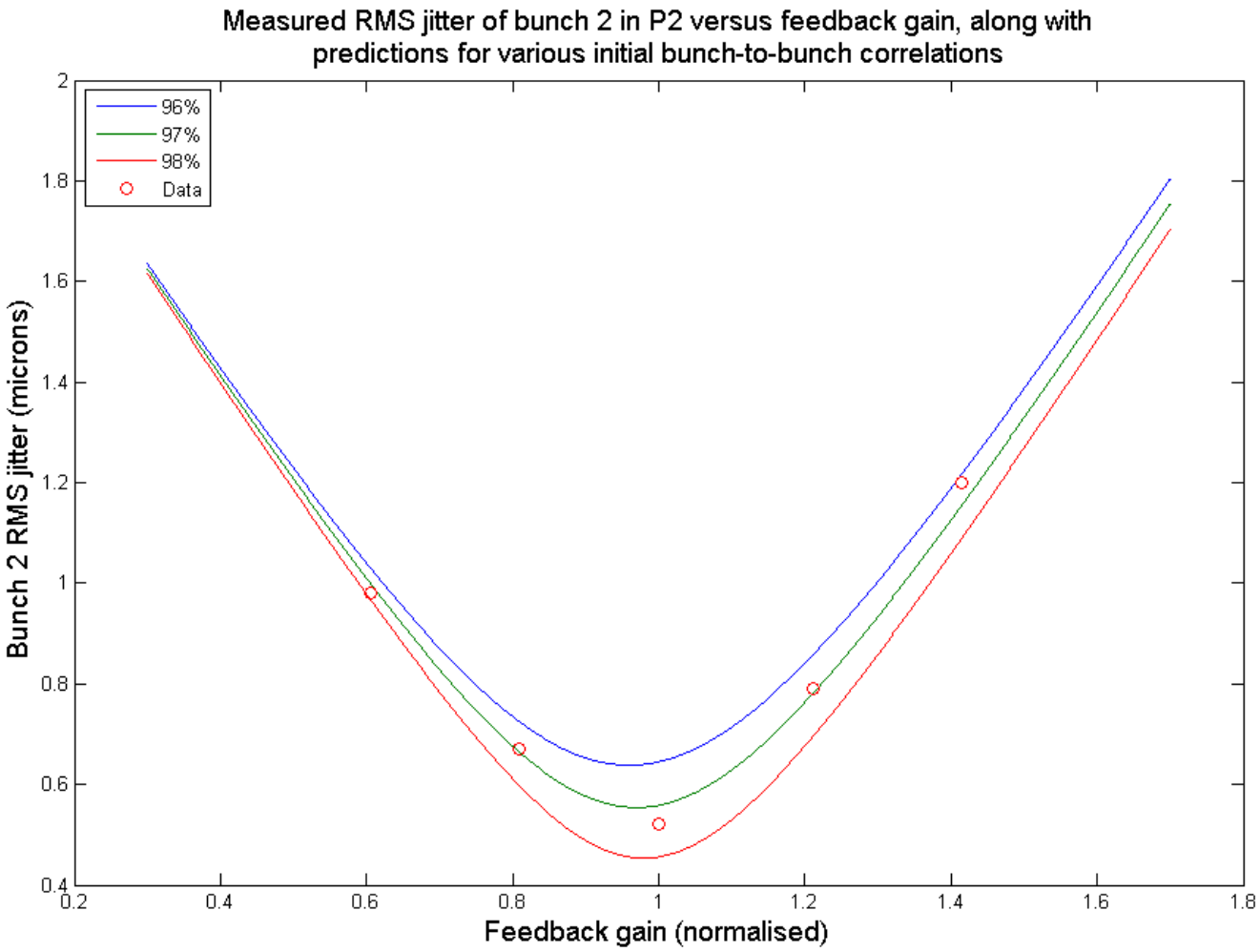
Bunch 1 **Bunch 2**



2.1 um → 0.4 um

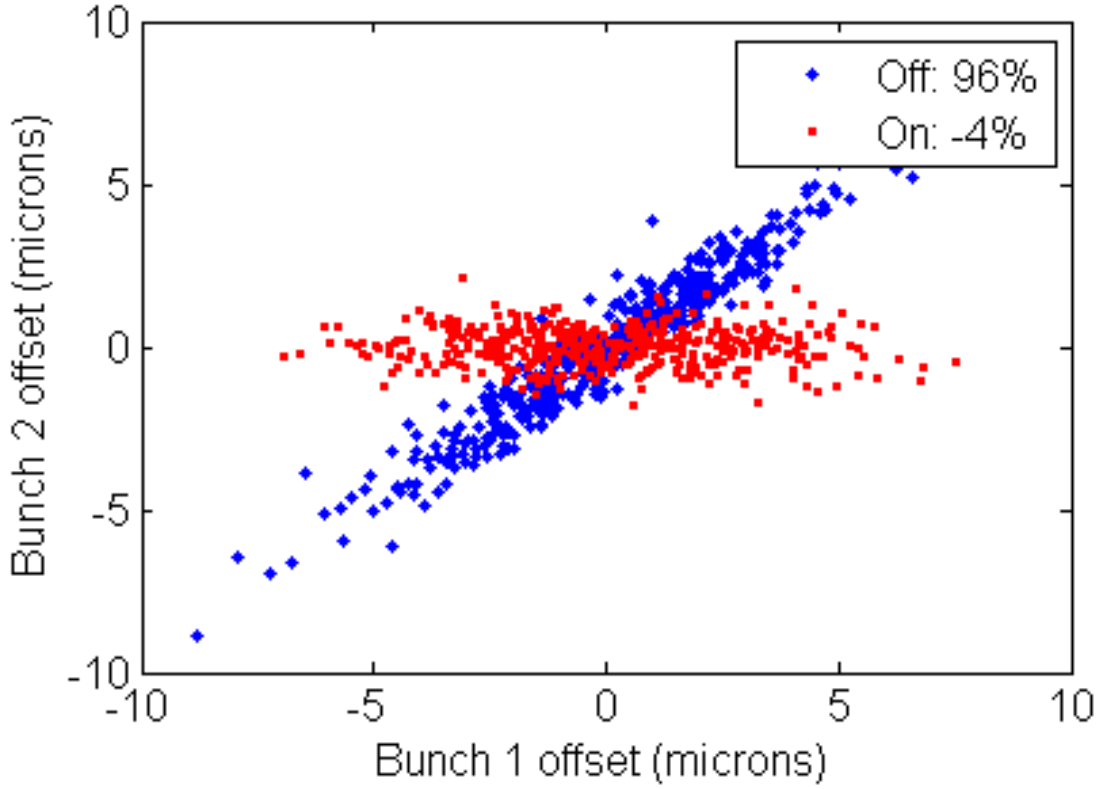
Factor of 5 jitter reduction

Bunch 2 jitter vs. gain



Bunch 1-2 correlations

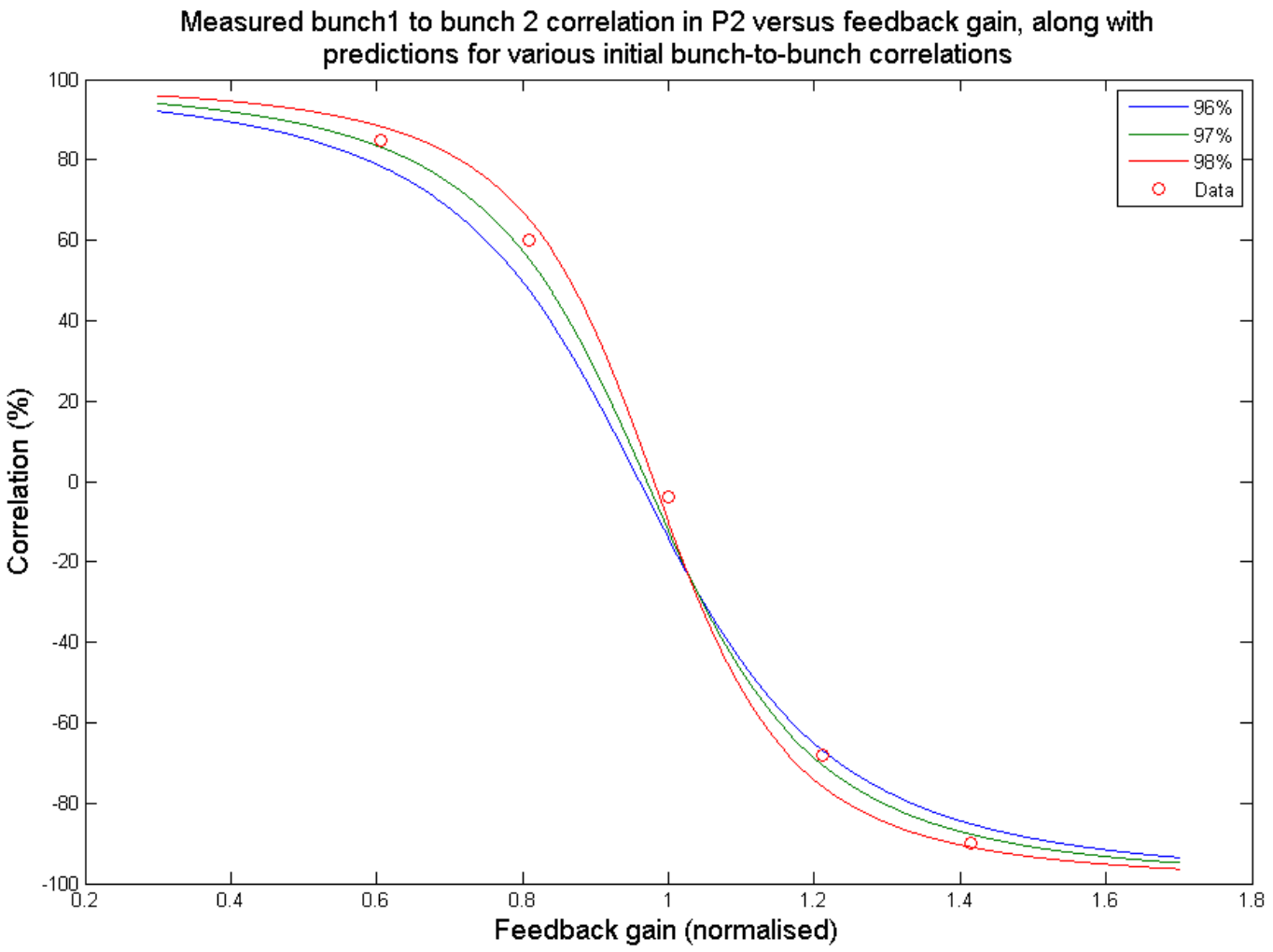
Bunch 2



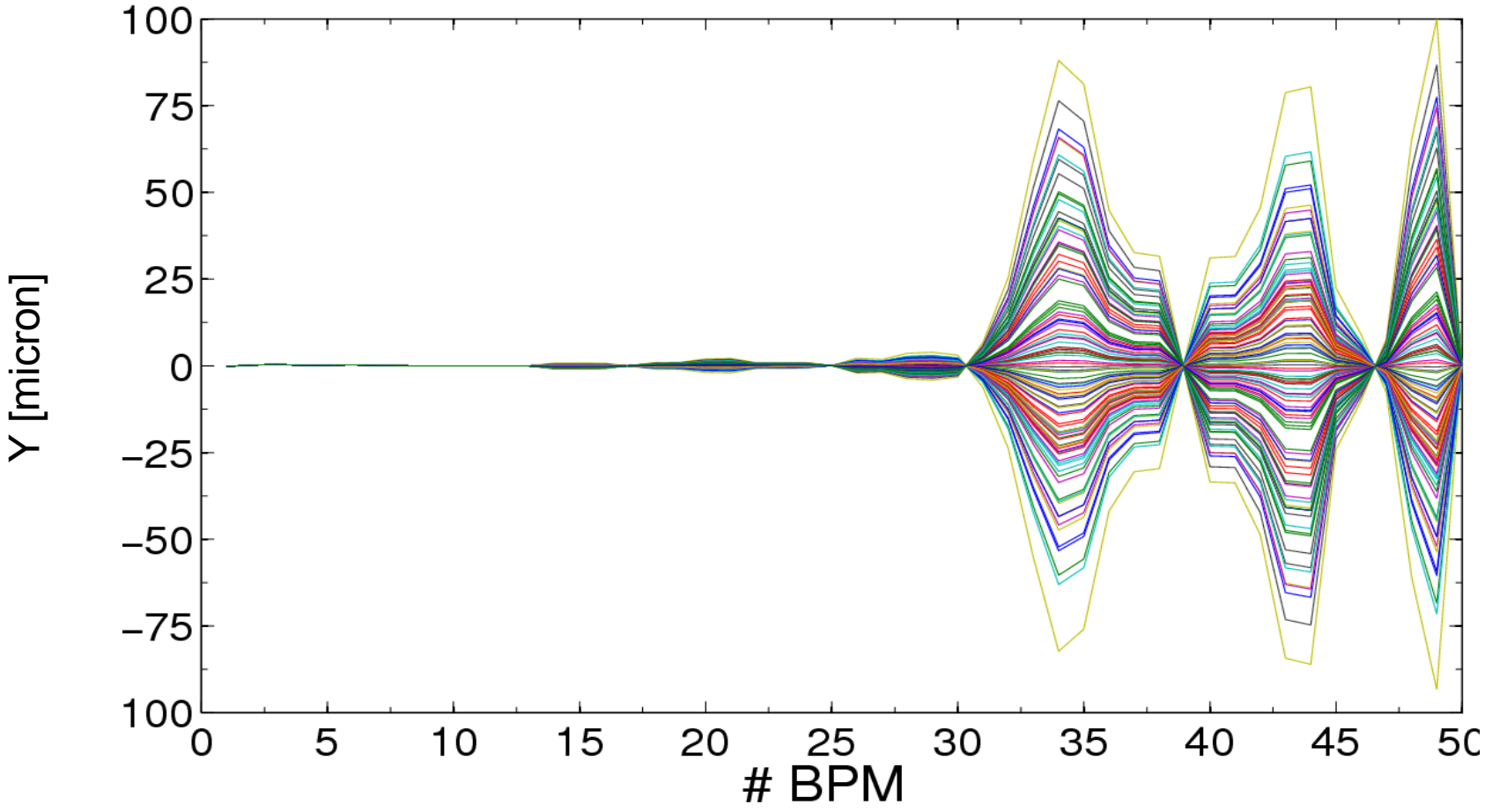
Bunch 1

Feedback removes bunch correlations

Bunch 1-2 correlations vs. gain

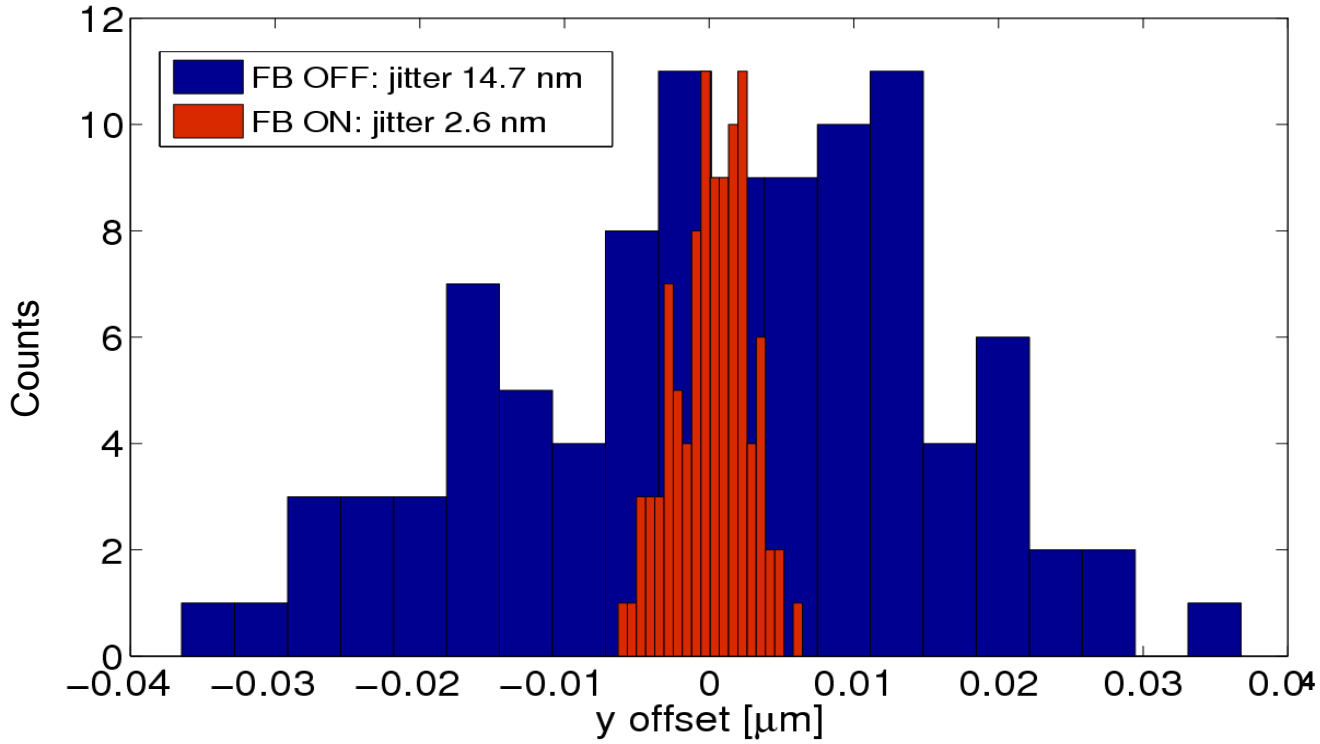


0.4 micron jitter propagation from P2



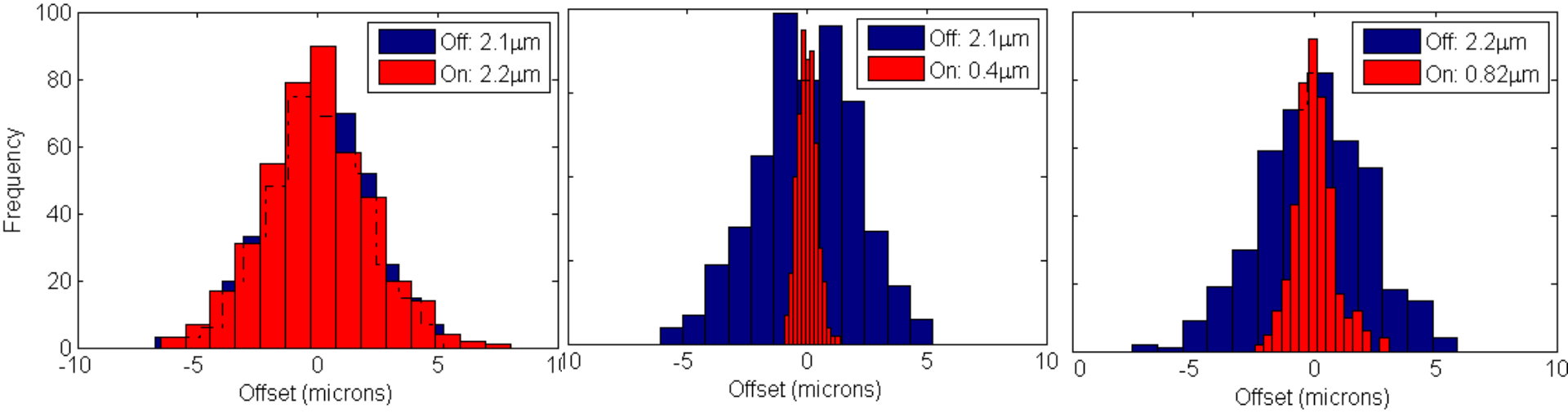
Jitter at ATF2 IP

Assuming perfect lattice, no further imperfections (!)



