Status of FONT5 feedback system beam tests

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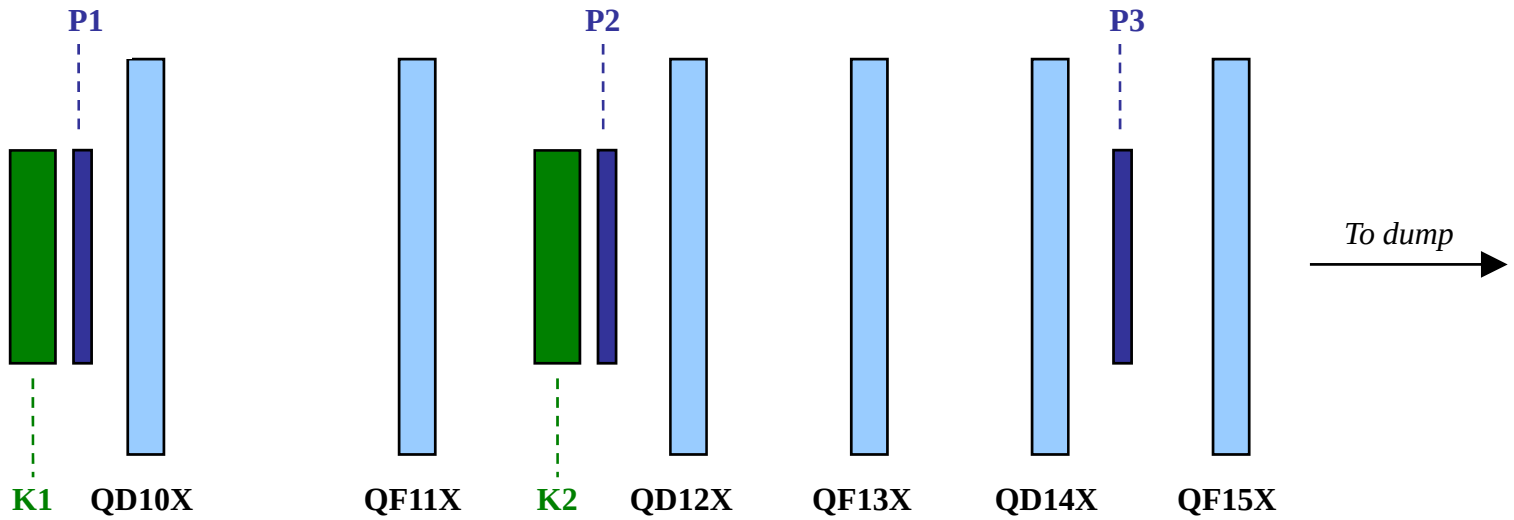
FONT5@ATF2

- There have been several iterations of the FONT system at ATF
- **FONT3**
  - All-analogue bunch-by-bunch feedback system
  - Single ATF extraction line stripline BPM disconnected and used in feedback loop
  - Feather adjustable gap stripline kicker
- **FONT4**
  - Configuration as with FONT3 but c.150ns bunch spacing
  - Digital feedback board sampled analogue front-end signals, ~120ns latency
  - Witness BPM signals used analogue processors – positions reconstructed offline
- **FONT5 system for ATF2 has been undergoing commissioning this run period**
  - 3 dedicated stripline BPMS
  - 2 dedicated stripline kickers
  - First fully-digitised FONT feedback and DAQ system

Installation

- 3 stripline BPMs and 2 fast kickers have been installed in the ATF2 extraction line



FONT P1-3:

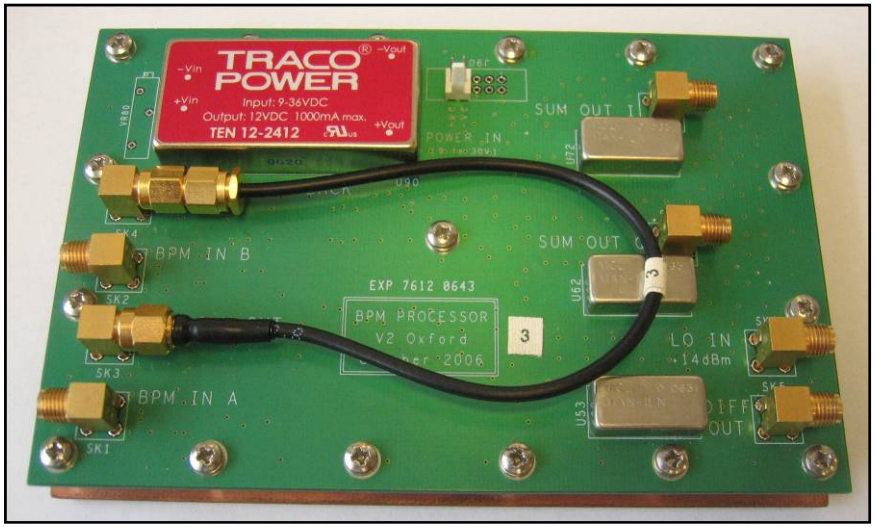
- Stripline BPMs made to existing ATF extraction line BPM specification

FONT K1-2:

