Latest Beam Test Results

of FONT4 ILC Intra-train Feedback Prototype

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Feedback On Nanosecond Timescales

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SLAC, KEK, DESY, CERN

Beam-based feedback for LC

- **ILC luminosity goal 10**34 / cm**2 / s**

  3000 or 6000 bunches, spacing 150 - 300ns

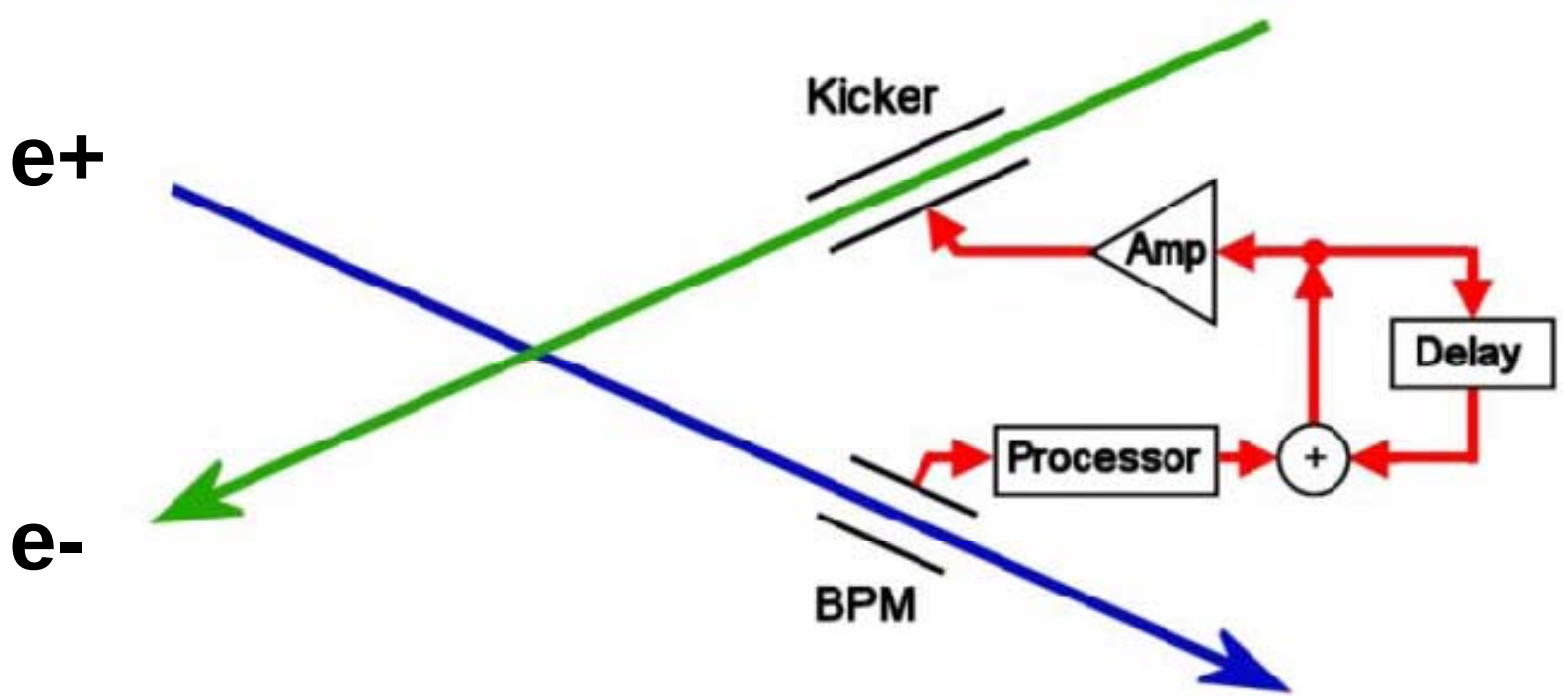
  → DIGITAL FB approach

- **CLIC luminosity goal 10**35 / cm**2 / s**

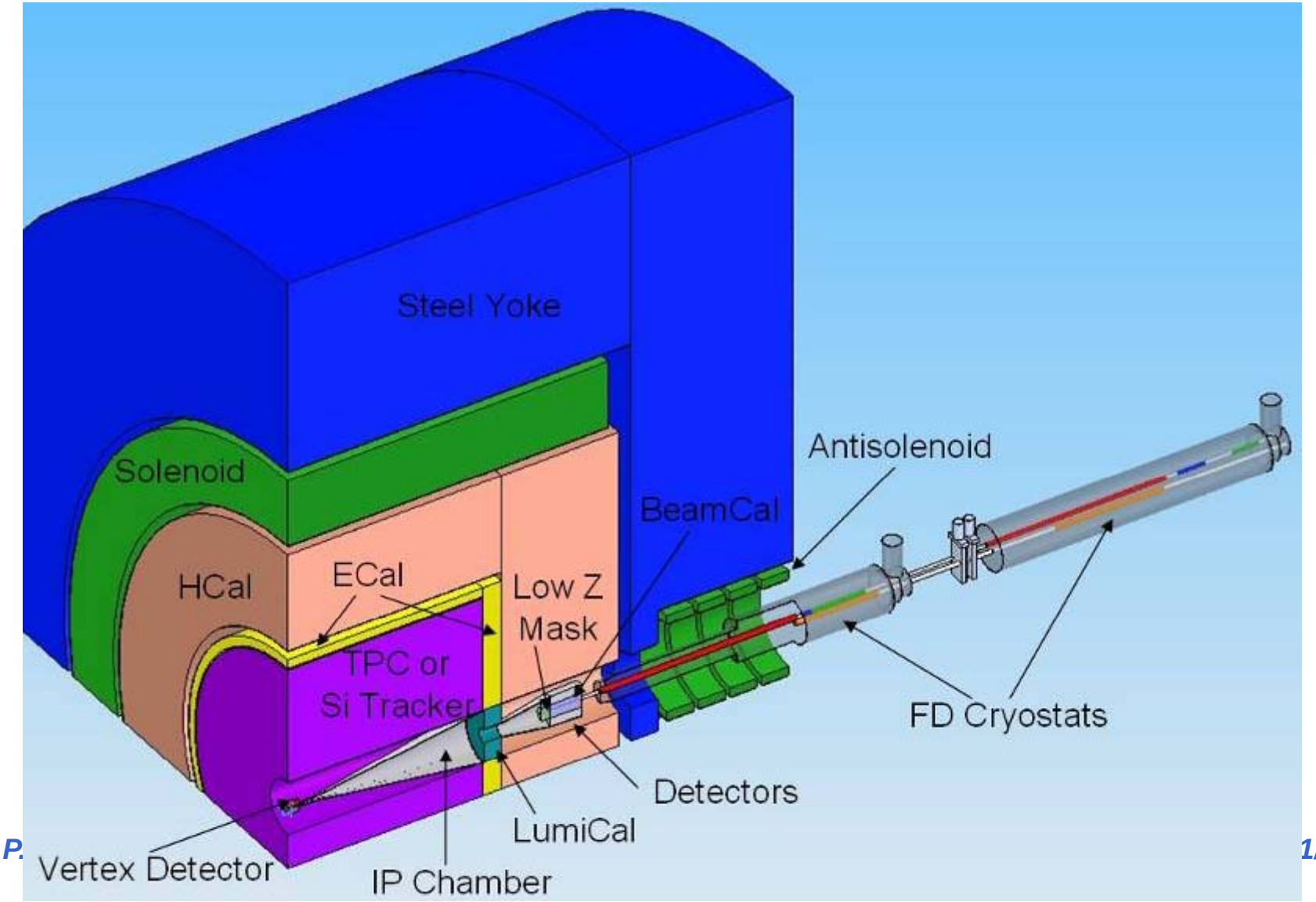
  c. 100 bunches, spacing c. < 1ns

  → ANALOGUE FB approach

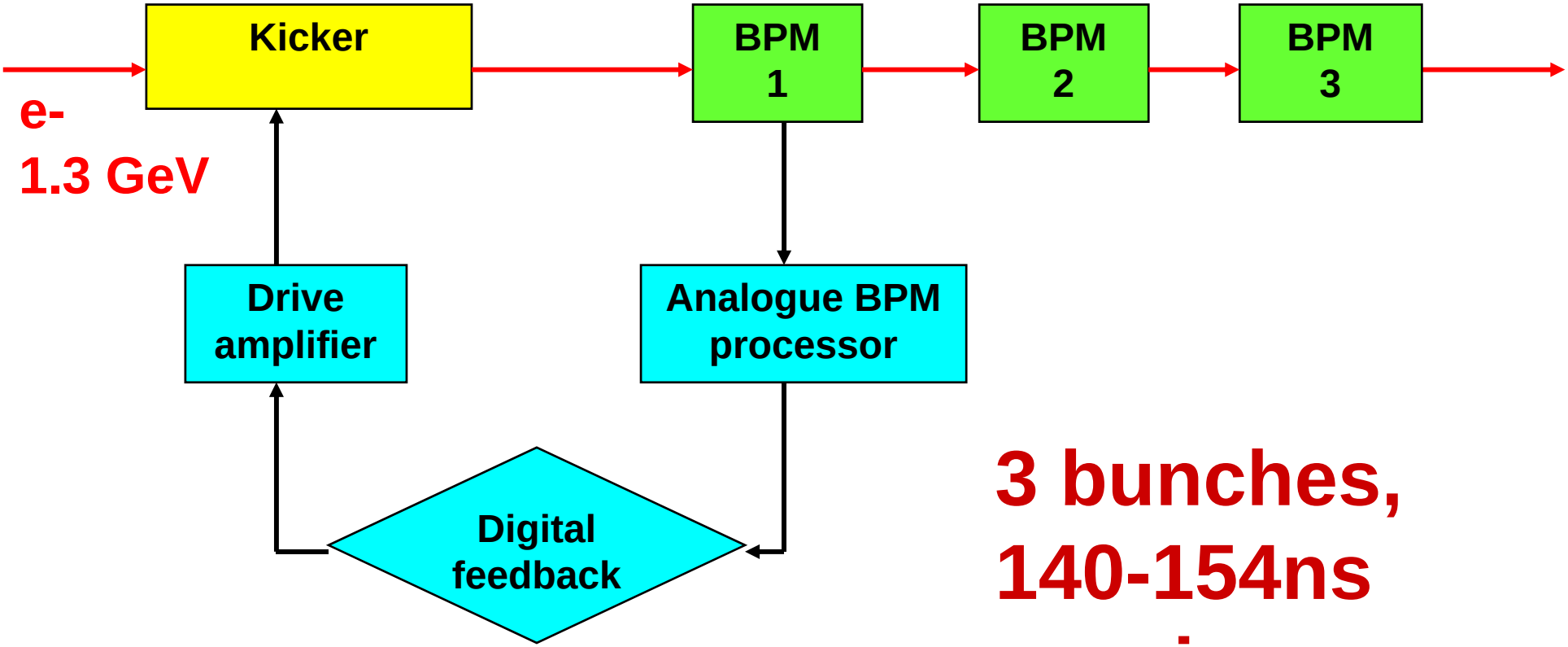
IP beam-based feedback for LC



Real engineering TBD

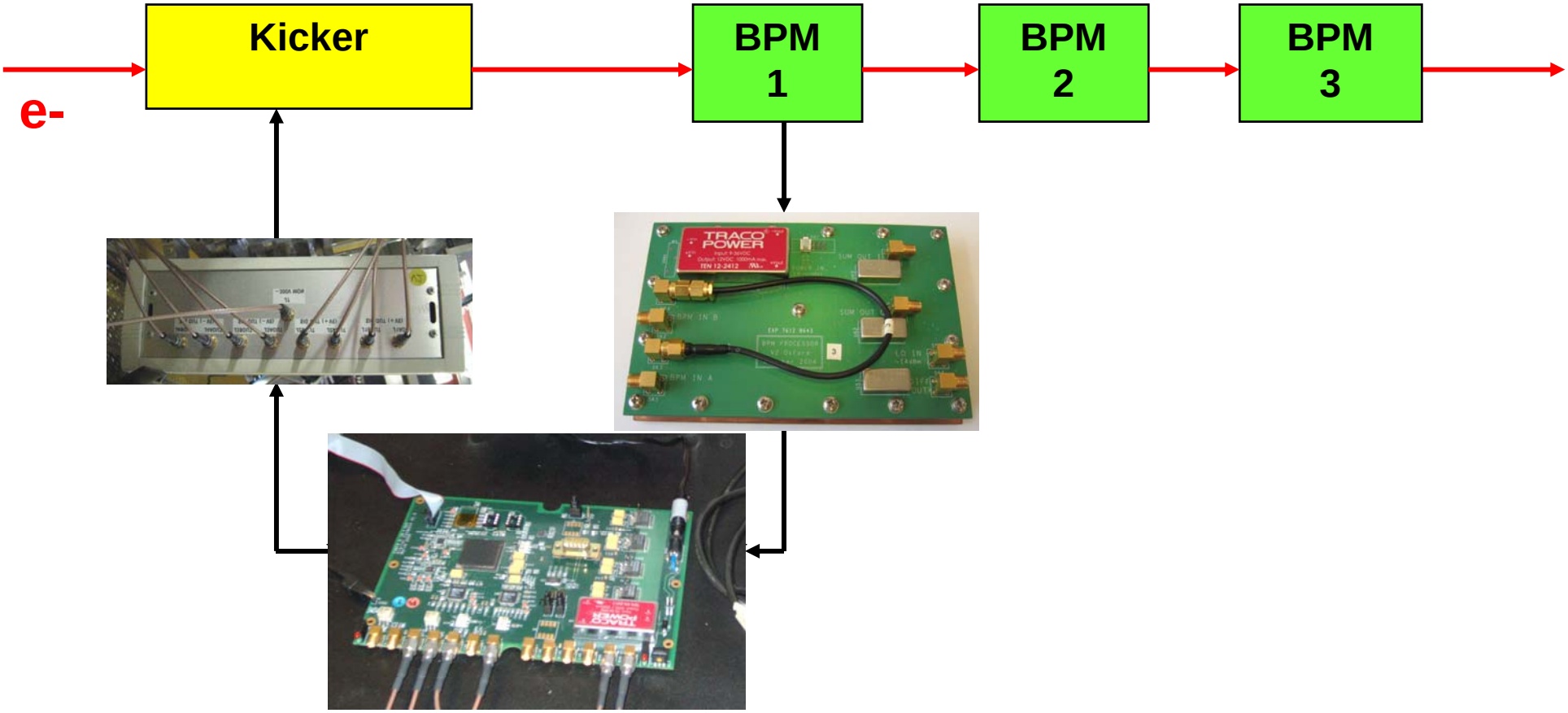


FONT4 ILC prototype at KEK/ATF

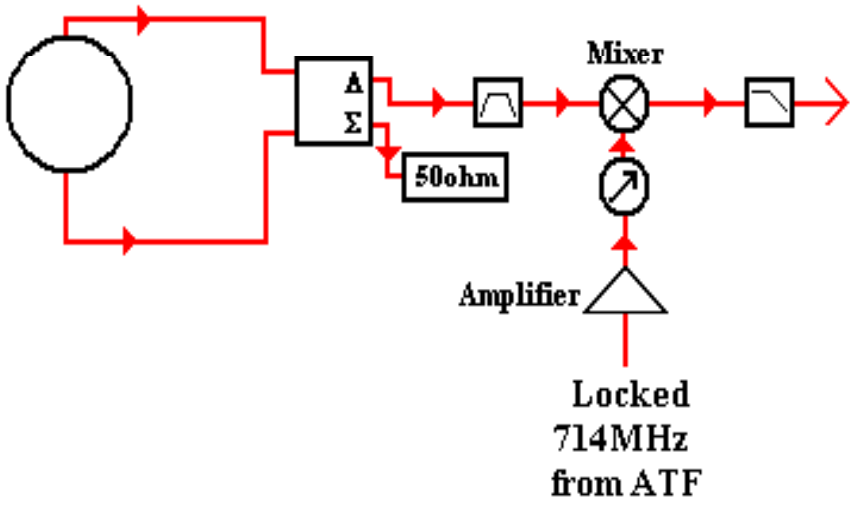


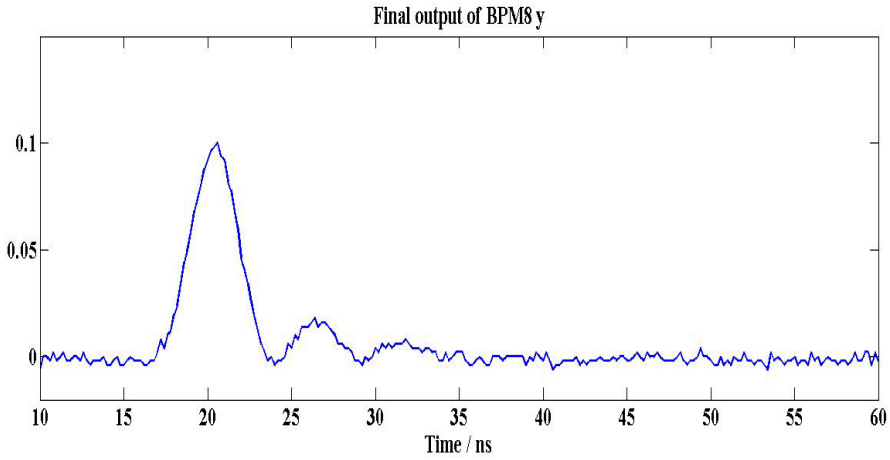
3 bunches, 140-154ns spacing

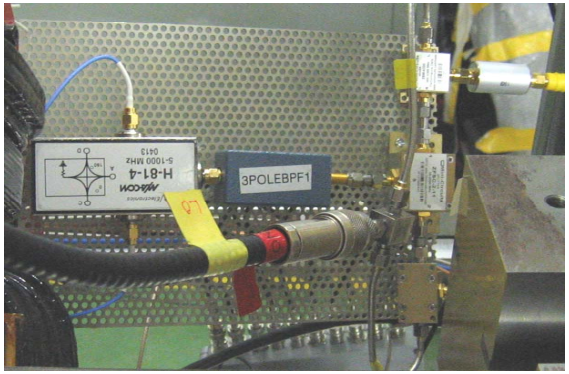