P2 → K1 loop jitter reduction

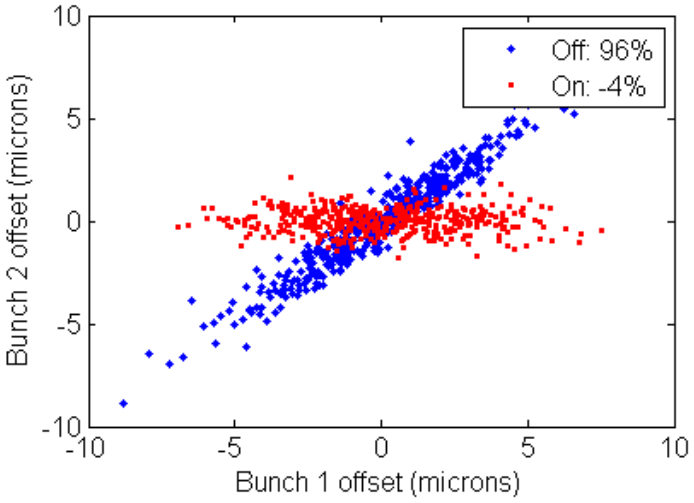
Bunch 1 **Bunch 2** **Bunch 3**



2.1 um → 0.4 um → 0.8 um

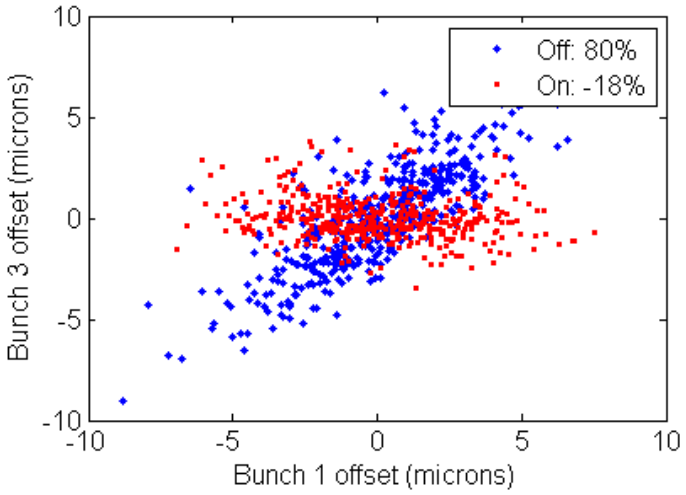
Bunch correlations

Bunch 2



Bunch 1

Bunch 3



Bunch 2

Summary so far

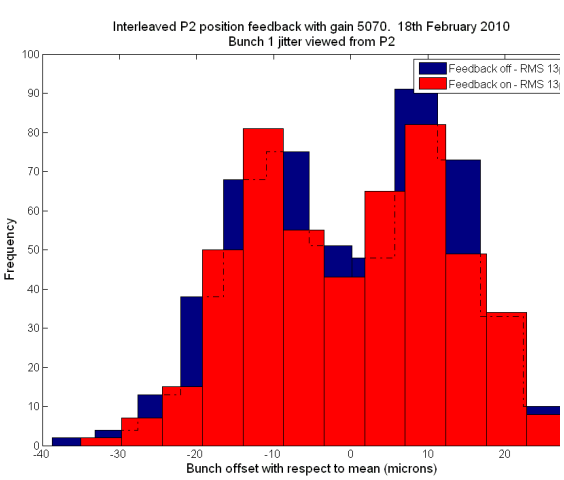
- **These spectacular results were obtained with beam of exceptional quality:**

Incoming train jitter:	**2um**
Bunch 1-2 correlations:	**98%**
Bunch 2-3 correlations:	**80%**

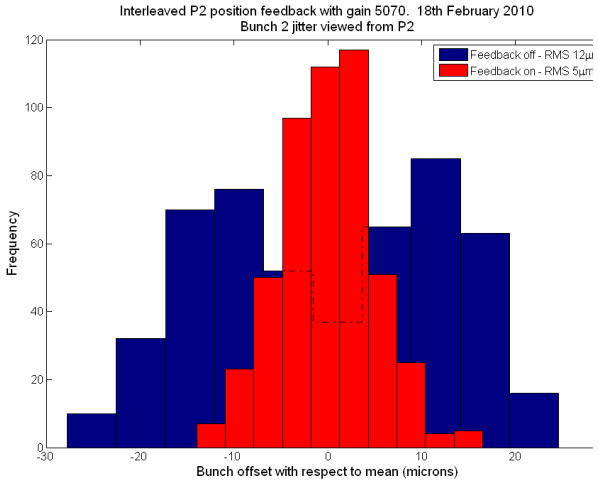
This is NOT typical!