- Current-driven stripline kickers from NLCTA
- Oriented to kick in the y-plane

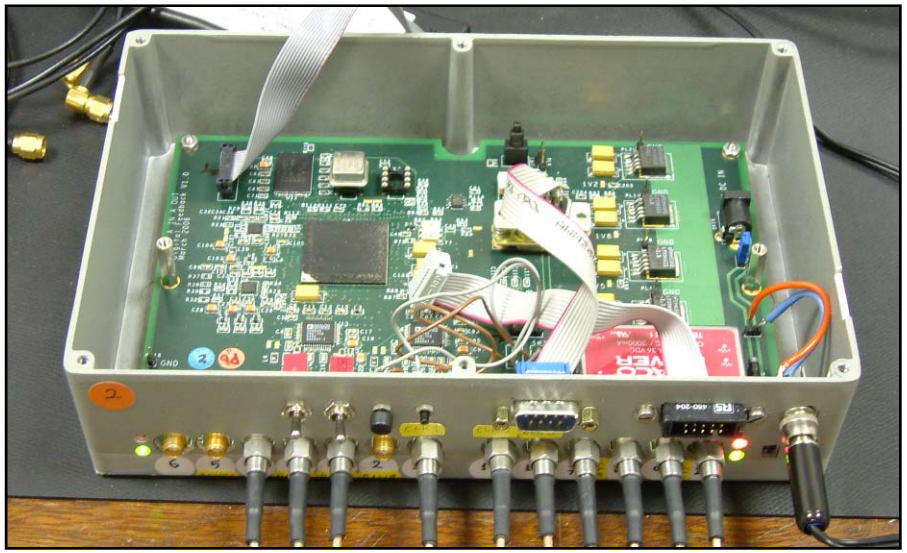
Stripline BPM Instrumentation 1

- **Analogue front end BPM processors**
  - FONT3 analogue processors
  - 714MHz LO based mixing scheme
  - Stripline signals mixed down to baseband
  - Hybrid produces sum and difference signals
  - ~1μm single-shot resolution



Stripline BPM Instrumentation 2

- **Digital feedback and DAQ board**
  - So far, using 3x FONT4 FB boards (will later describe next generation FB board)
  - Boards based around Xilinx Virtex 4 FPGAs
  - 2x Analogue Devices ADCs clocked at 89.25MHz per board
  - Sum and difference sampled on peak
  - **DAQ** - digitised signals made available pulse-by-pulse over ATF LOCAL network
  - **Feedback** – DAC gives inter-bunch FB signal based on normalised position

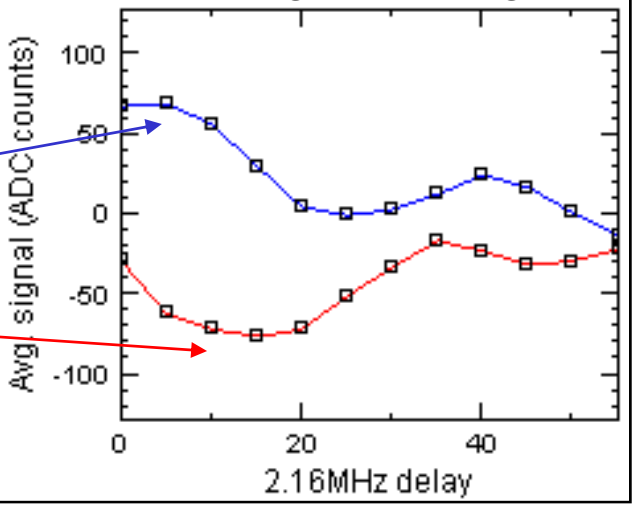


Digital sampling

- Feedback board digital sampling uses low latency clocked ADCs
- Sample-time accuracy and **stability** essential for successful operation
- Sample-time determined by several factors:
  - Virtex4 FPGA clocked at 357MHz derived externally from the 714MHz LO
  - ADC clock 357/4 generated on FPGA
  - Both extraction kicker fire and 2.16MHz ring clock are used
  - Extraction kicker fire selects ‘filled’ 2.16MHz cycle
  - Start of sampling pattern is set in units of 2.8ns with respect to ring clock edge
  - FPGA input delays allow fine tuning in 70ps taps