FONT4 ILC prototype at KEK/ATF



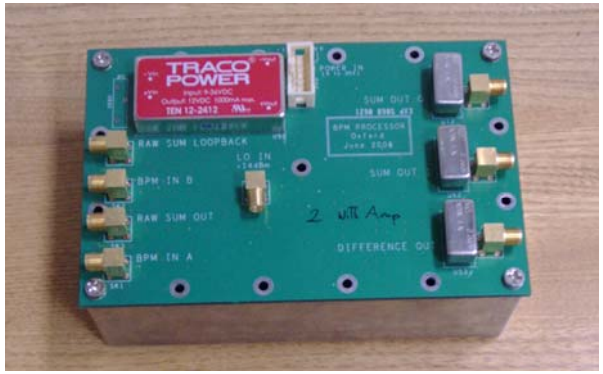
BPM processor







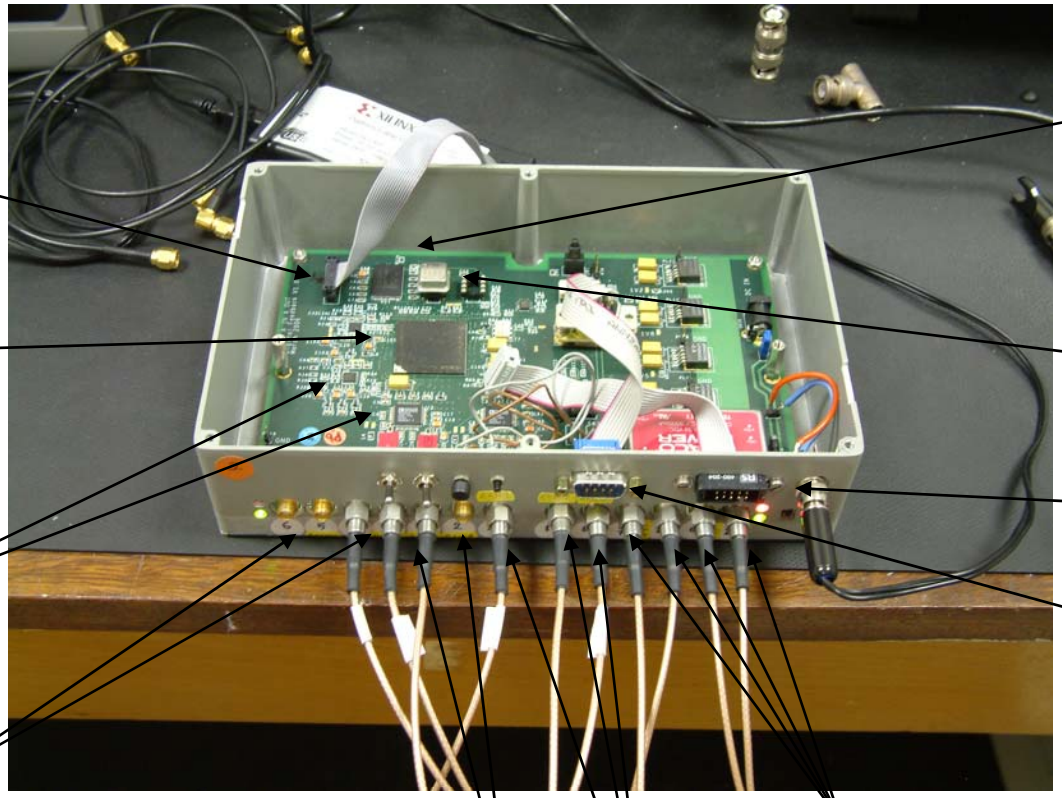
2005



2006

2007

Digital Feedback Board



Kicker driver amplifier

Specifications:

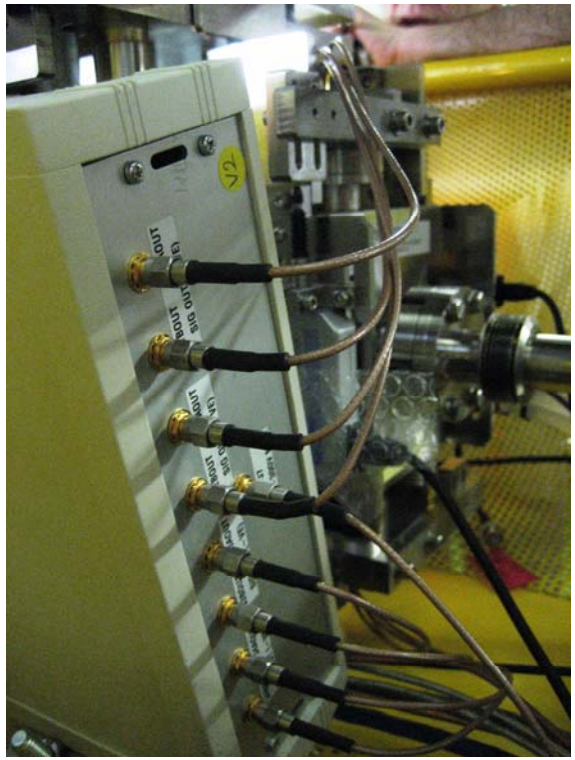
- **+- 15A (kicker terminated with 50 Ohm)**
- **+- 30A (kicker shorted at far end)**
- **35ns risetime (to 90%)**
- **pulse length 10 us (specified for 20-60 bunches)**
- **repetition rate 10 Hz**

Outline design done in Oxford

Order placed with TMD Technologies Sept 06

Two prototype units delivered Dec 06

Tested numerous times with beam in 2007 and 2008



Latency estimate

- Time of flight kicker – BPM: 4ns
- Signal return time BPM – kicker: 10ns

  Irreducible latency: 14ns

- BPM processor: 10ns
- ADC/DAC (3.5 89 MHz cycles) 40ns
- Signal processing (9 357 MHz cycles) 28ns
- FPGA i/o 3ns
- Amplifier 35ns
- Kicker fill time 3ns