P2 → K1 loop jitter reduction
(February 2010)

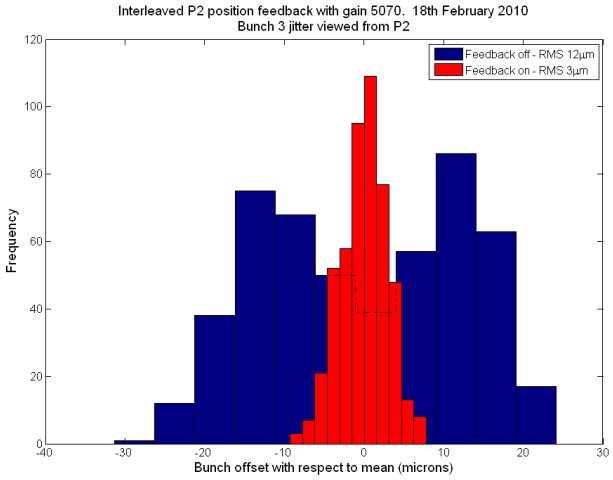
Bunch 1



Bunch 2



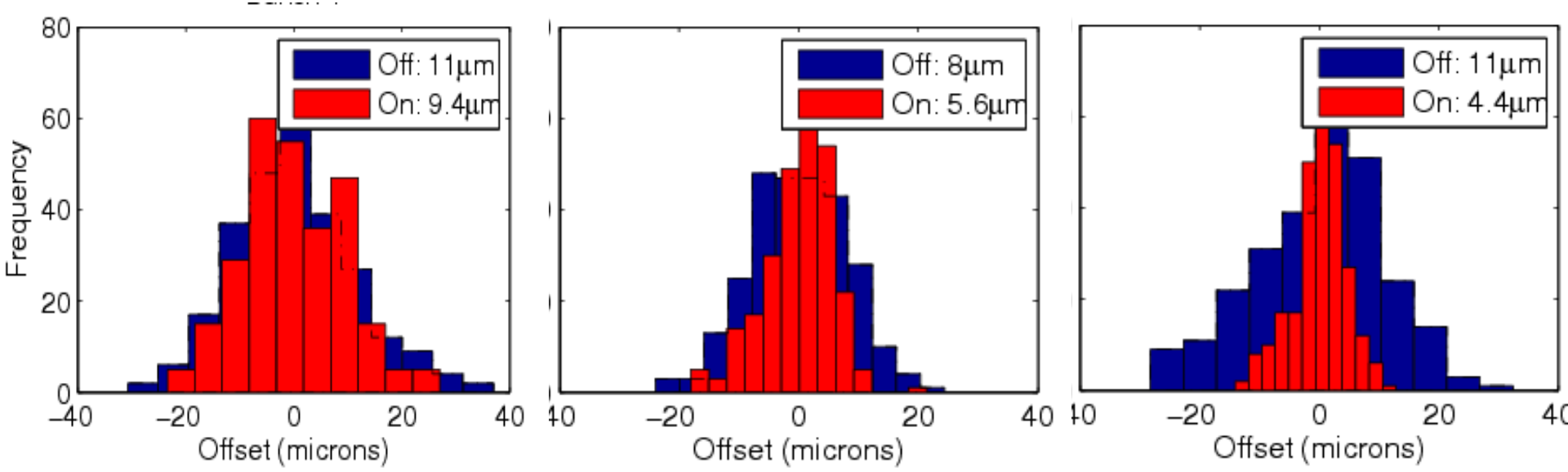
Bunch 3



13 um → 5 um → 3 um

Coupled loop jitter reduction
(December 2010)

Bunch 1 **Bunch 2** **Bunch 3**



9.4 um → **5.6 um** → **4.4 um**

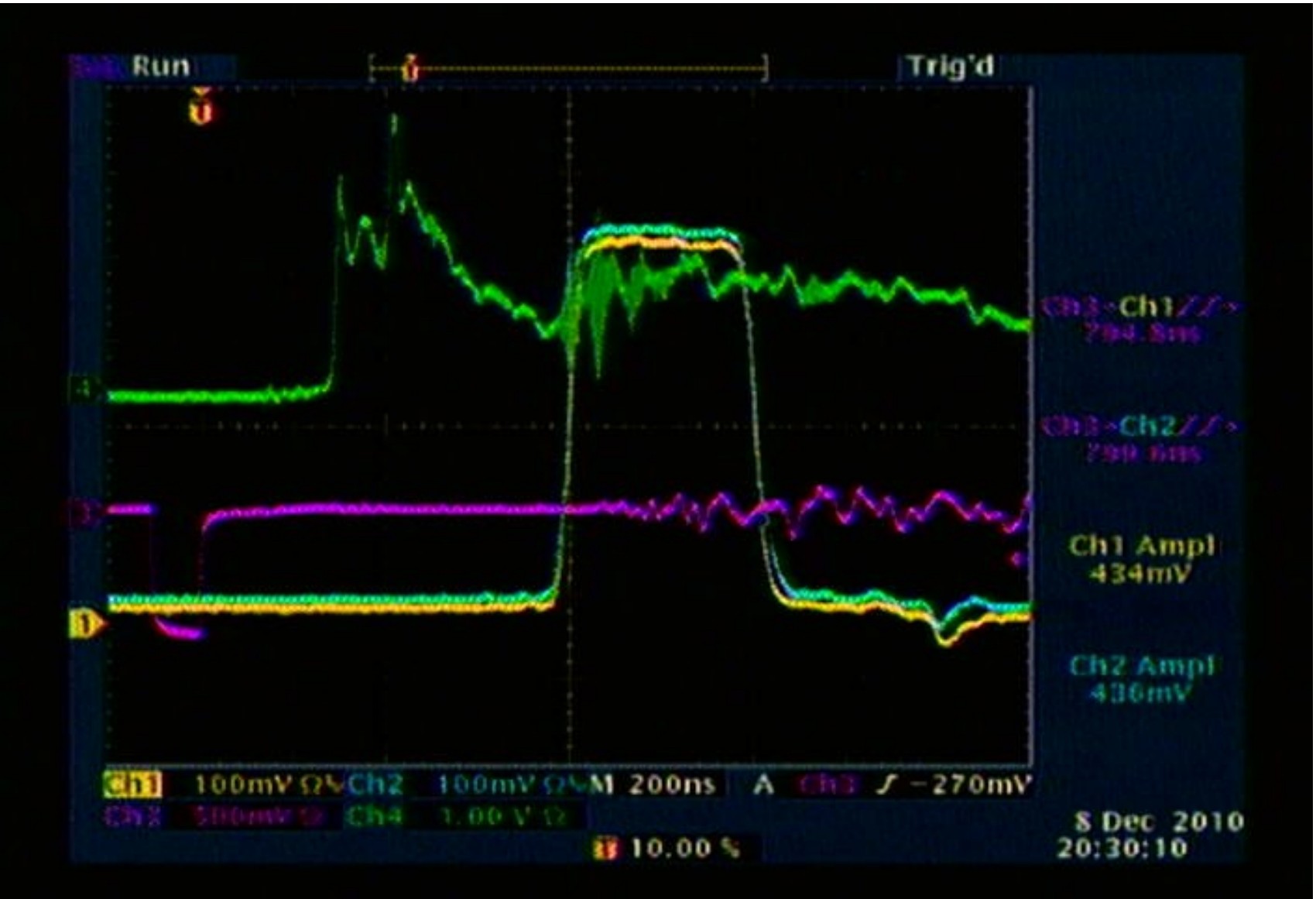
Machine studies

- **Have made some efforts to understand causes of poorer beam quality:**

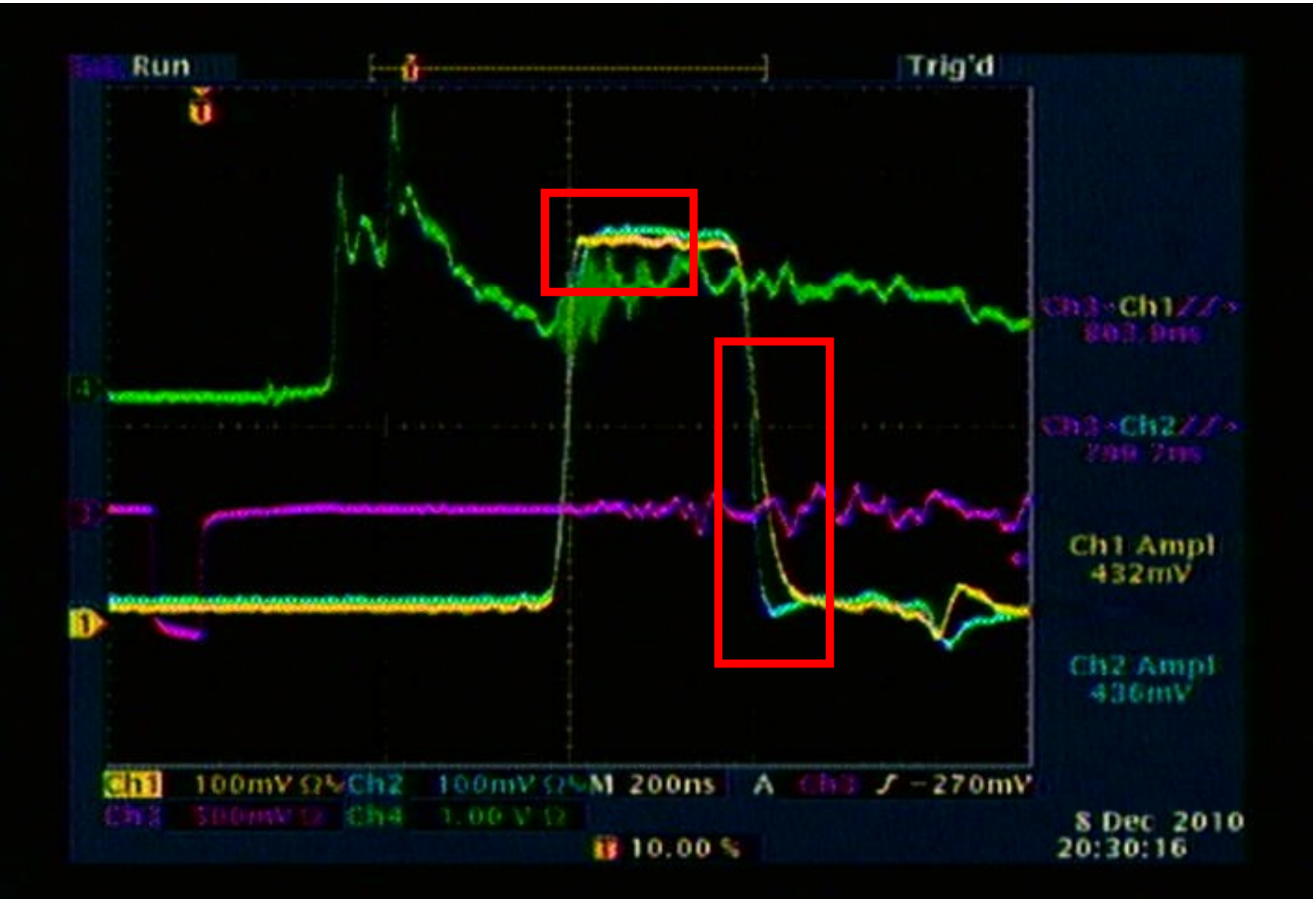
  Damping ring configuration – inconclusive