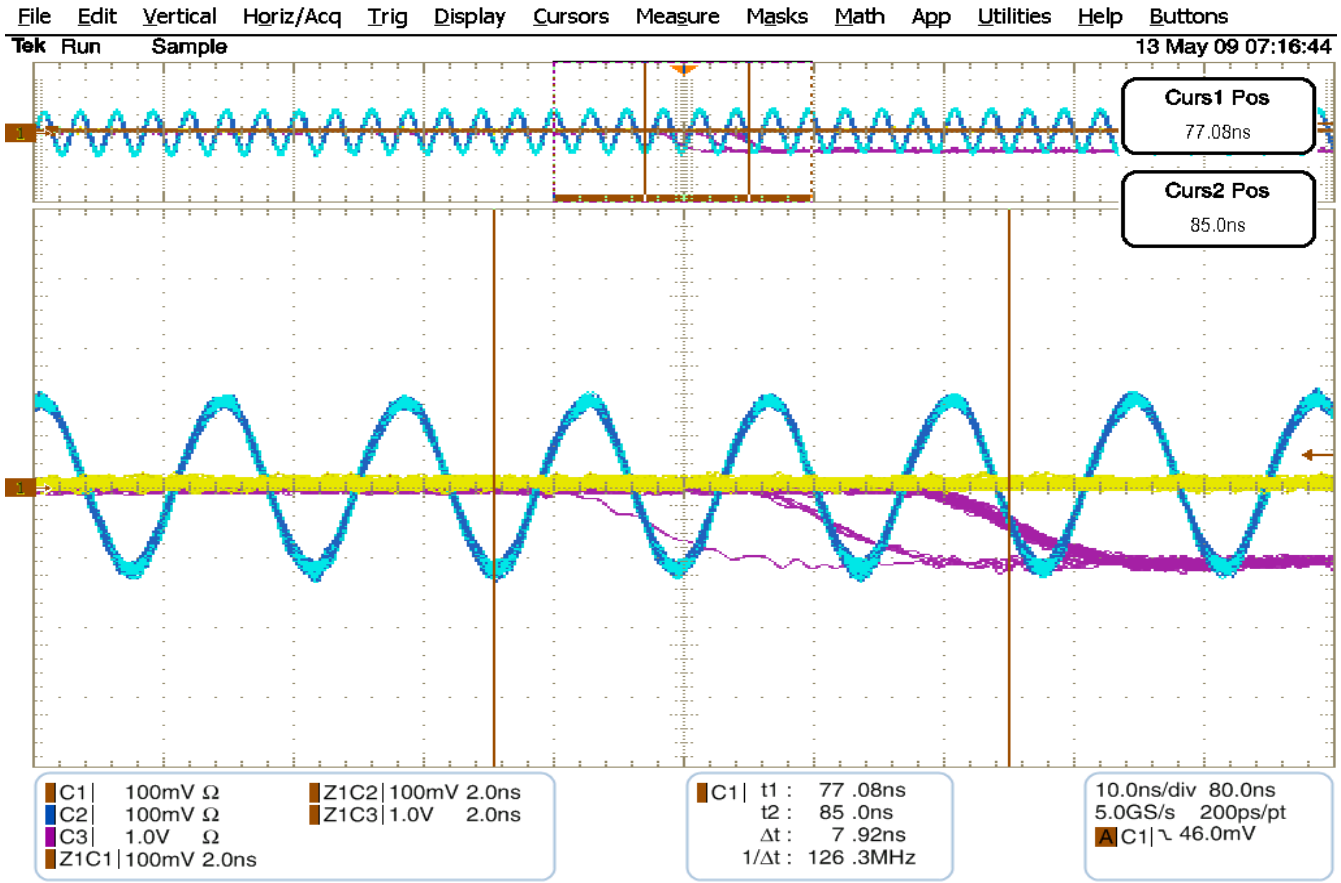
Sample-time scan over +ve difference

Sample-time scan over -ve sum



Timing signal problems 1

- We have seen instability of the 2.16MHz ring clock with respect to the beam
- This fault is intermittent, and can sometimes vanish for days before reappearing
- The jumps below are of 2.8ns, and translate into 2.8ns jumps in ADC sample-time



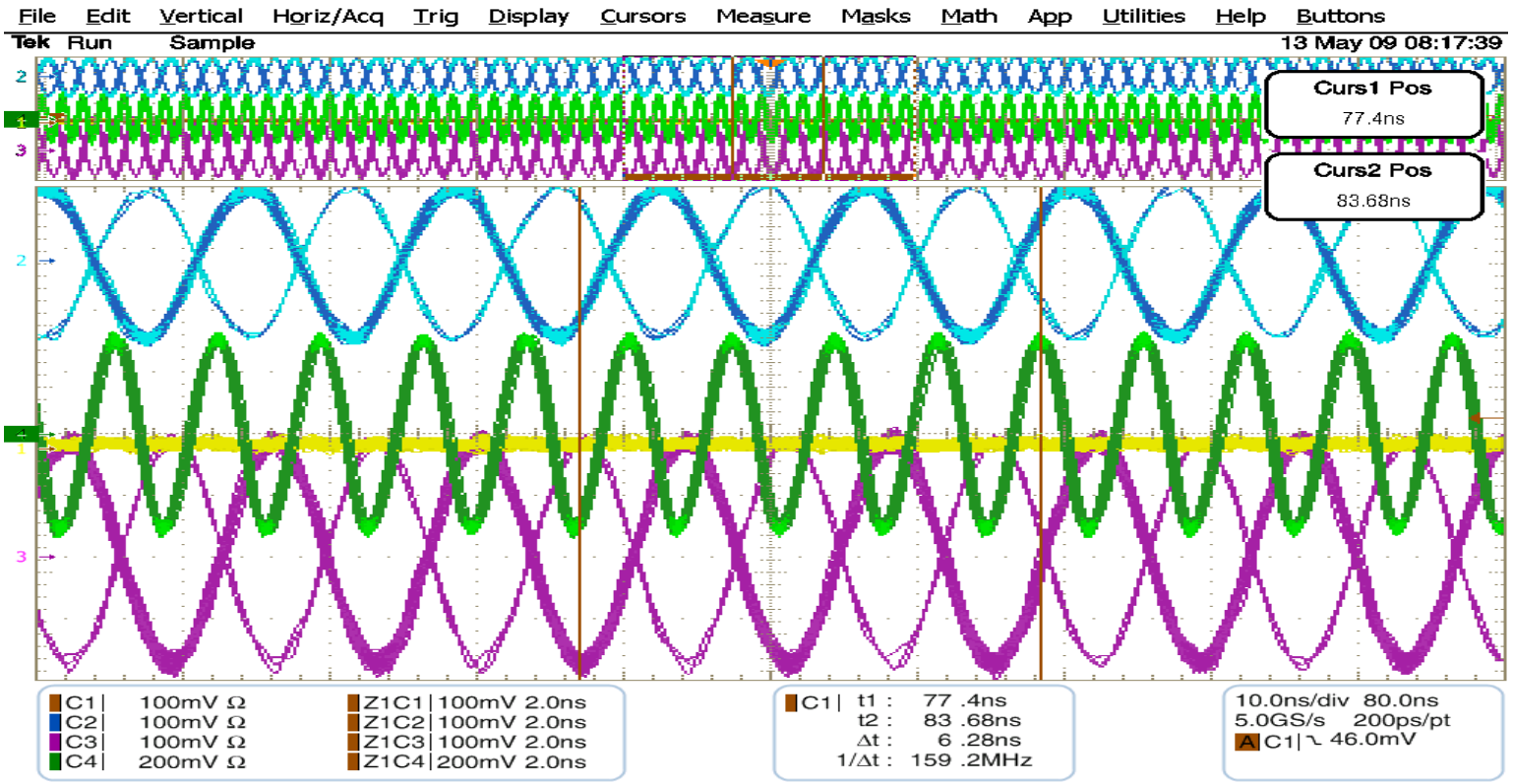
FONT 357MHz

Stripline

2.16 MHz edge

Timing signal problems 2

- 180º phase jumps in 357MHz also causing FONT ADC sample time errors
- FONT and cavity BPM independently derive 357MHz from the 714MHz optical line to the power supply room
- Both 357MHz signals show **correlated** phase jumps with respect to stripline
- Implies a common cause – 714MHz. We have temporarily replaced machine LO