  Electronics latency: 119ns

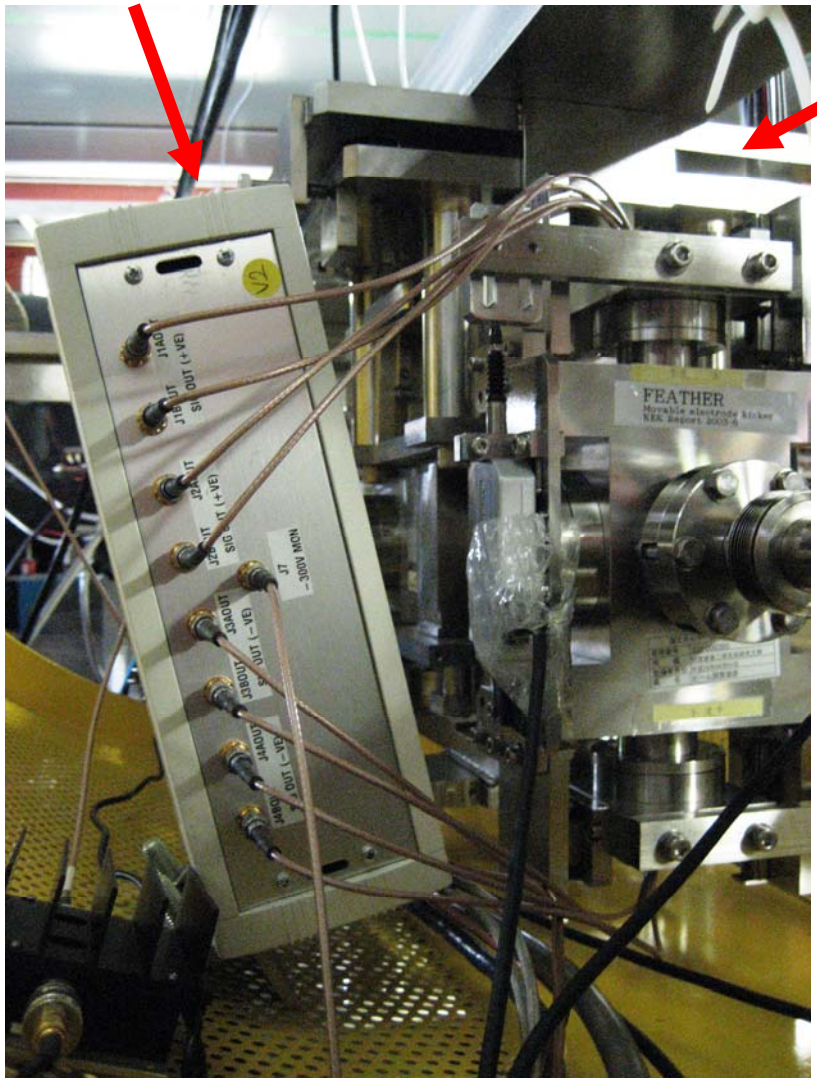
- Total latency budget: 133ns

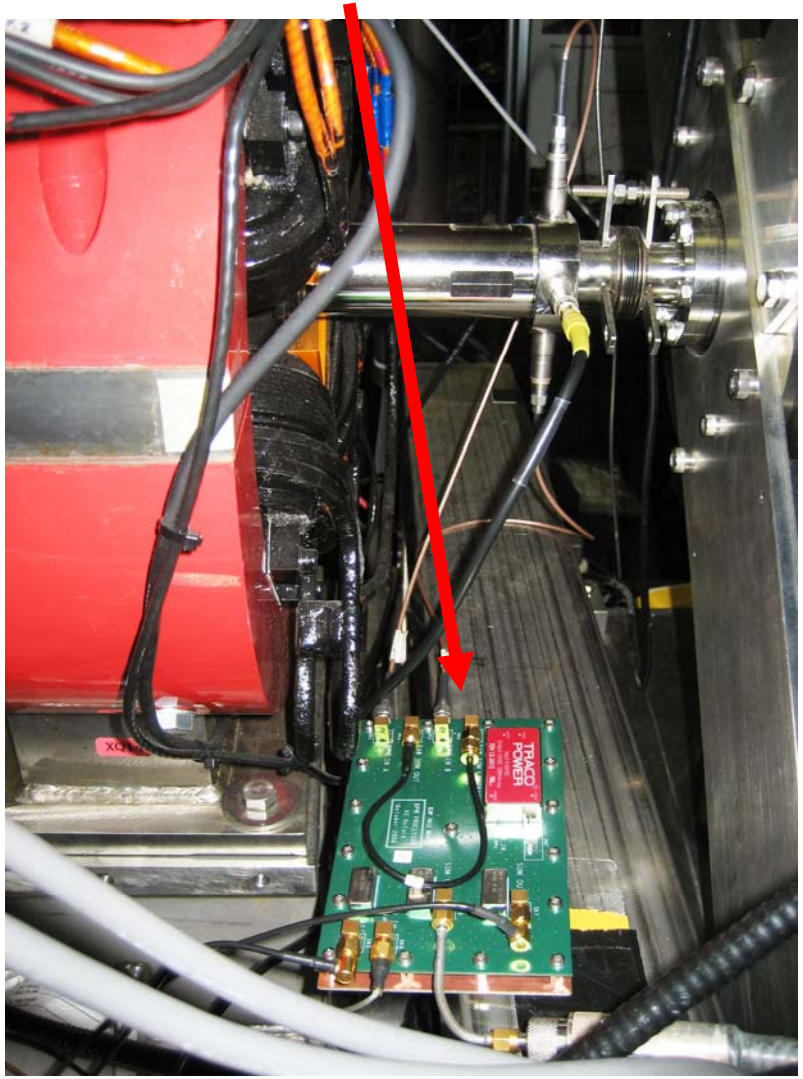
FONT beamline section

Amplifier

FEATHER
Kicker

BPM processor board





May 2008 Feedback Tests

1. **Beam in fixed position: vary FB loop gain**

2. **Vary incoming beam position: optimise FB gain**
   nominal +-150 um range around zero

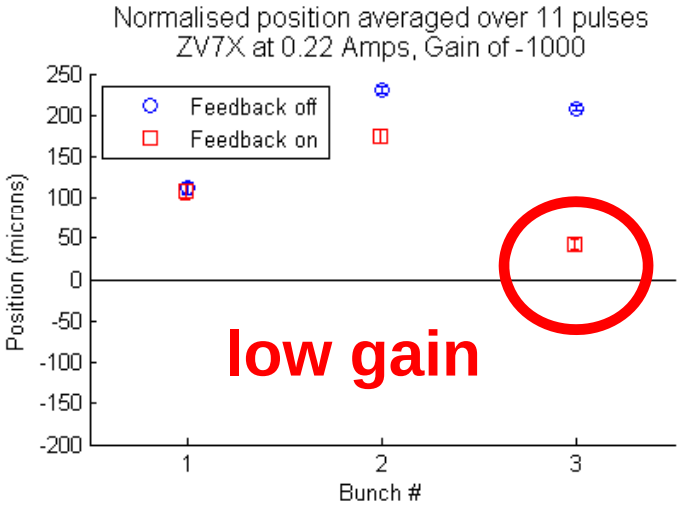
3. **Leave beam free-running and correct w. optimal gain**

- **gain settings: 1000 (low), 1500 (medium), 1700 (high), 2000 (v. high)**