  Extraction kicker setup – more conclusive

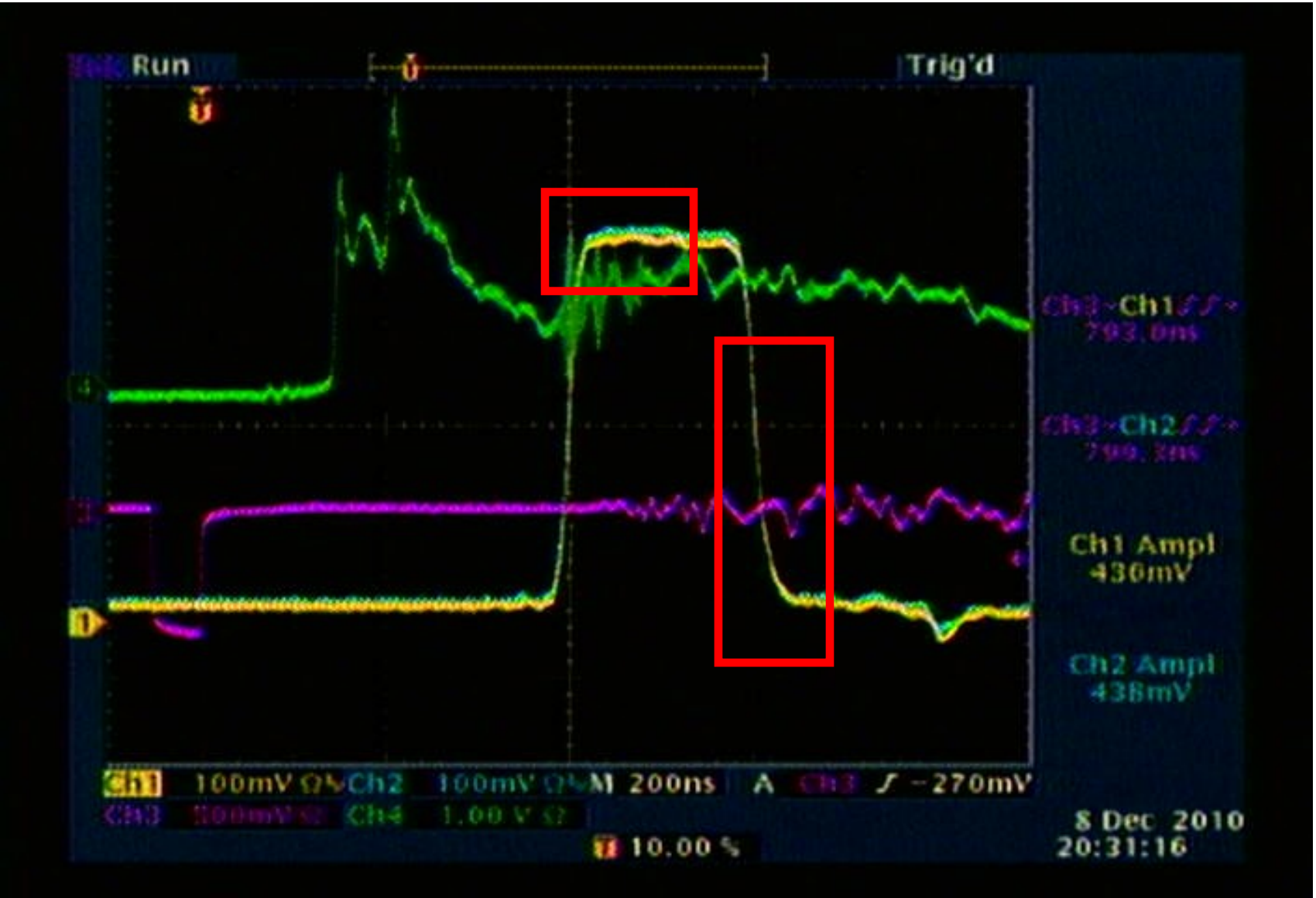
Extraction kicker pulse (1)



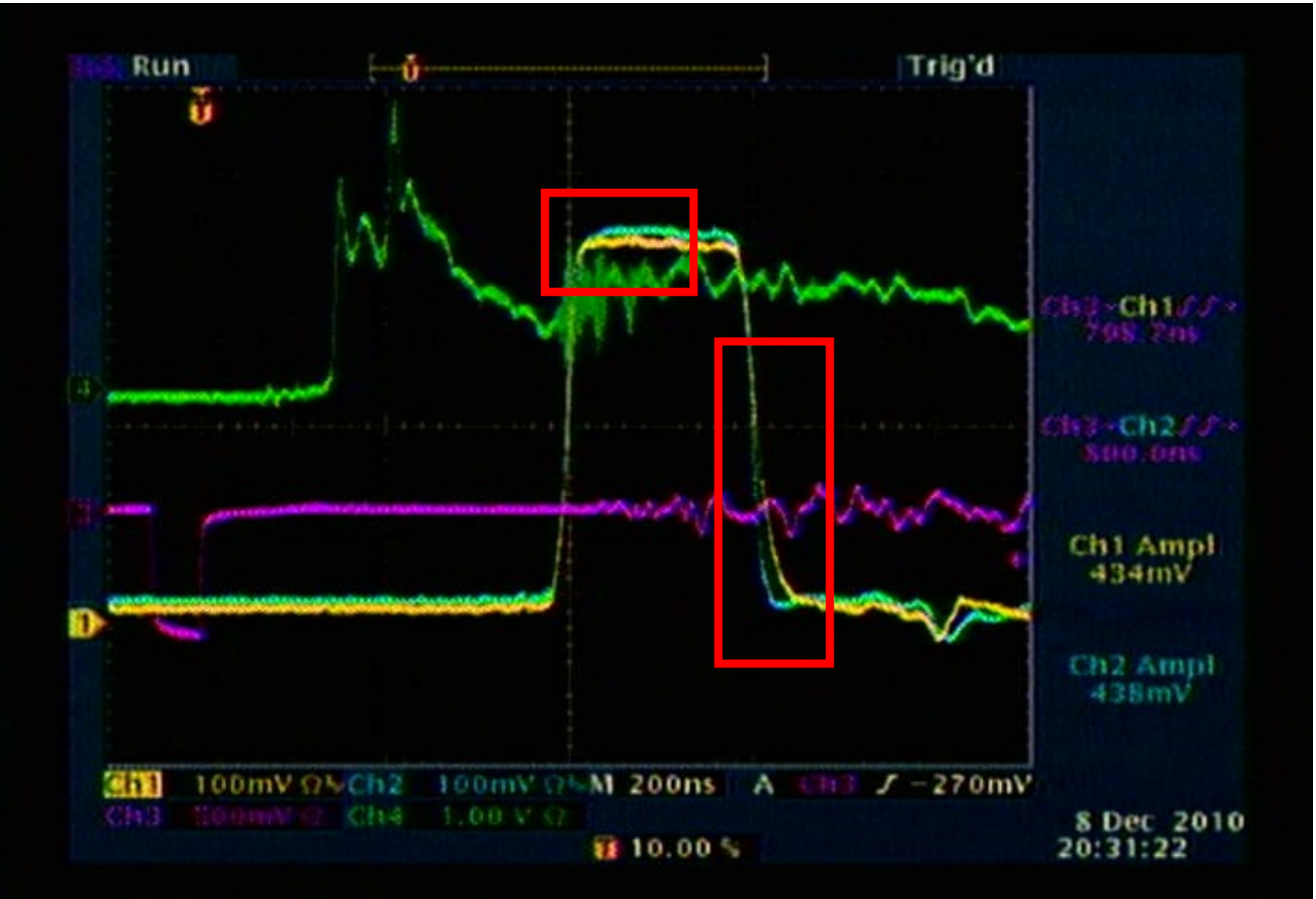
Extraction kicker pulse (2)



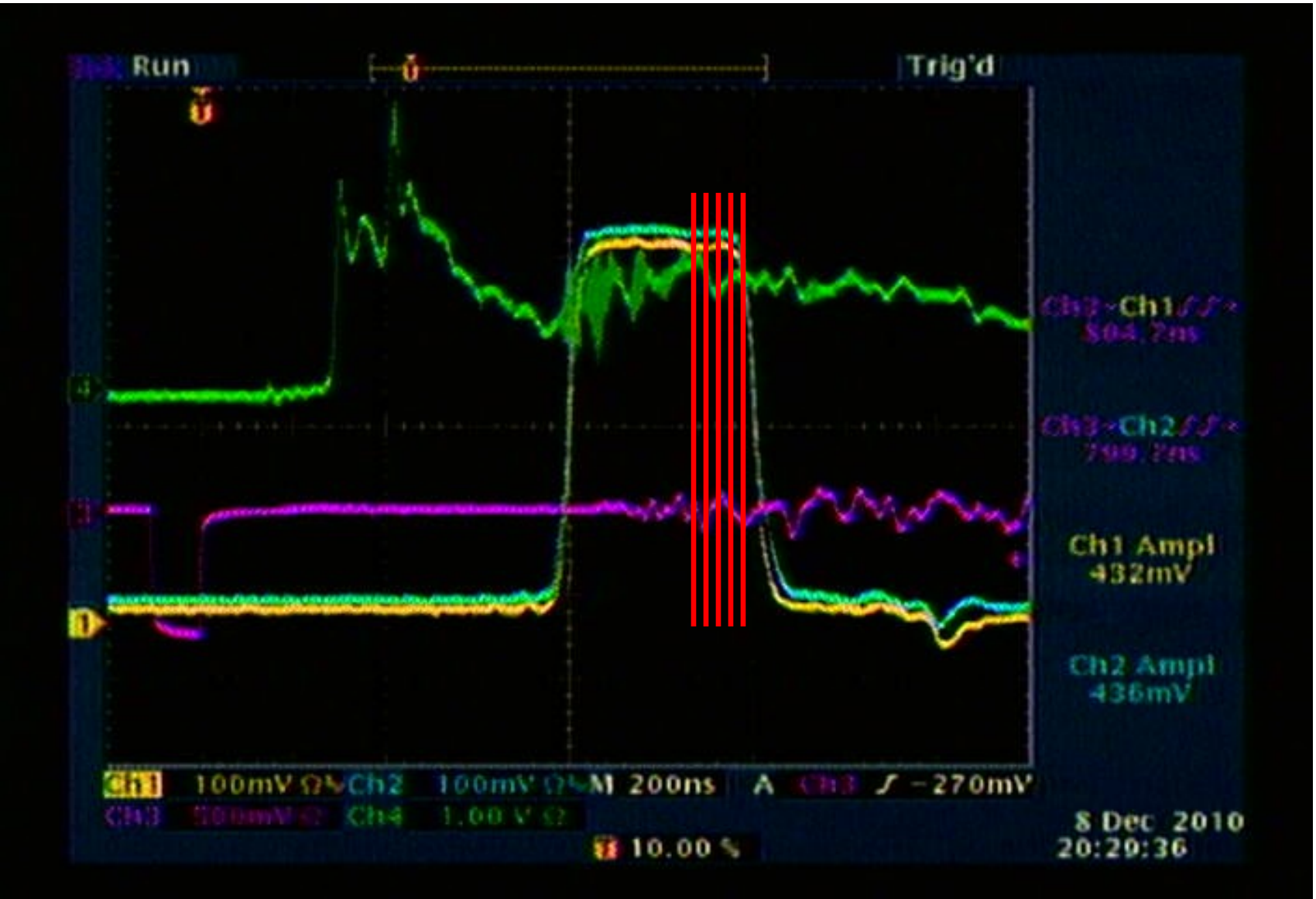
Extraction kicker pulse (3)