Cavity BPM 357MHz

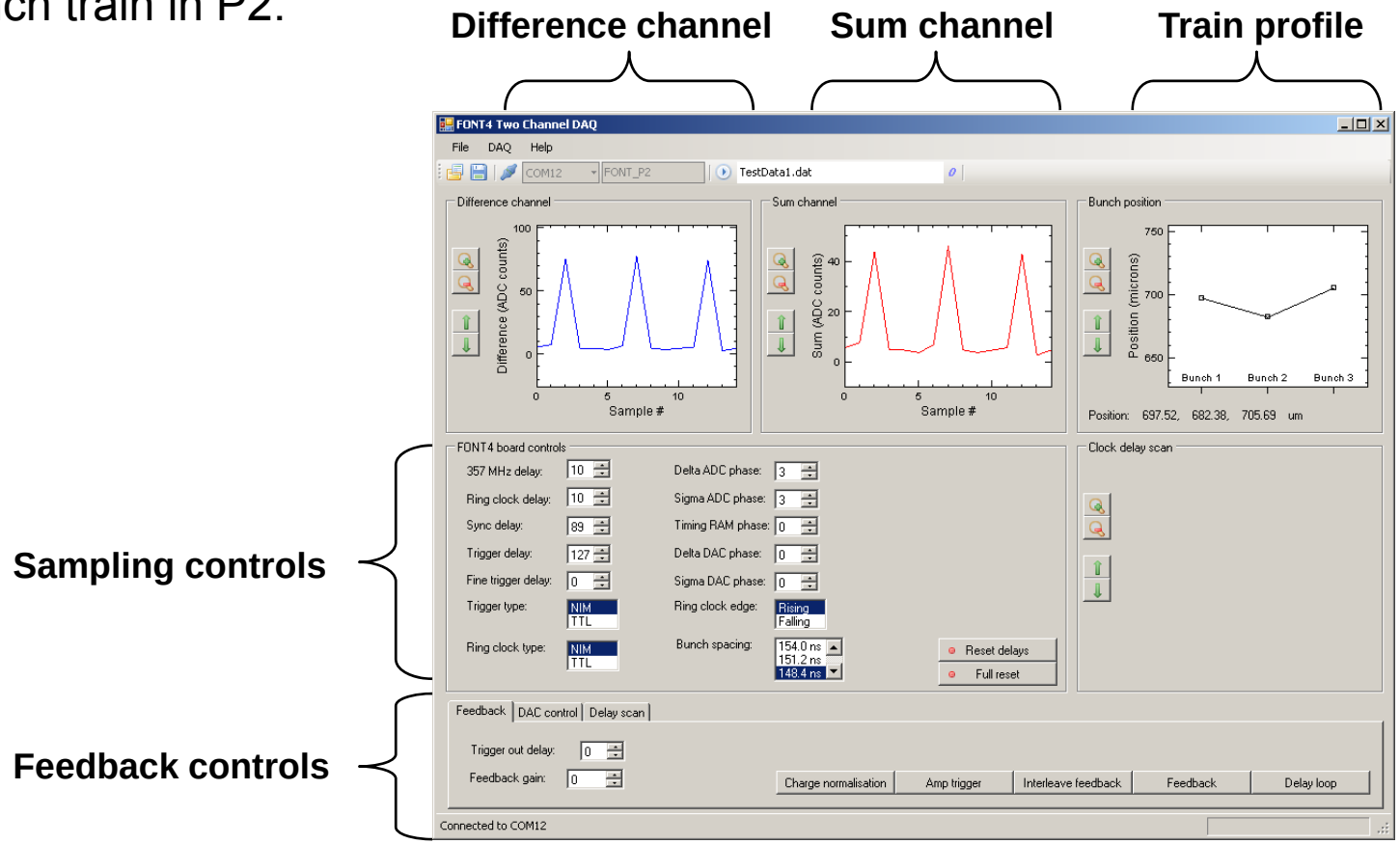
Original 714MHz

Stripline

FONT 357MHz

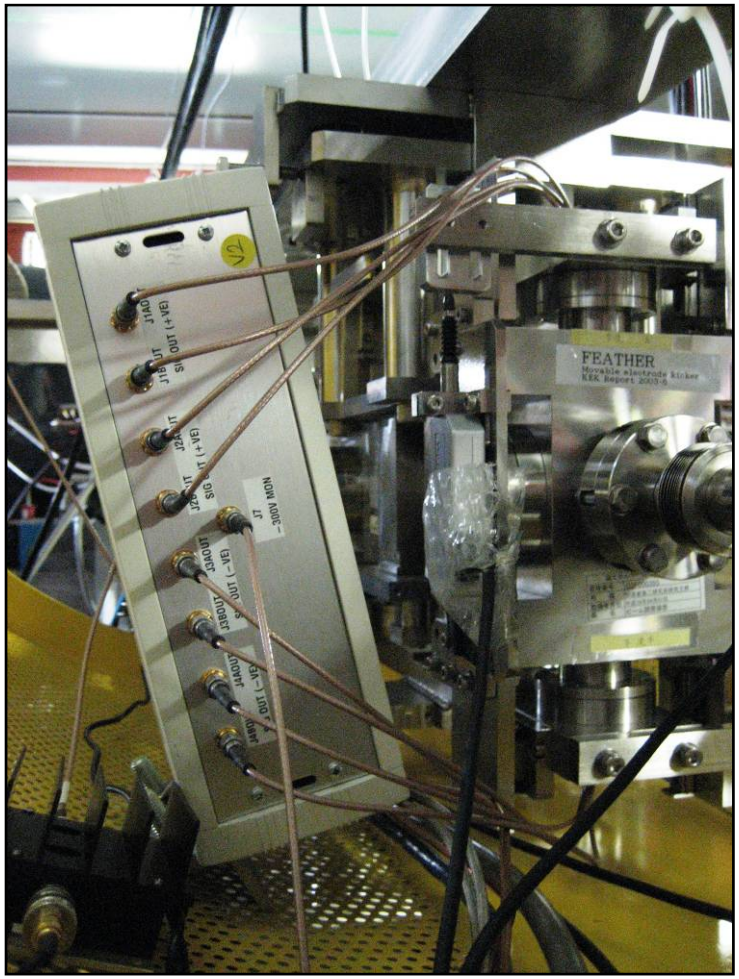
New DAQ firmware/software

- The three BPM sum and difference channels are digitised
- Updated firmware brings data onto ATF LOCAL via RS232 (pulse-by-pulse)