- **Two modes of feedback:**
  no delay loop, with delay loop

- **Data analysis in progress – all results preliminary!**

Example (1) of May 2008 Results



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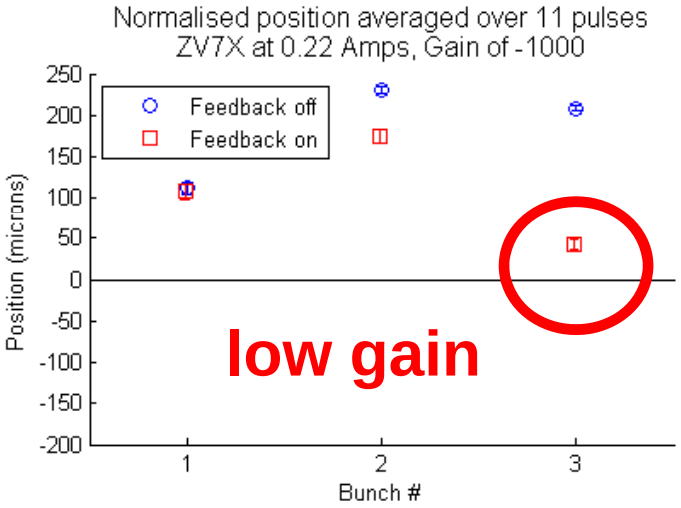

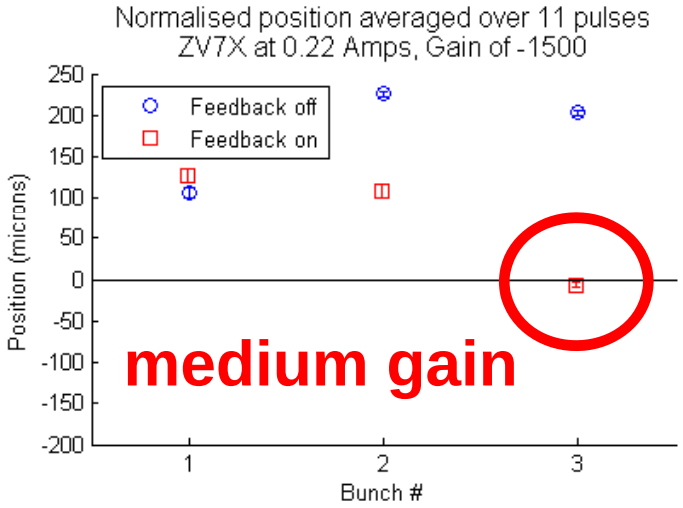

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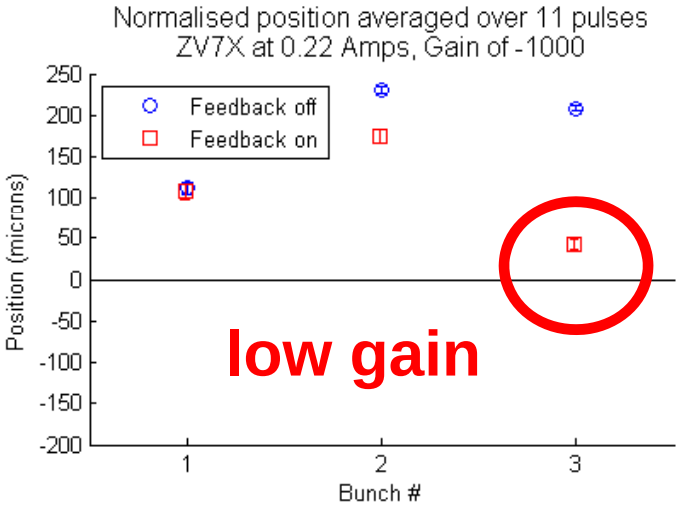
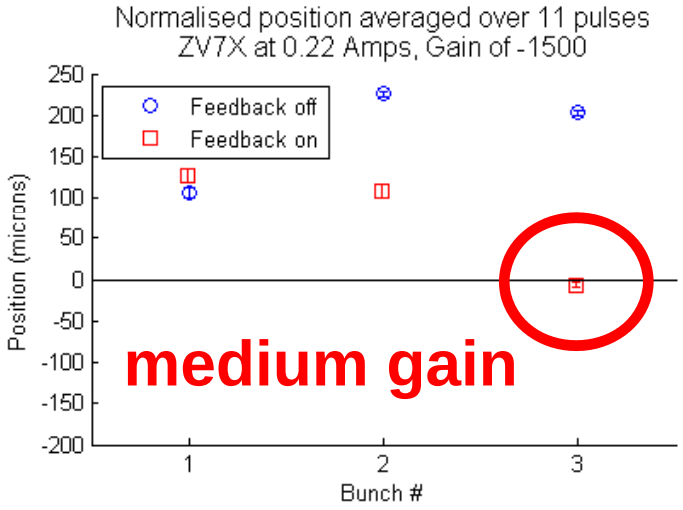
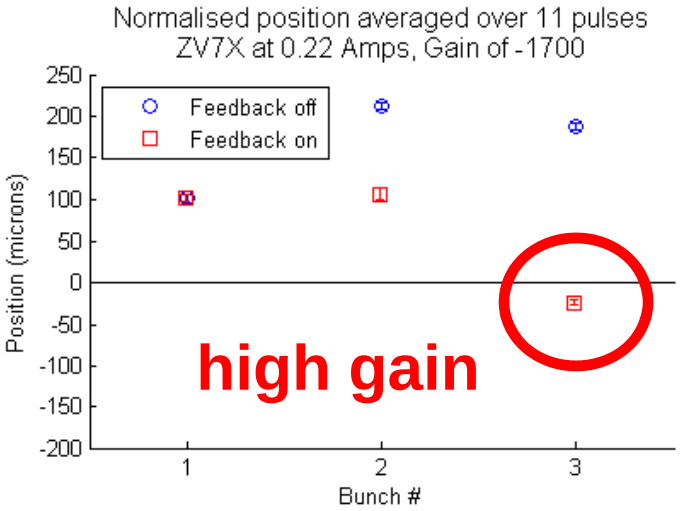
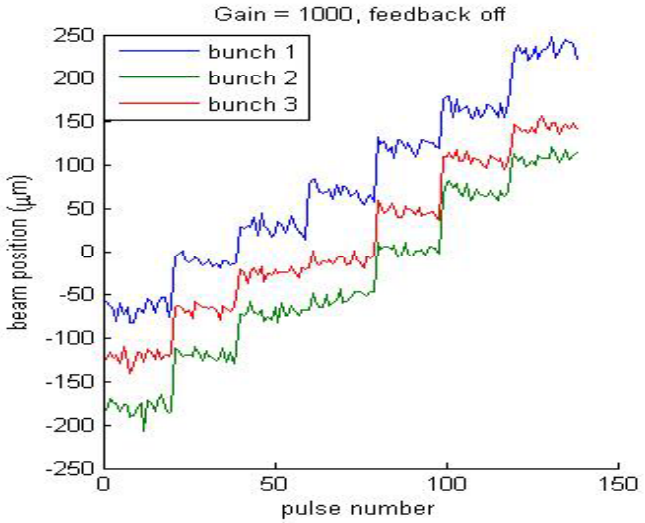
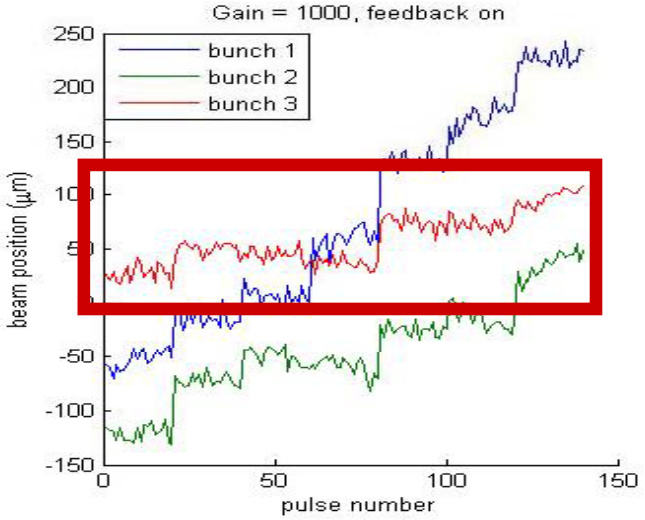