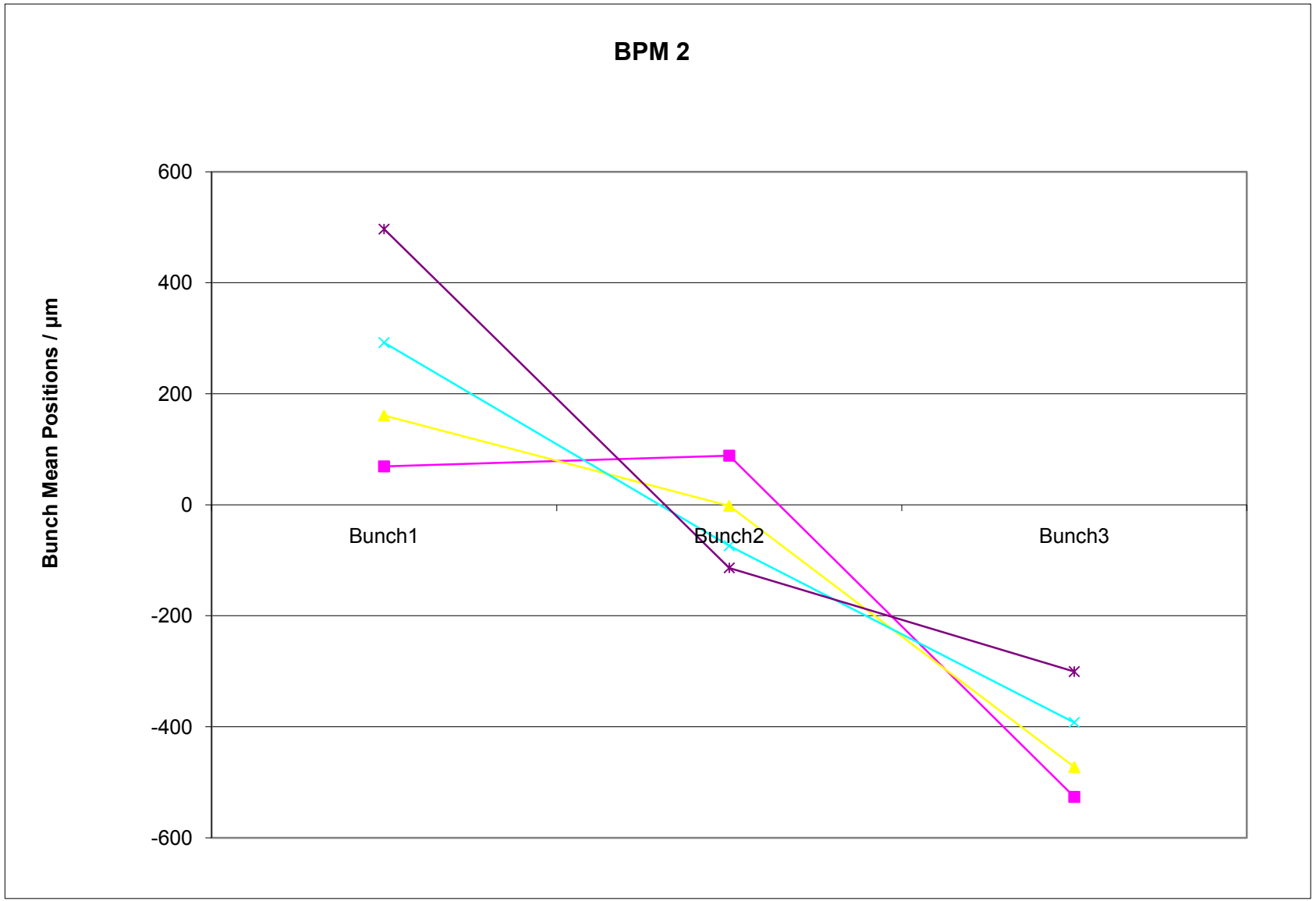
Extraction kicker pulse (4)



Kicker timing study



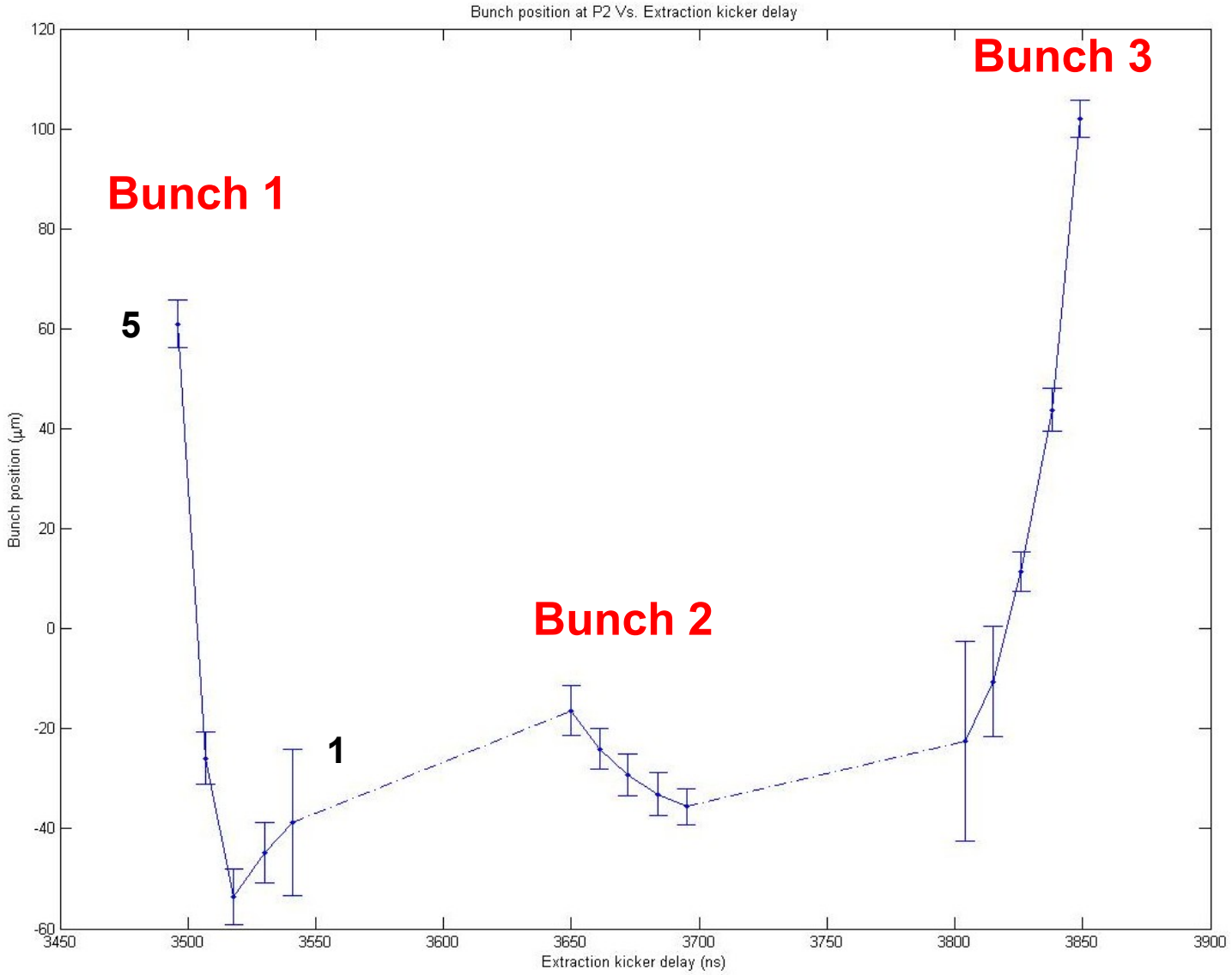
x positions at P2 vs. timing



y results at P2 vs. timing

	Banana (um)	B12 (%)	B23 (%)	Jitter (um) B1	B2	B3
1	140	0	89	14.6	3.6	3.8
2	88	58	95	6.1	4.5	4.6
3	65	44	88	5.5	4.2	3.9
4	15	59	51	5.3	4.0	11.0
5	83	80	55	4.7	5.1	20.0