- FB board control and DAQ accomplished via new software interface (C++/CLI)
- Example 3-bunch train in P2:



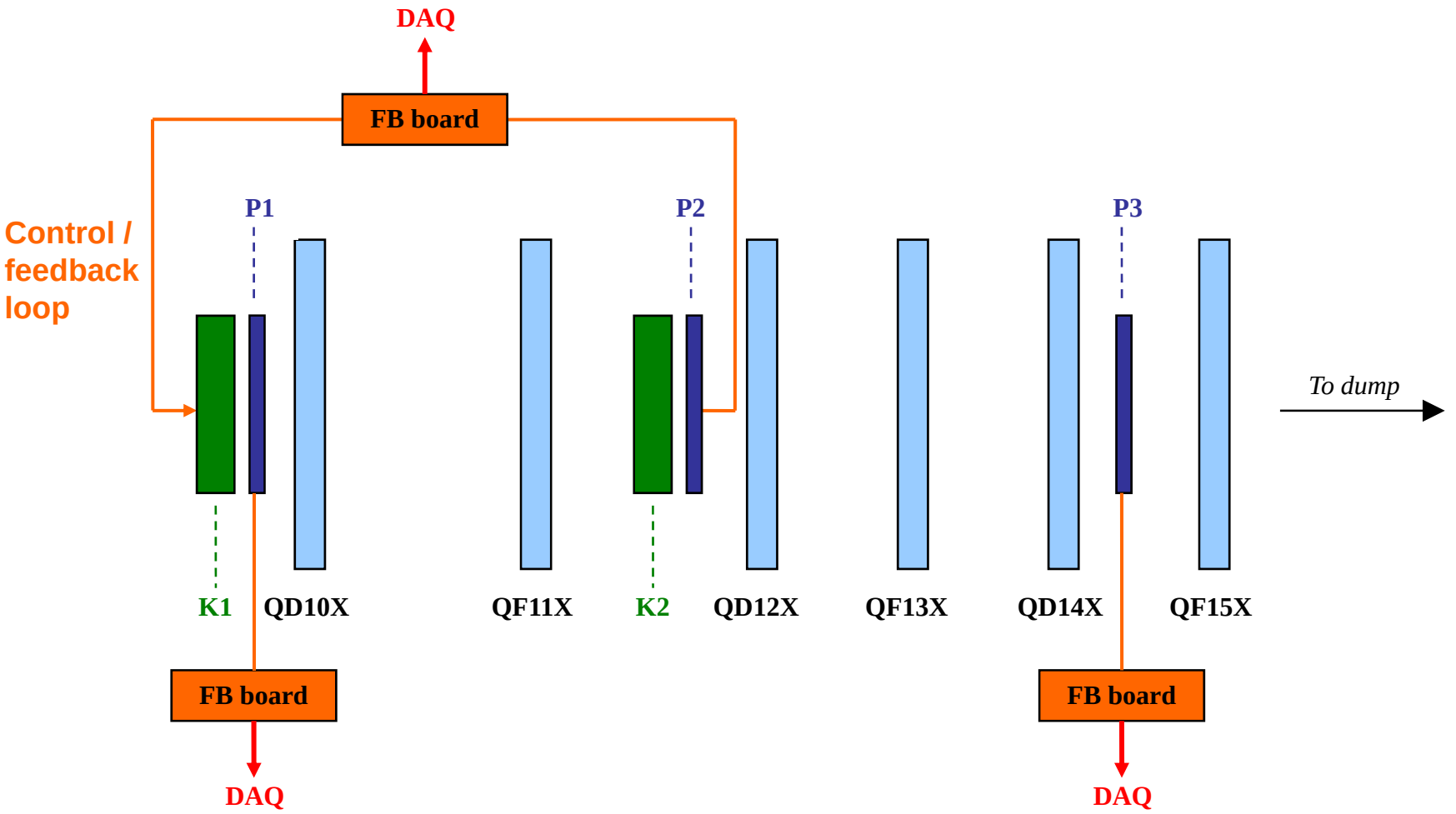
Stripline kickers

- Fast fixed-gap stripline kickers from NLCTA
- Kicker amplifiers commissioned from TMD Technologies Ltd (UK)
- Strips current-driven
- Amplifiers approx. ±35 Amps full-scale