Example (2) of May 2008 Results





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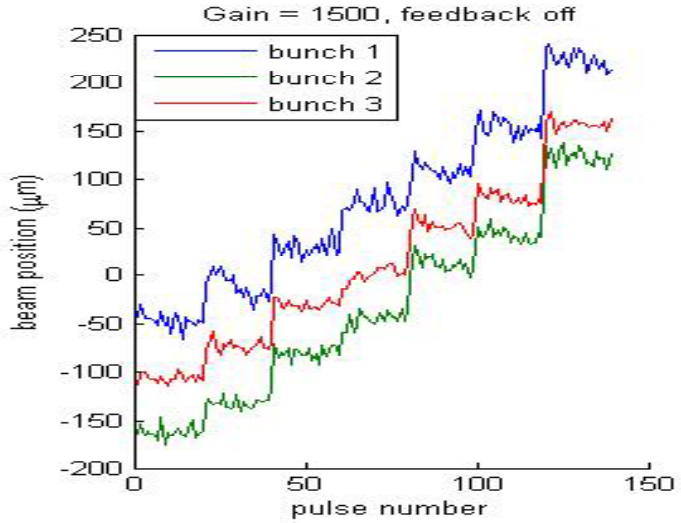

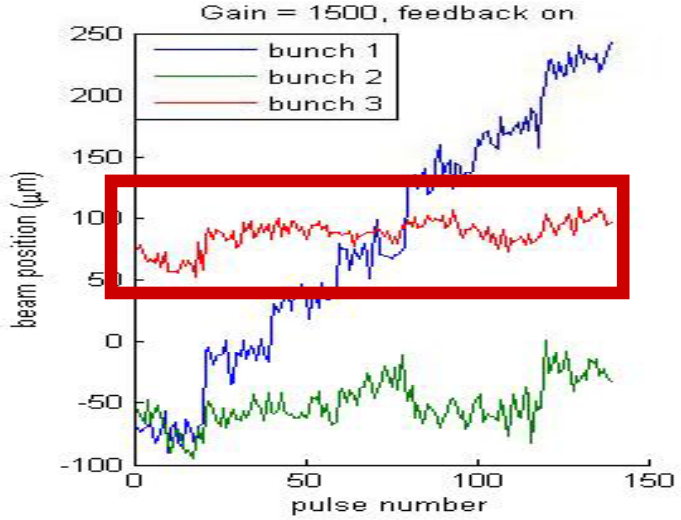

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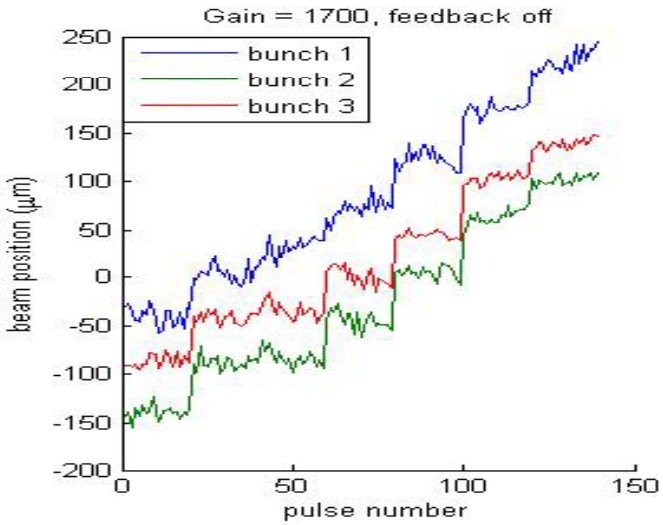
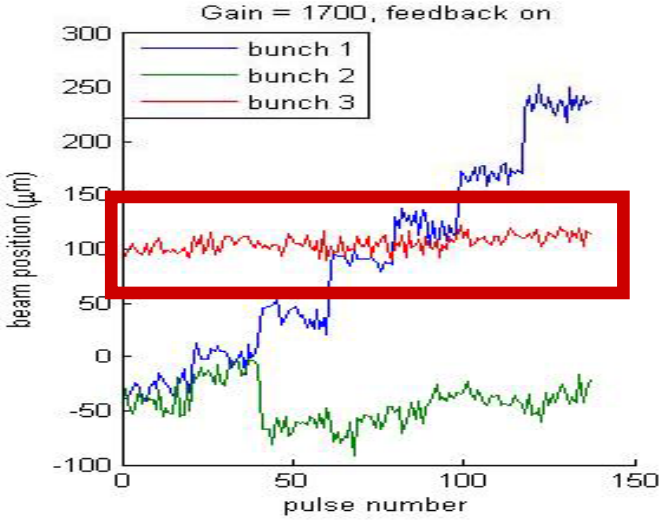
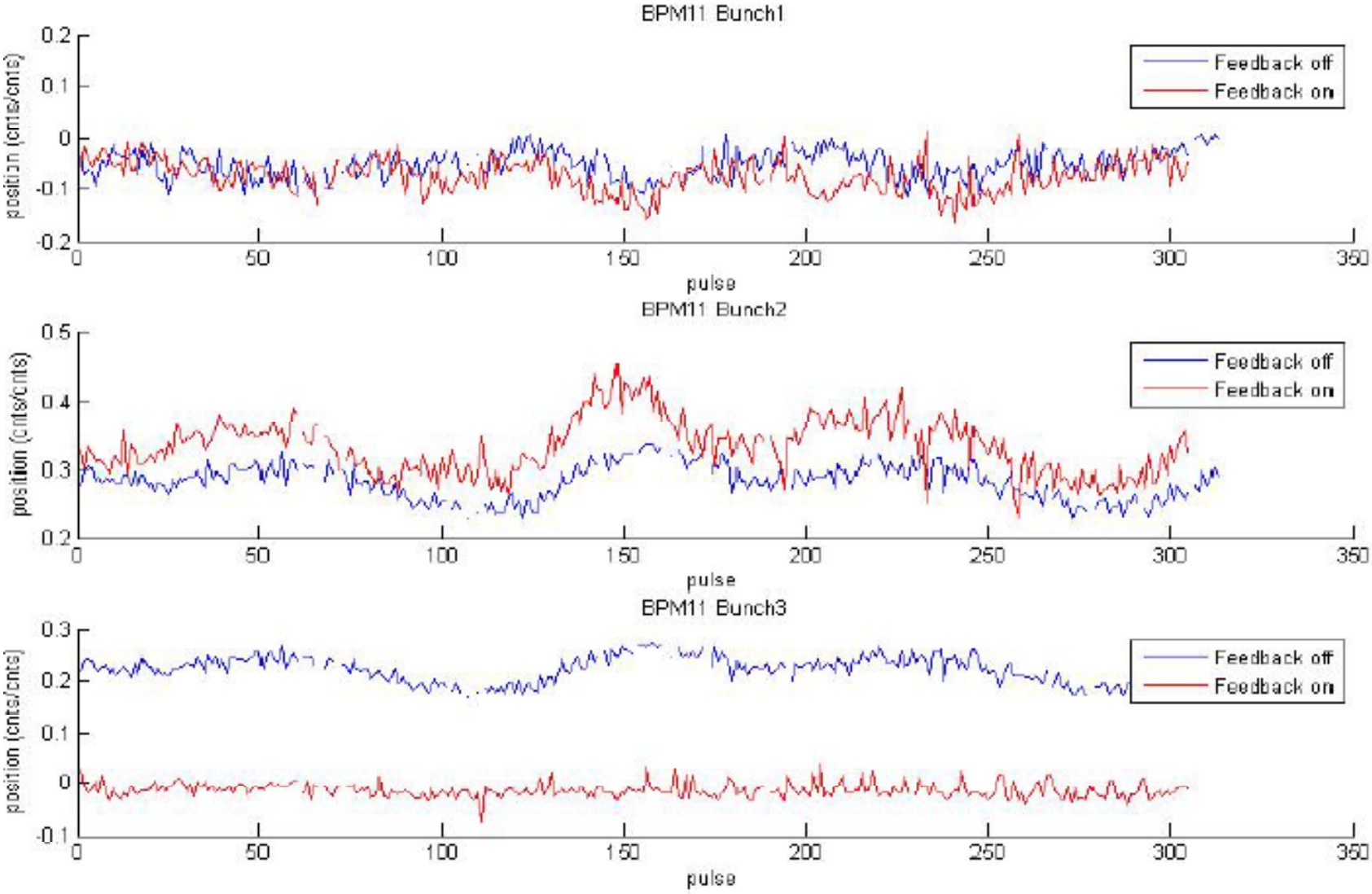