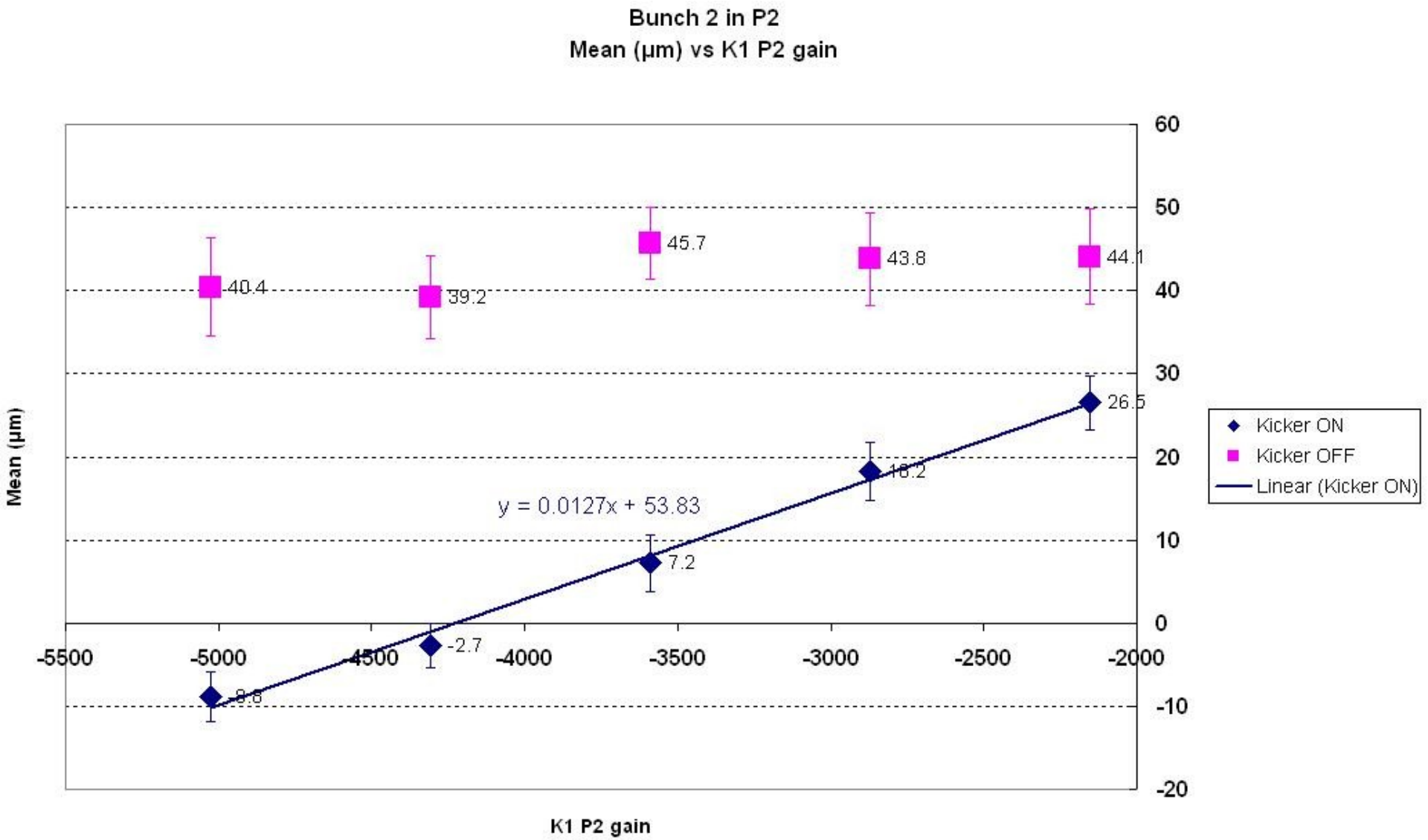
y positions at P2



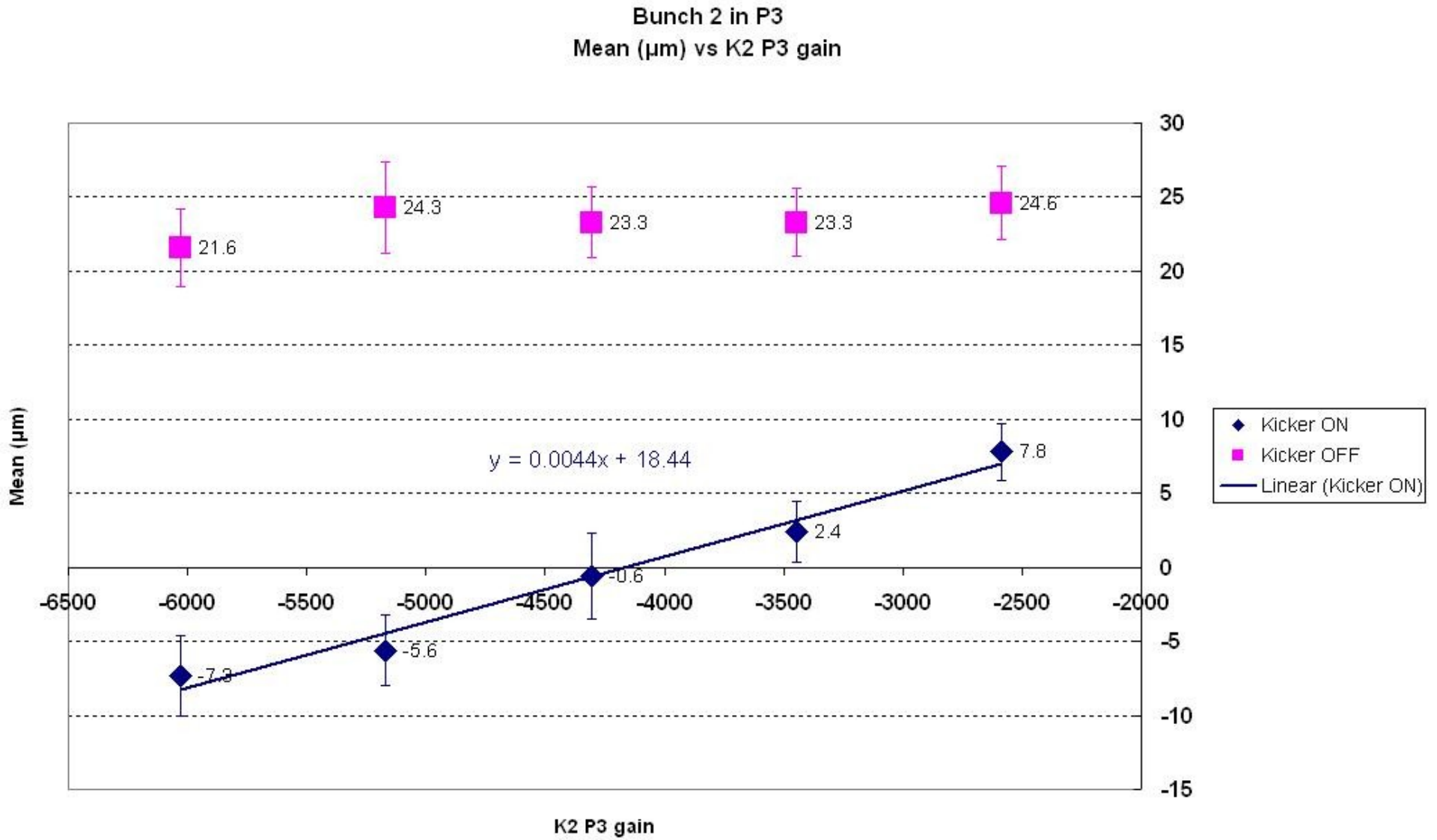
Further Feedback Tests

- **K1 – P2 loop**
- **K2 – P3 loop**
- **K1 – P2 + K2 – P3 uncoupled**
- **K1 – P2 + K2 – P3 coupled**