FONT5 test configuration for this run

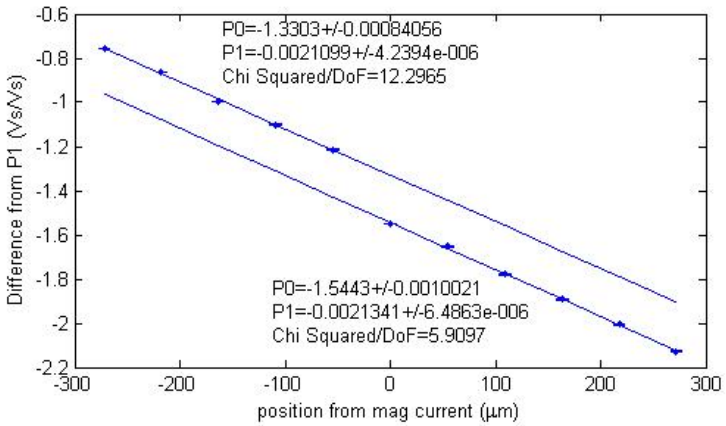
- P1 and P3 are witness BPMs – FB boards used for DAQ
- P2 FB board is used for both DAQ and control of K1 whilst K2 is unused
- Data taken in single-bunch mode



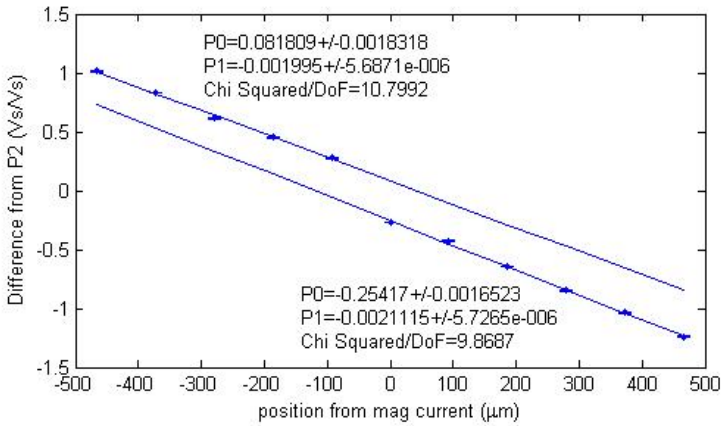
BPM calibration

- Scans of the ZV6X corrector are giving consistent calibrations across the 3 BPMs

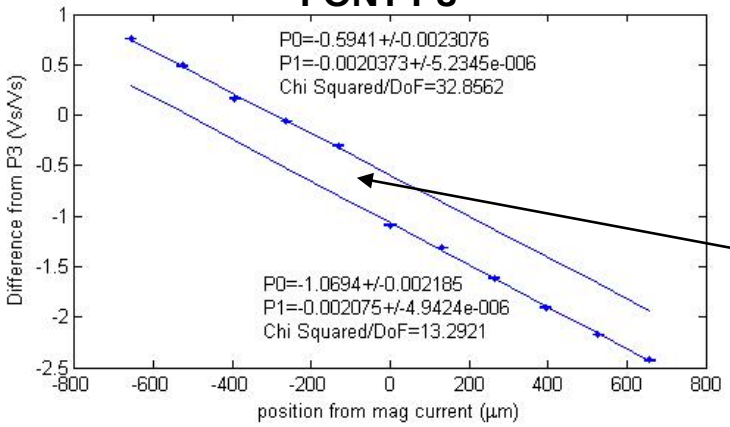
FONT P1



FONT P2



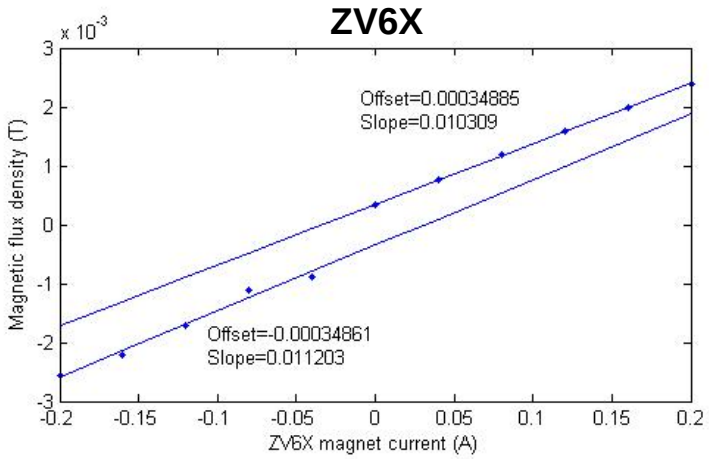
FONT P3

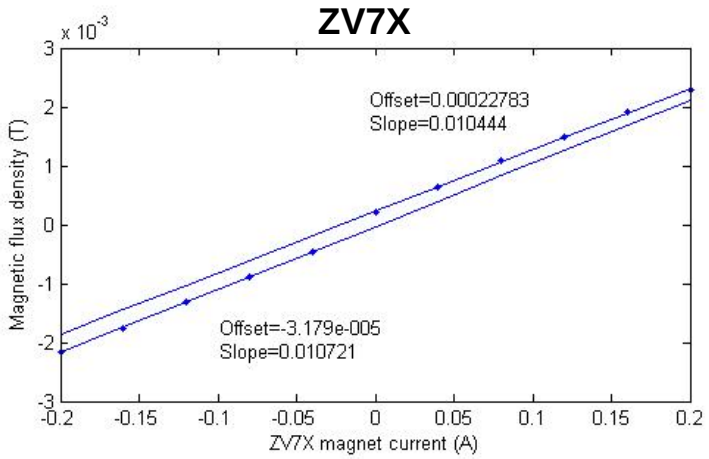


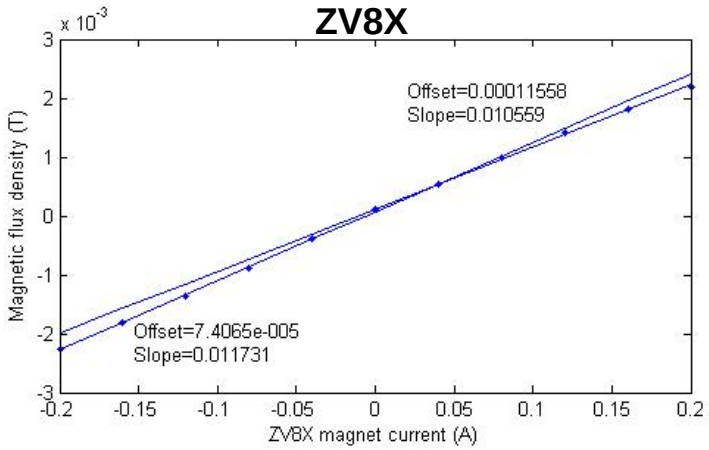
Note discontinuities

BPM calibration: corrector B-field measurements

- Checked linearity of three corrector fields with Hall probe
- Some correctors show jumps in field strength for +ve and –ve currents