Example (3) of May 2008 Results



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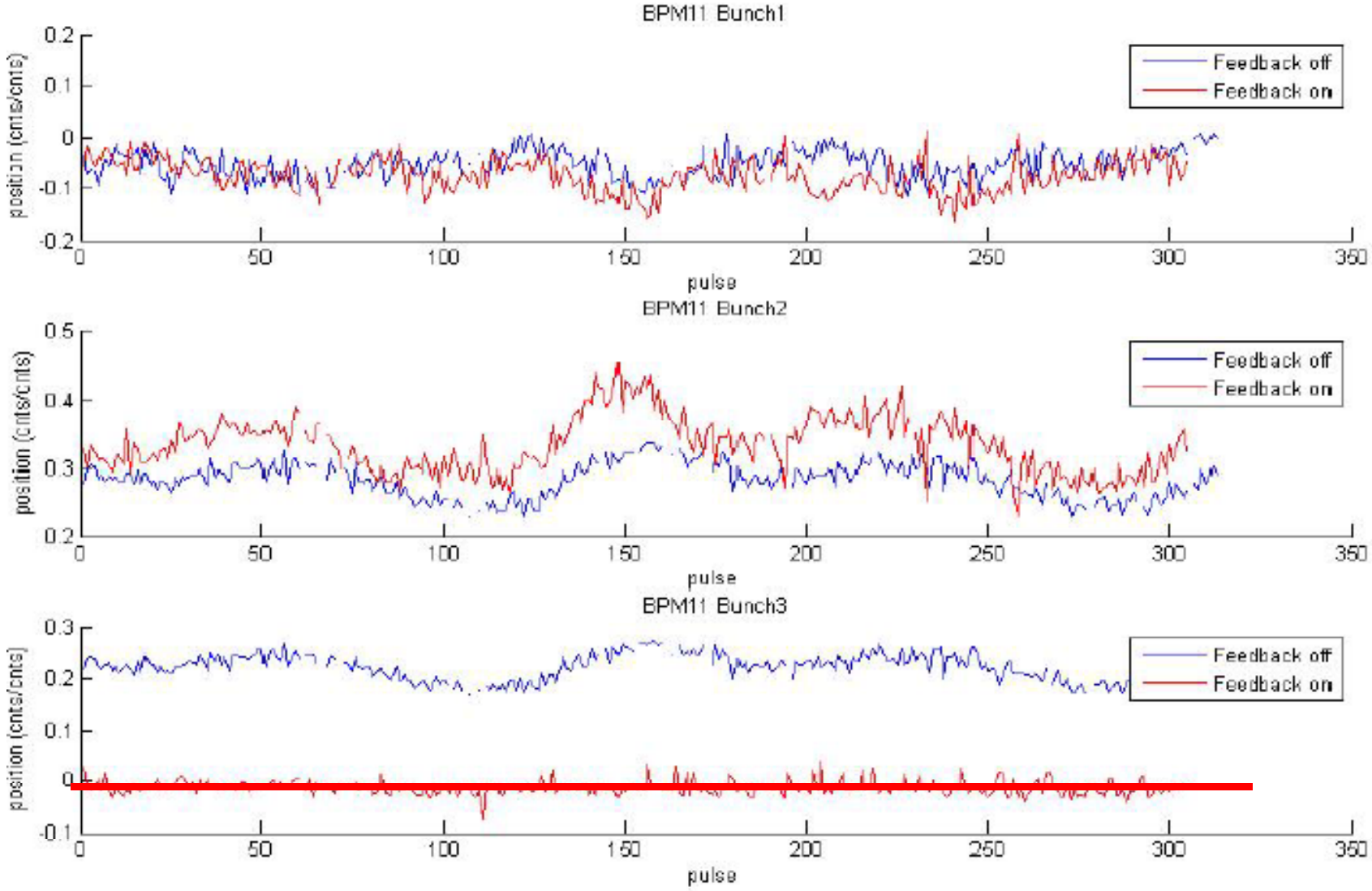
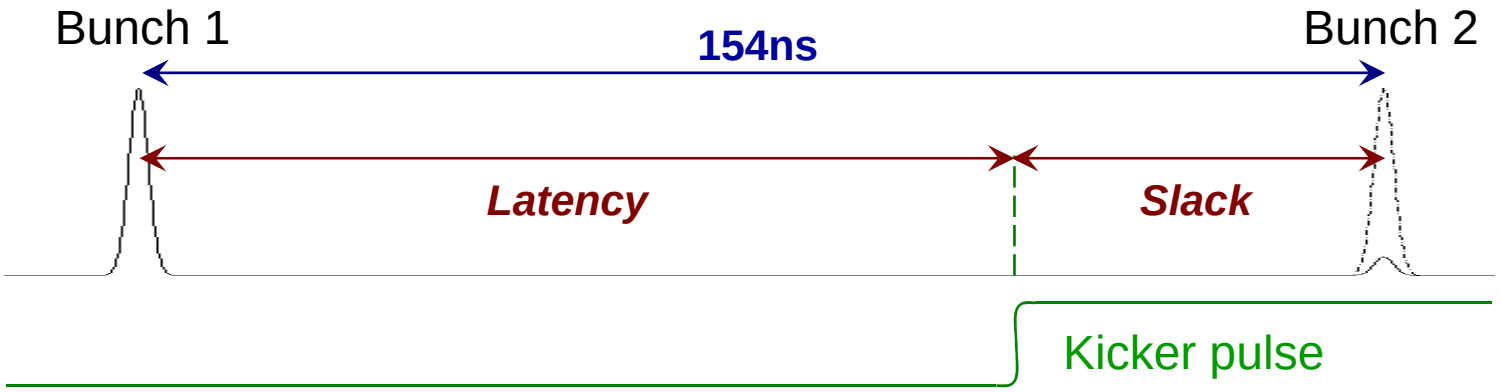
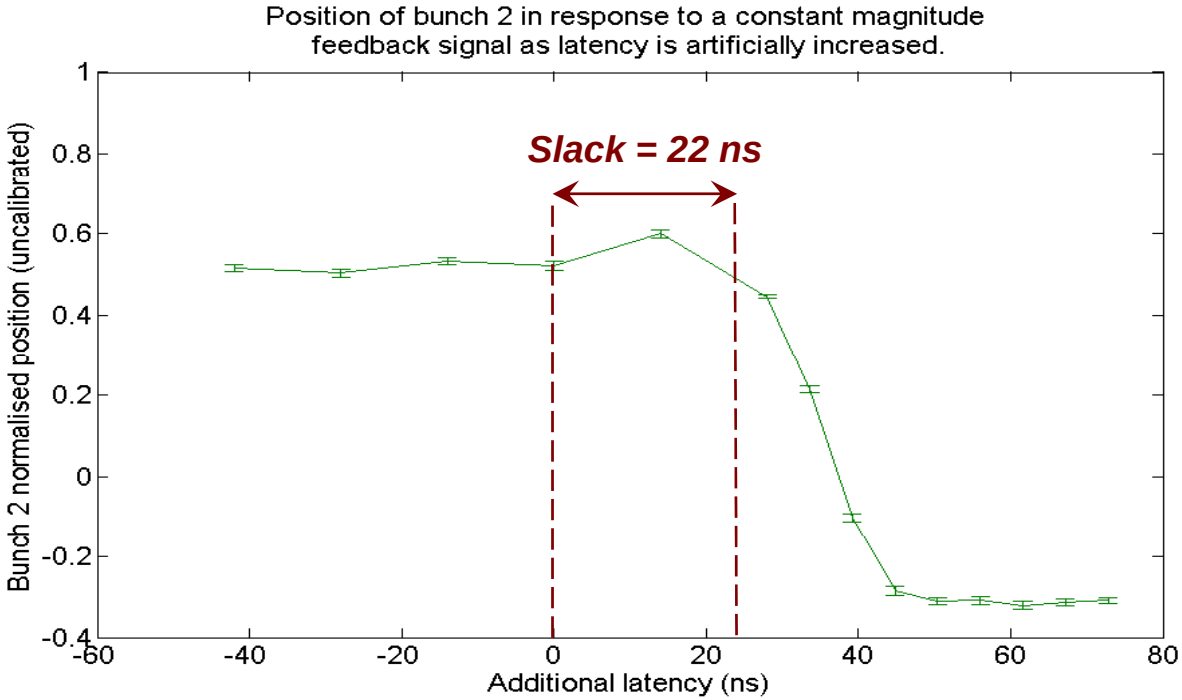


