Review of beam feedback issues

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Overview

- **Reminder of possible beam feedbacks for ATF/ATF2**
- **Status of FONT4 ILC intra-train prototype**
- **Discussion of ATF2 feedback deployment**
  - **Critical issues**
  - **Hardware**
  - **System integration**

From original ATF2 proposal

- **Goal 1:**

  micron-level beam stability in y needed at entrance to ATF2 final focus

- **Goal 2:**

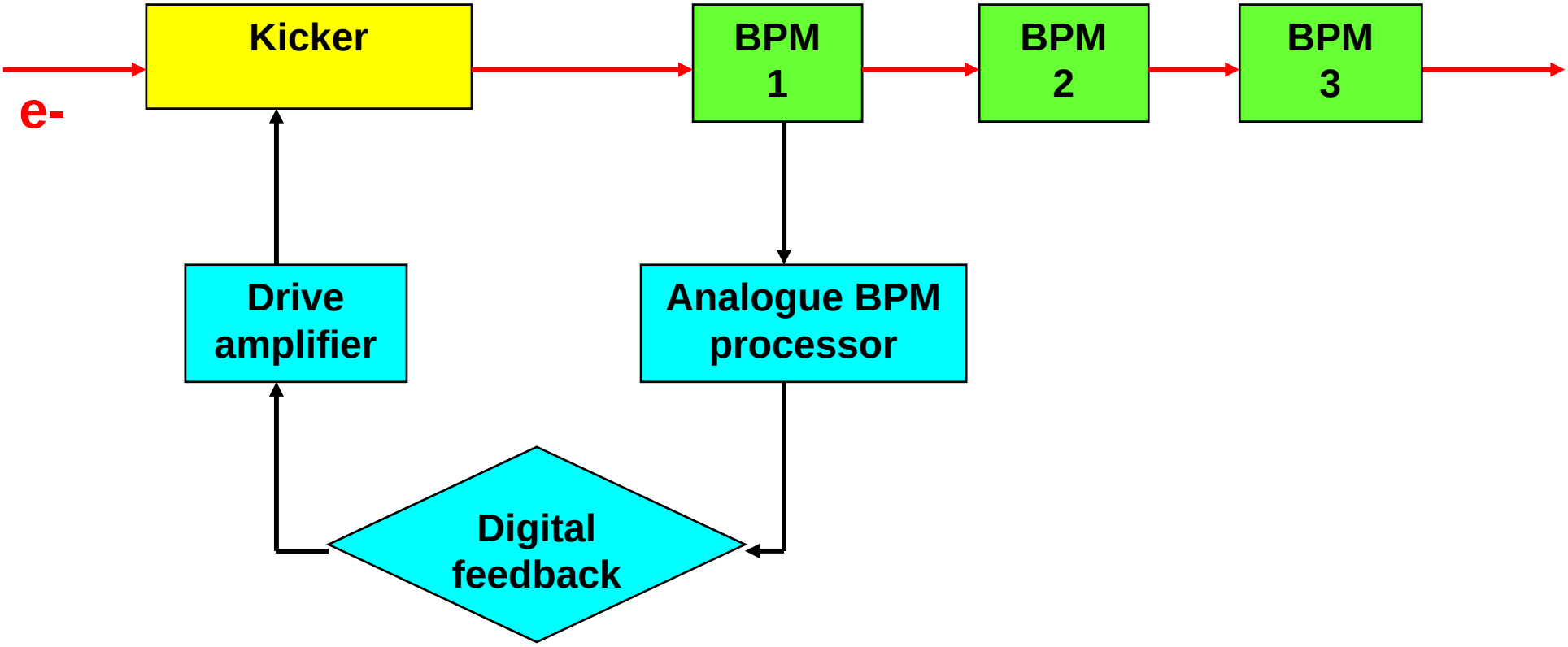
  sub-micron beam stability needed

Possible beam feedbacks

- **Final focus 'slow': pulse-to-pulse (or slower)**
  LAL Group
- **Intra-train, located upstream**
  FONT Group
- **IP intra-train based on IPBPM (Honda-san)**
- **Feed-forward system involving damping ring**
  FONT Group (Kalinin)