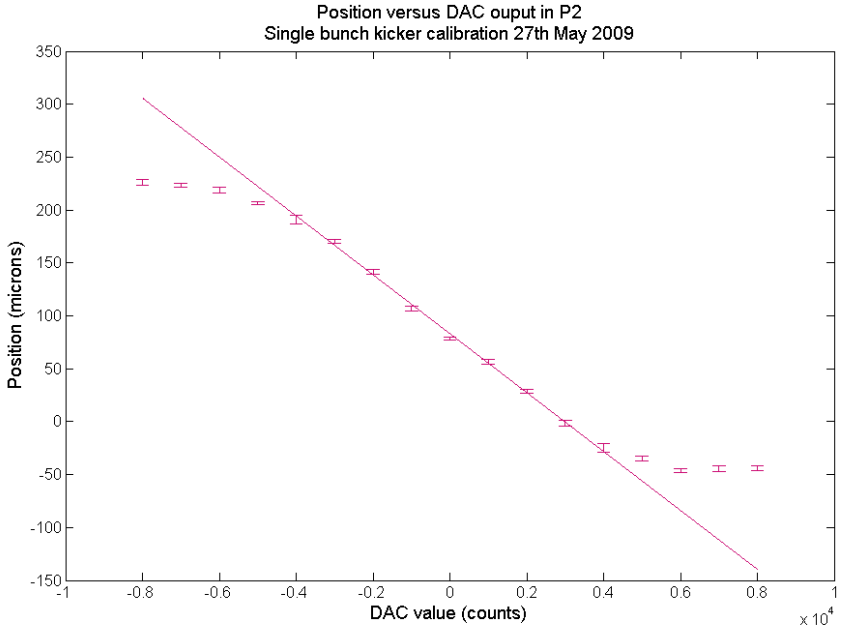


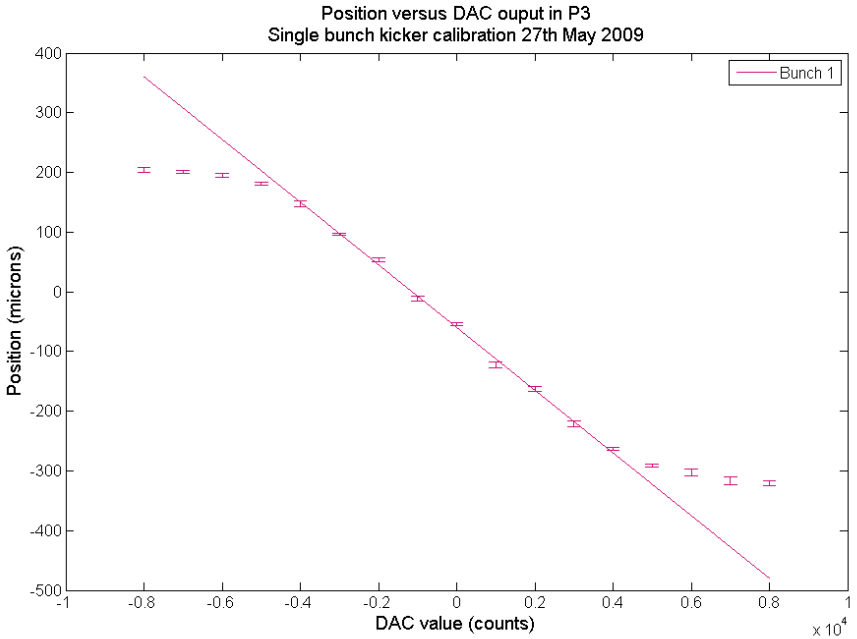




Kicker calibration

- Constant currents were fed to the K1 kicker using the P2 FB board DAC





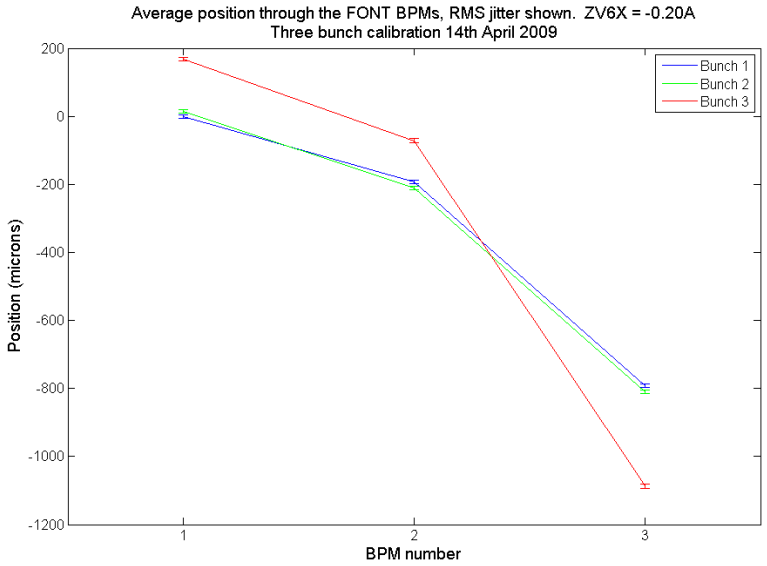
- Response linear in expected region
- Corresponds to ±40 micro-radian maximum deflection

Bunch charge level

- In recent months ‘normal’ bunch intensity seems about 0.2×10^{10}
- This has been varied considerably around $0.1 - 0.3 \times 10^{10}$
- By spending a fair amount of time tuning we often reach 0.5×10^{10}
- At these charges, we have resolution estimates at the few micron level
- For future resolution studies and feedback operation we would aim for $\sim 1 \times 10^{10}$
- This never seemed a problem in the past
- Perhaps we’re missing a necessary trick?