Latency measurement





Latency

= 154 - slack

= 132 ns

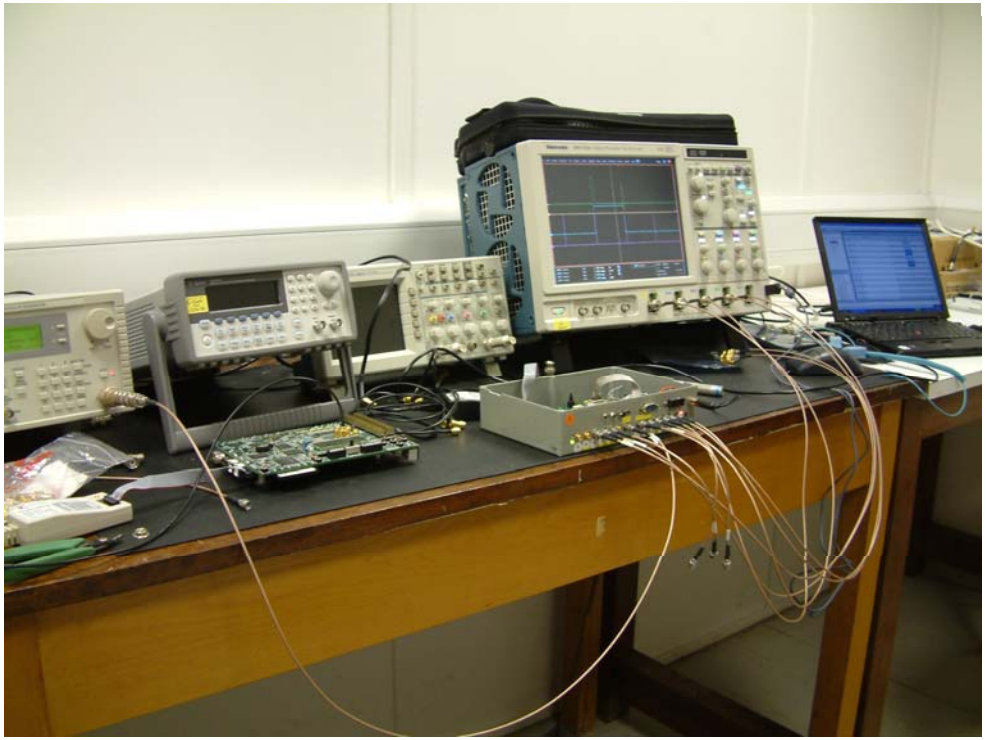
+ 8ns (1/Q)

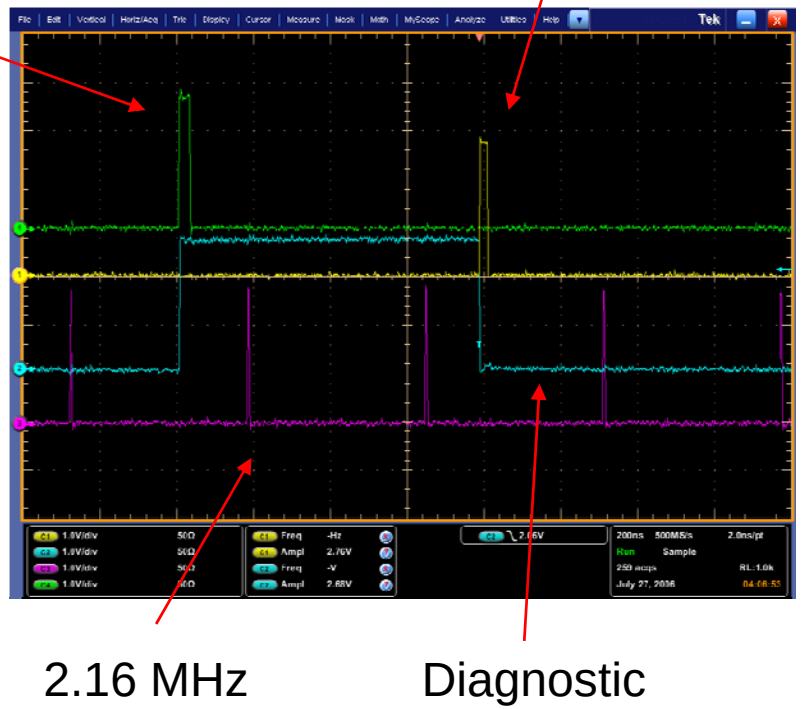
FONT bench test system

Manufacture synchronised ILC bunch-train, clocks, and trigger

Develop algorithms and program FPGA

Close loop





FONT plans (1)

New ATF2 beamline being commissioned

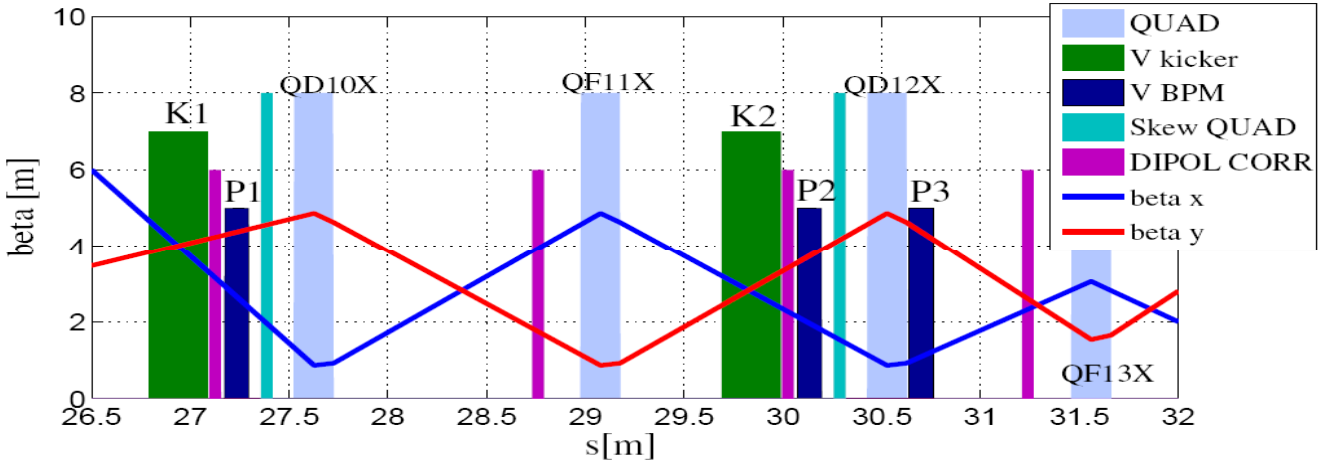
Providing 'turn-key' bunch-by-bunch FB system for achievement of ATF2 goals:

- **35 nm beam spot**
- **stabilisation at nanometer level at IP**

VITAL DEMONSTRATION OF FINAL-FOCUS CAPABILITY FOR ANY FUTURE LINEAR COLLIDER!

ATF2 FB system

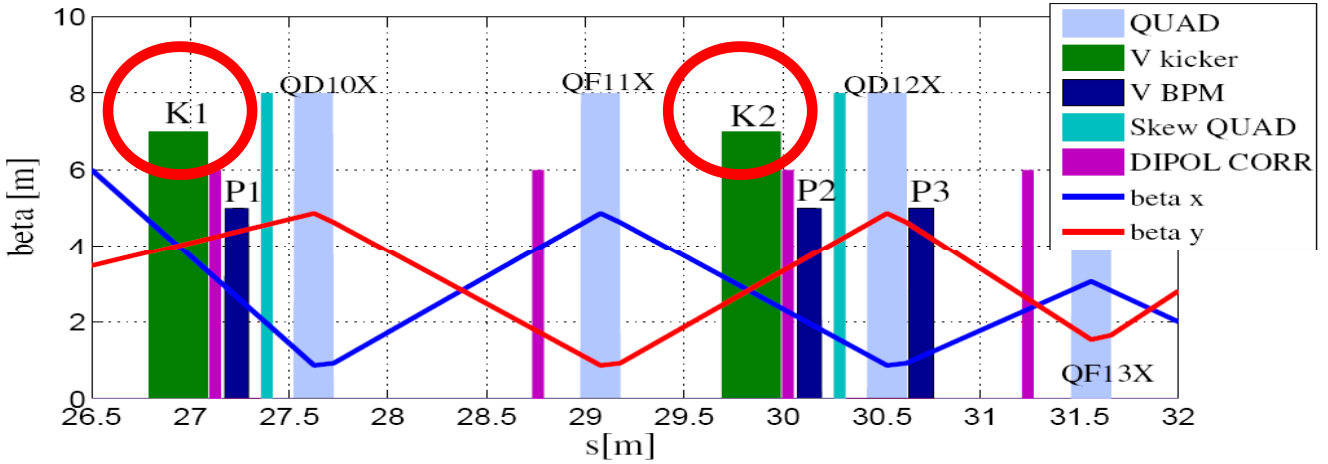
Dedicated system:



- **2 stripline kickers + fast drive amplifiers**
- **3 stripline BPMs + fast analogue front-end electronics**
- **9-channel digital FB processor**

ATF2 FB system

Dedicated system:



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ATF2 FB system

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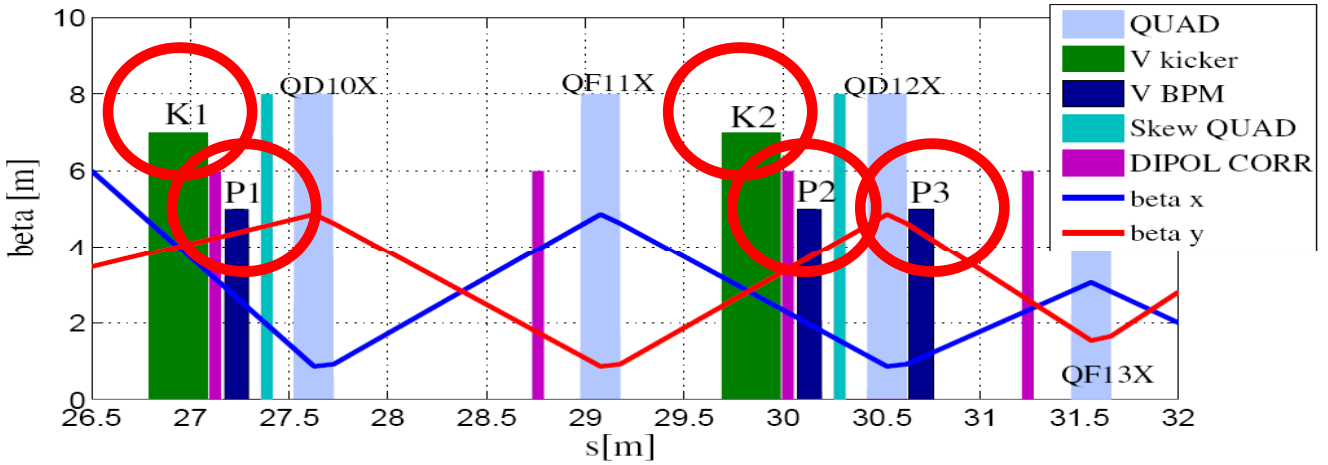

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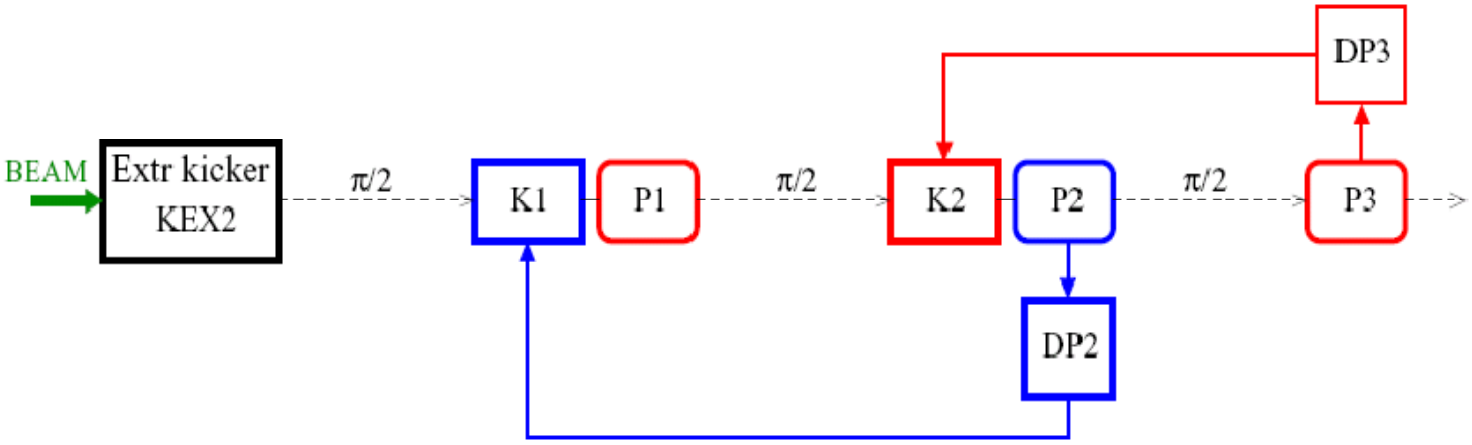
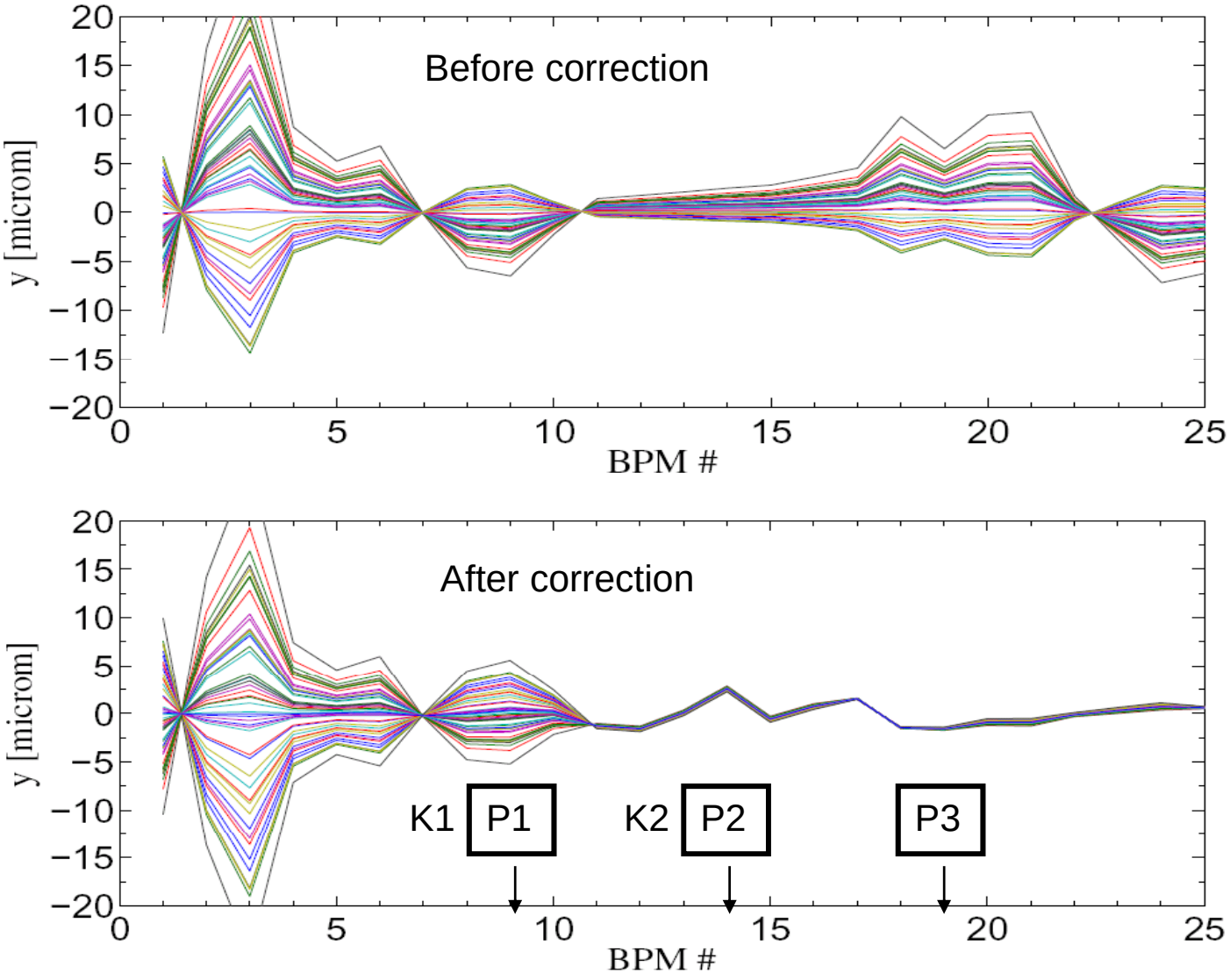
Flexible FB / FF operation



Time of flight P2-K1 = 10.7 ns
Time of flight P3-K2 = 10.5 ns

Results of vertical position correction



Resta Lopez

FONT plans (2)

The next major development would be FB tests using a long ILC-like train of 20-60 bunches

(FONT4 amplifier was specified to allow this)

- **Would allow us to make FB algorithms robust:**
  - **account for bunch-bunch correlations along train**
  - **adaptive gain as beam conditions change (drift)**
  - **incorporate feed-forward information from upstream beam-related 'luminosity' signal for fast scanning?**

FONT plans (3)

CLIC:

Simulations of luminosity performance of machine

Design of feedback and feed-forward systems

Phase stability of CLIC drive beam:

opportunity for prototyping + beam tests at CTF3