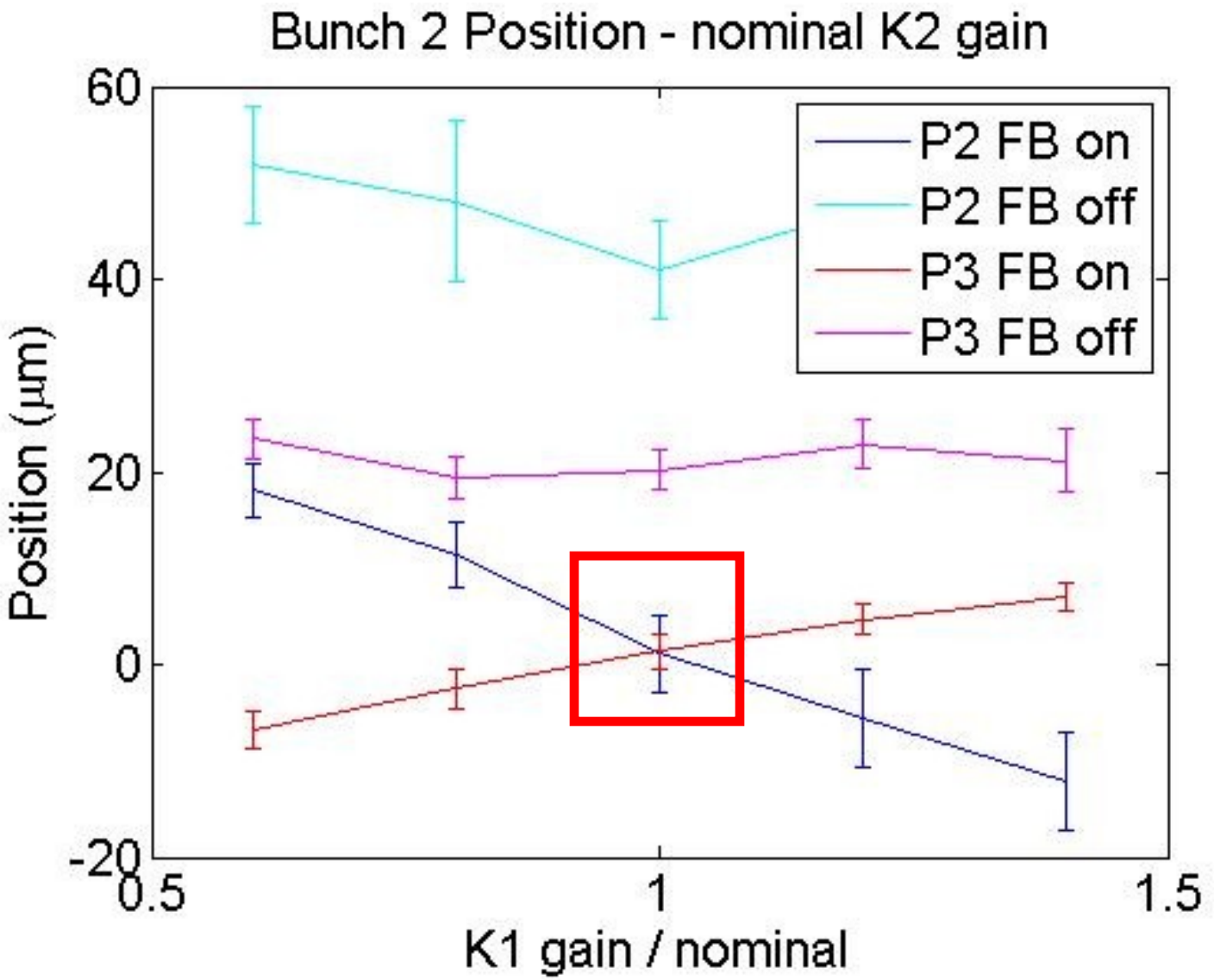
K1 – P2 loop gain scan



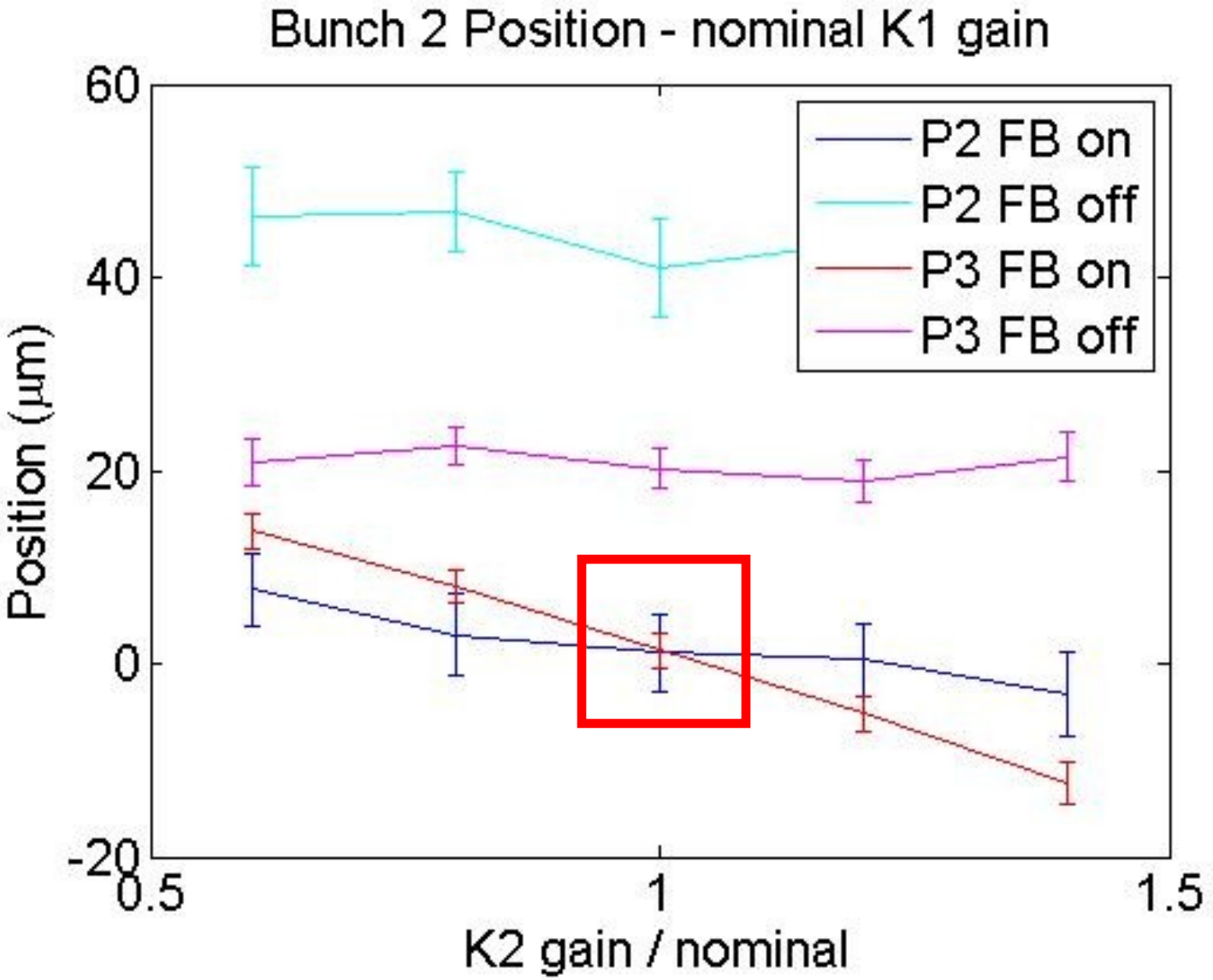
K2 – P3 loop gain scan



K1 – P2 + K2 – P3 coupled: K1 gain scan



K1 – P2 + K2 – P3 coupled: K2 gain scan

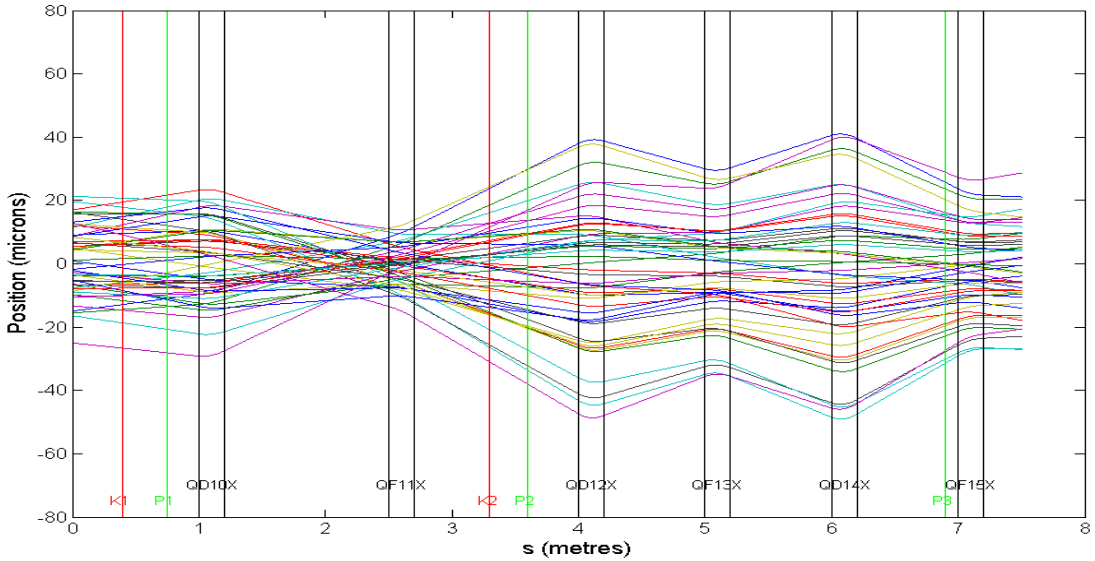


Possible Next Steps

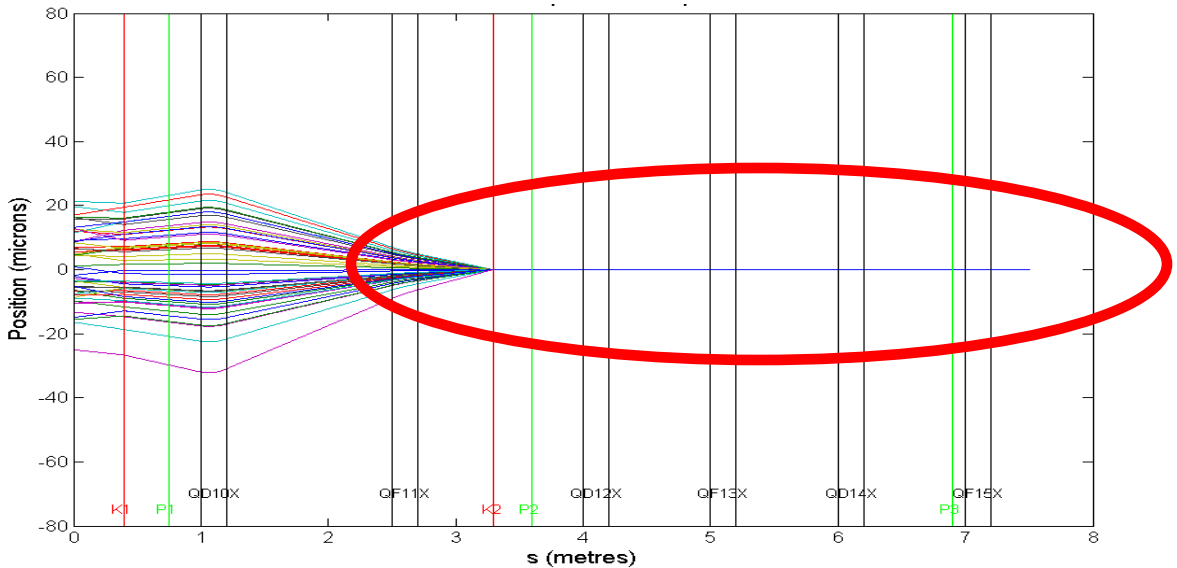
- **Beam quality: more systematic study of extraction kicker timing, bunch spacing …**
- **Run with just 2 bunches for optimal bunch-bunch correlations?**
- **Instrument downstream BPMs with FONT electronics to monitor downstream performance**

FB simulation: P2-K1+P3-K2 coupled

Bunch 1



Bunch 2



Possible Next Steps

- **Beam quality: more systematic study of extraction kicker timing, bunch spacing …**
- **Run with just 2 bunches for optimal bunch-bunch correlations?**
- **Instrument downstream BPMs with FONT electronics to monitor downstream performance**
- **IP FB – tomorrow's talk**
- **Tests with a long bunchtrain in the extraction line?**

Multi-bunch studies

- Now that the FONT5 system is fully operational it would be highly desirable to test it with a LONG bunch train
- We have modified the DAQ and firmware for this purpose, but so far there has been no opportunity to test it
- We would be interested in trying FONT with the fast-extraction kicker and 20-30 bunches
- Very important for PhD theses of Robert Apsimon and Douglas Bett

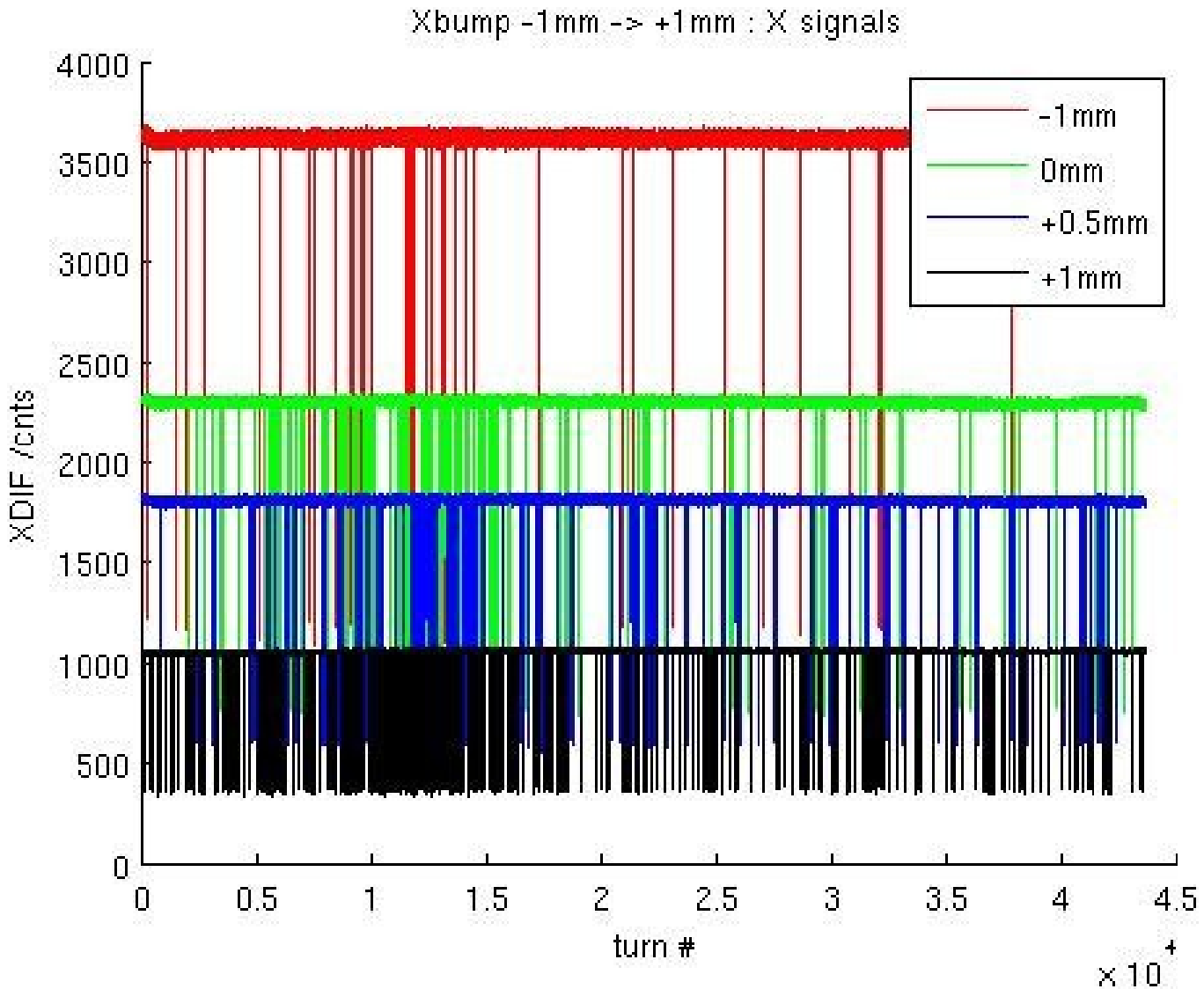
DR studies

- Instrumented BPM ‘LW26’ in ring with FONT BPM processors
- Wrote modified firmware + DAQ for DR:

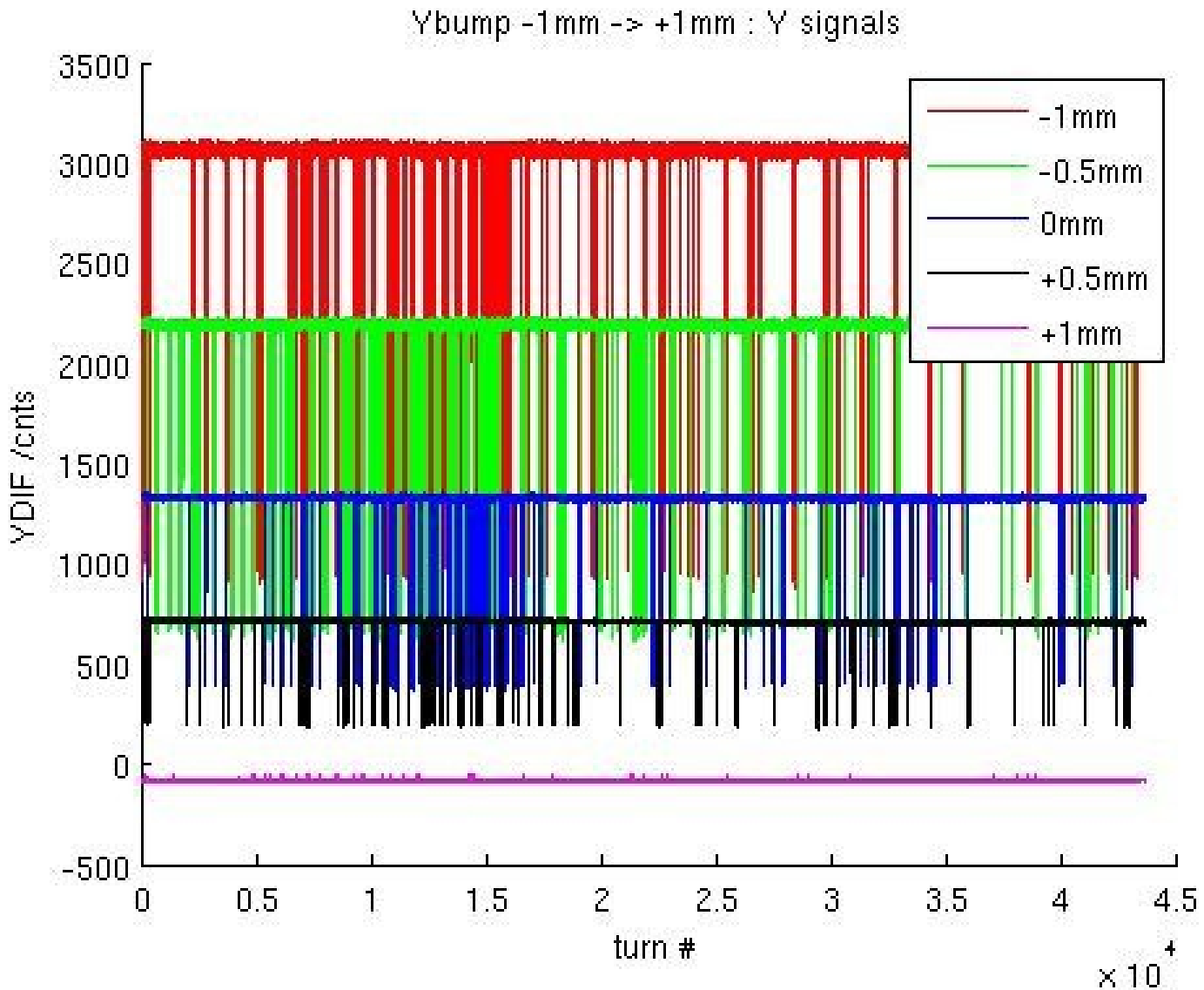
  monitor beam turn-by-turn
- Debugged in parasitic running October-December
- Issues with 2.16MHz clock
- Record up to c. 40k turns of data:

  either sequentially, or 1 in n turns

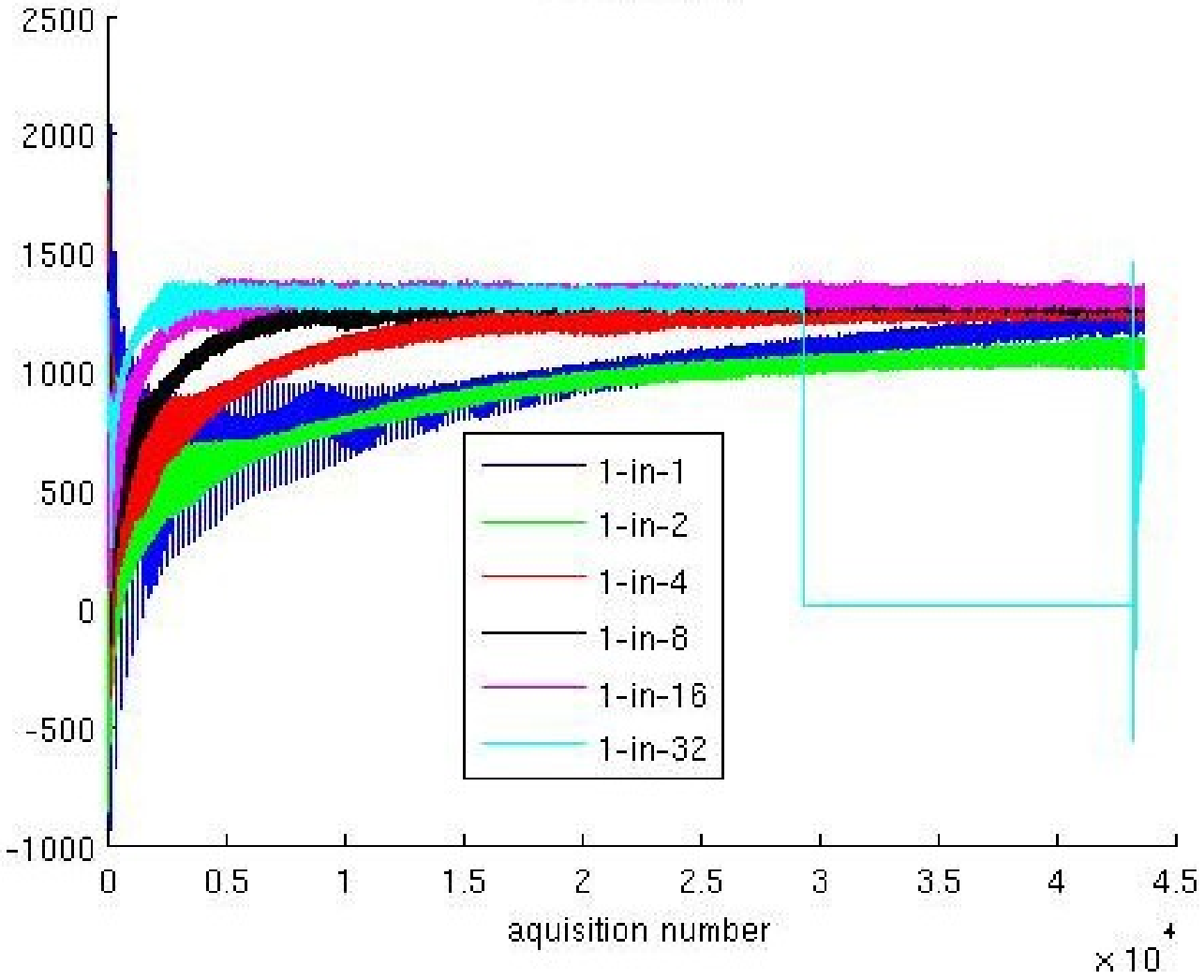
DR x orbit bumps



DR y orbit bumps



DR y: 1 in n turns



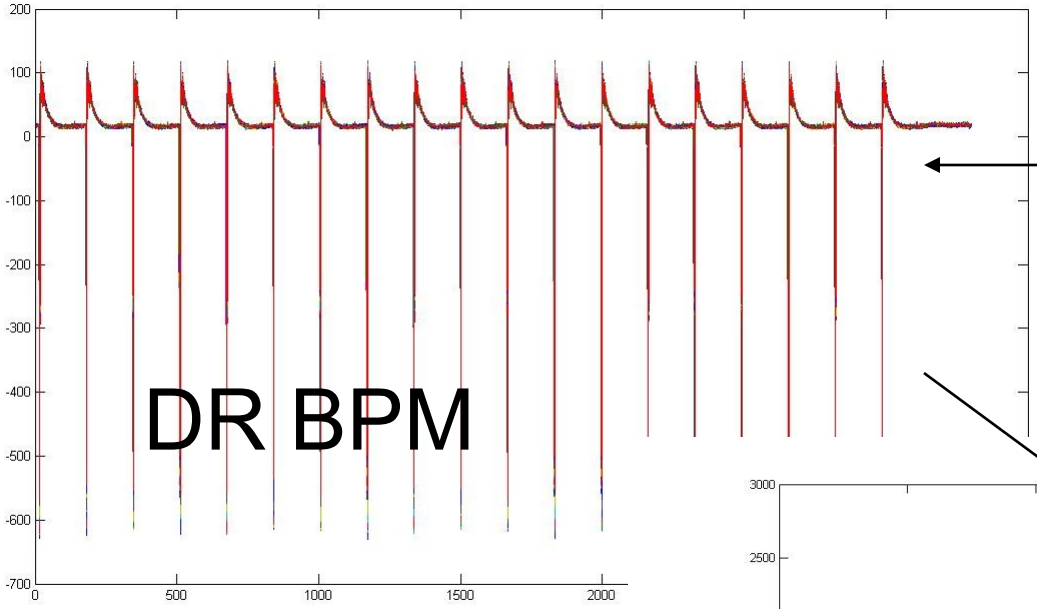
DR studies

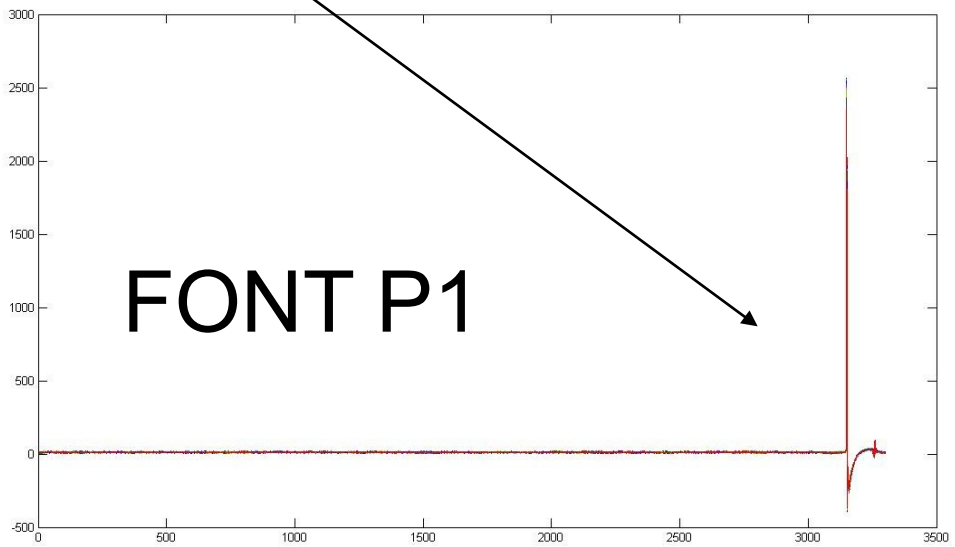
- Instrumented BPM ‘LW26’ in ring with FONT BPM processors
- Wrote modified firmware + DAQ for DR:

  monitor beam turn-by-turn
- Debugged in parasitic running October-December
- Issues with 2.16MHz clock
- Record up to 30k turns of data:

  either sequentially, or 1 in n turns
- Correlate DR – extraction line measurements

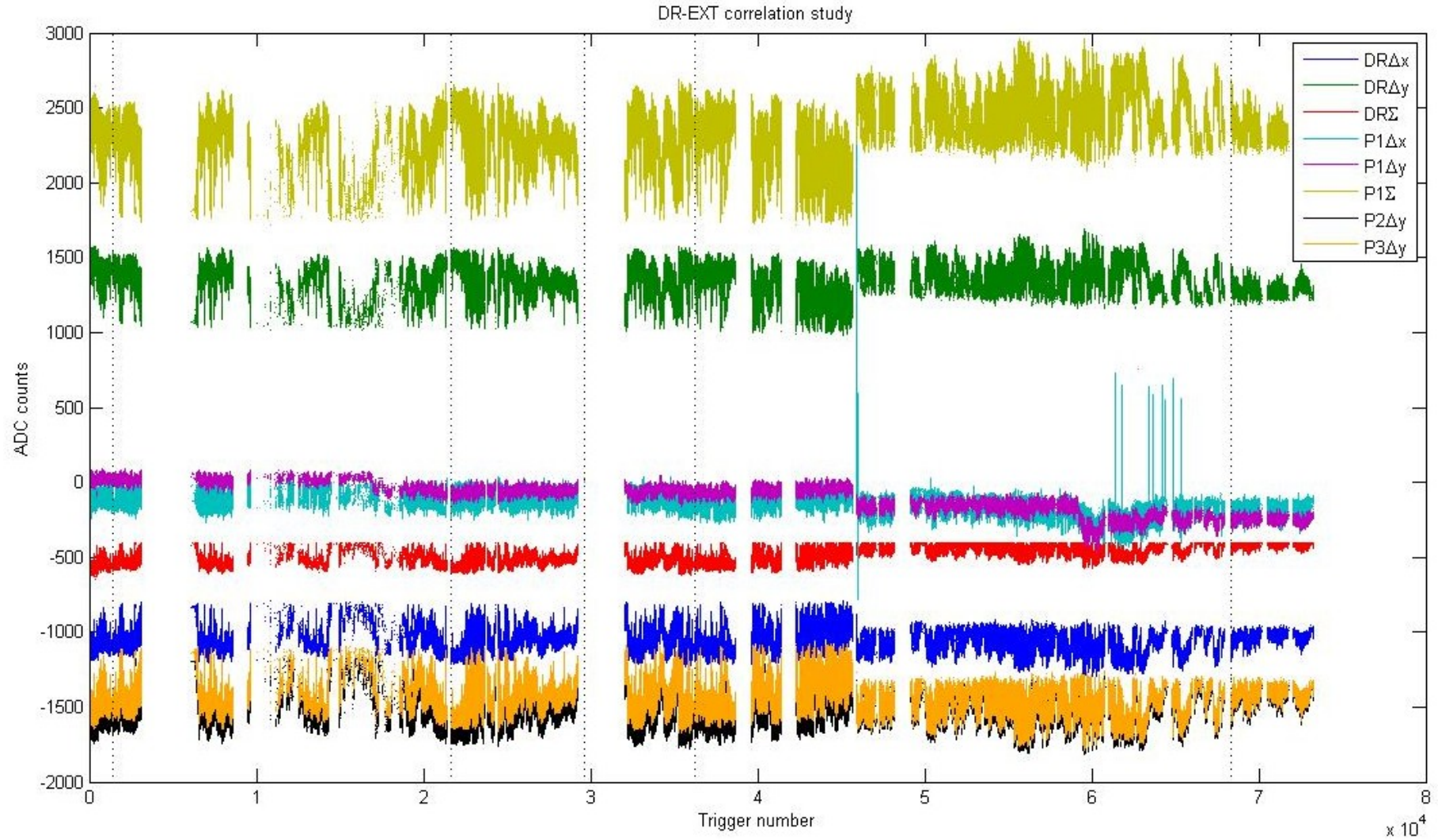
Last 19 DR turns + extraction





36 hours of parasitic data!

00:38 11:19 15:32 19:01 11:57



Correlations

	DRΔx	DRΔy	DR Σ	P1Δx	P1Δy	P1 Σ	P2Δy	P3Δy
DRΔx		-0.97	0.60	0.27	0.34	-0.93	0.97	0.99
DRΔy	-0.97		-0.62	-0.20	-0.24	0.90	-0.97	-0.98
DR Σ	0.60	-0.62		-0.22	-0.44	0.30	0.74	0.54
P1Δx	0.27	-0.20	-0.22		0.38	-0.38	0.14	0.27
P1Δy	0.34	-0.24	-0.44	0.38		-0.58	0.15	0.38
P1 Σ	-0.93	0.90	-0.74	-0.38	-0.58		-0.85	-0.96
P2Δy	0.97	-0.97	0.74	0.14	0.15	-0.85		0.96
P3Δy	0.99	-0.98	0.54	0.27	0.38	-0.96	0.96	

PRELIMINARY