Three-bunch extraction issues

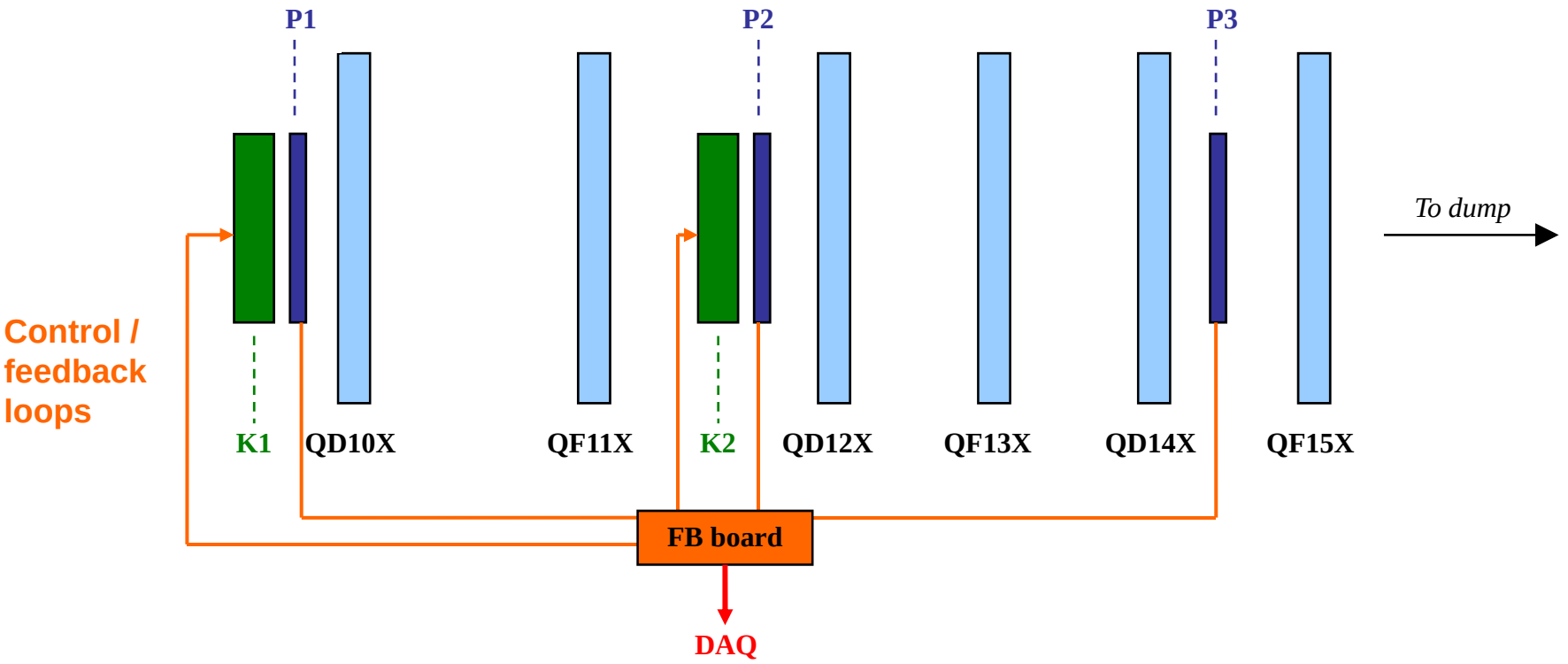
- For feedback tests, we extract three bunches with c.150ns bunch spacing
- We have been having difficulty extracting three bunches onto the same orbit



- Bunch 3 consistently refuses to follow bunches 1 & 2 regardless of ext. kicker timing
- Next run period, FONT will perform a systematic investigation of 3-bunch extraction
- Comments and suggestions from interested parties are welcome!

FONT5 digital feedback board 1

- The next-generation FONT5 digital feedback board is on order
- We expect to have it in the lab in two weeks
- The board has 9 ADC channels, and is based around a Xilinx Virtex5 FPGA
- A single board will control the entire FONT5 installation, i.e:



FONT5 digital feedback board 2

- Single point of DAQ simpler to manage
- 3 channels per BPM allow digitisation of the sum signal plus both x- and y- plane differences
- All BPM signals are monitored by the same FPGA
- Either kicker's FB signal may be function of any/all BPM signals
- Allows for multi-BPM feedback algorithms, e.g:
    - Position and angle correction in one plane
    - Two-kicker position correction for greater range
- More complex algorithms possible depending on jitter characteristics
- Tests commence in October

Summary

- Independent FONT installation (3 BPMs, 2 kickers) complete
- BPMs instrumented with analogue front-ends and digital feedback boards
- Feedback boards drive kicker amplifiers giving ±40 micro-radian kick
- DAQ system running reliably
- Calibration of BPMs, kickers sensible and consistent
- However:
    - Still seeing jumps in ring clock – beam timing
    - Unable to generate stable 357MHz from machine LO
    - Third extracted bunch does not follow the first two
- Next run period we will:
    - Install new FONT5 9-channel feedback board
    - Investigate three-bunch extraction
    - Run tests of multi-BPM feedback algorithms