FONT4 ILC prototype at KEK/ATF

1.3 GeV beam, 3 bunches spaced at 154ns



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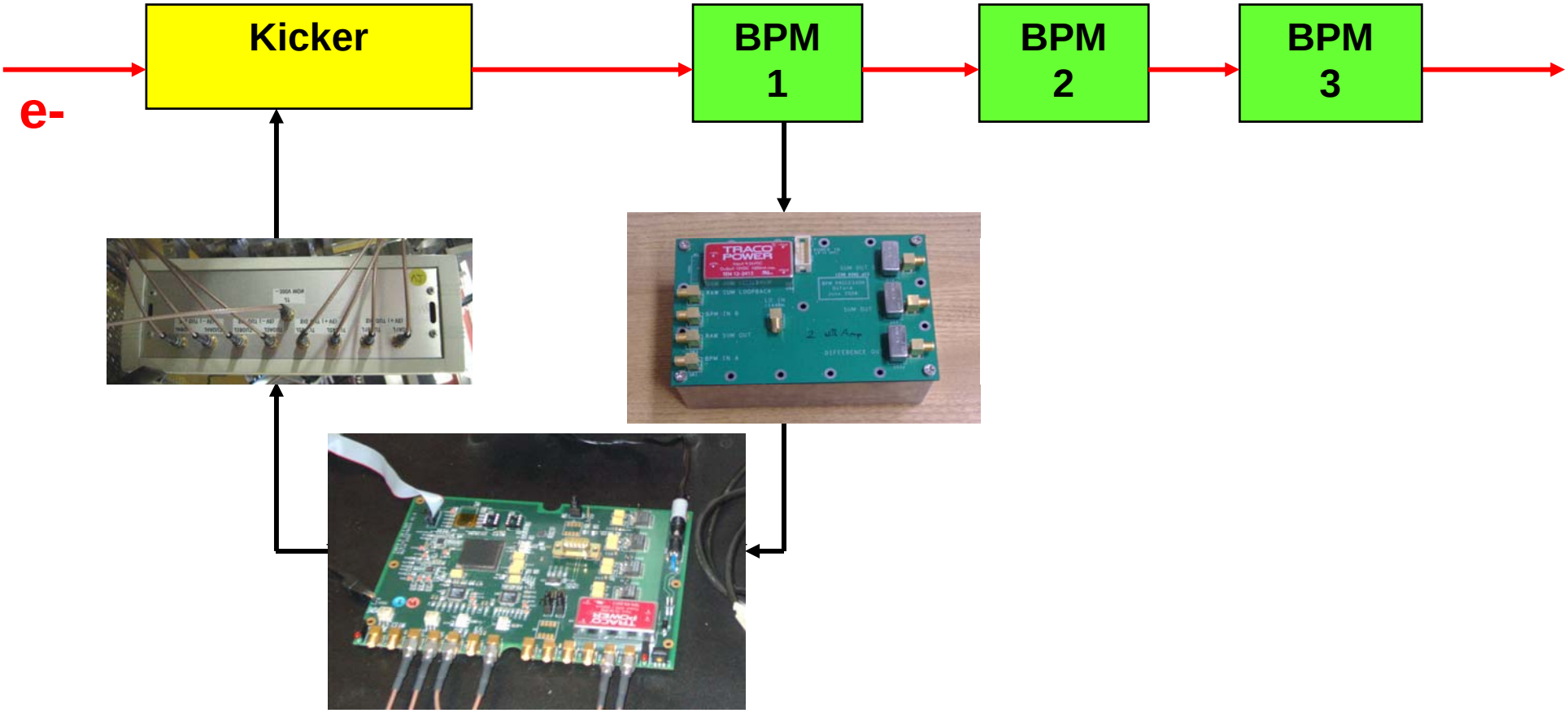
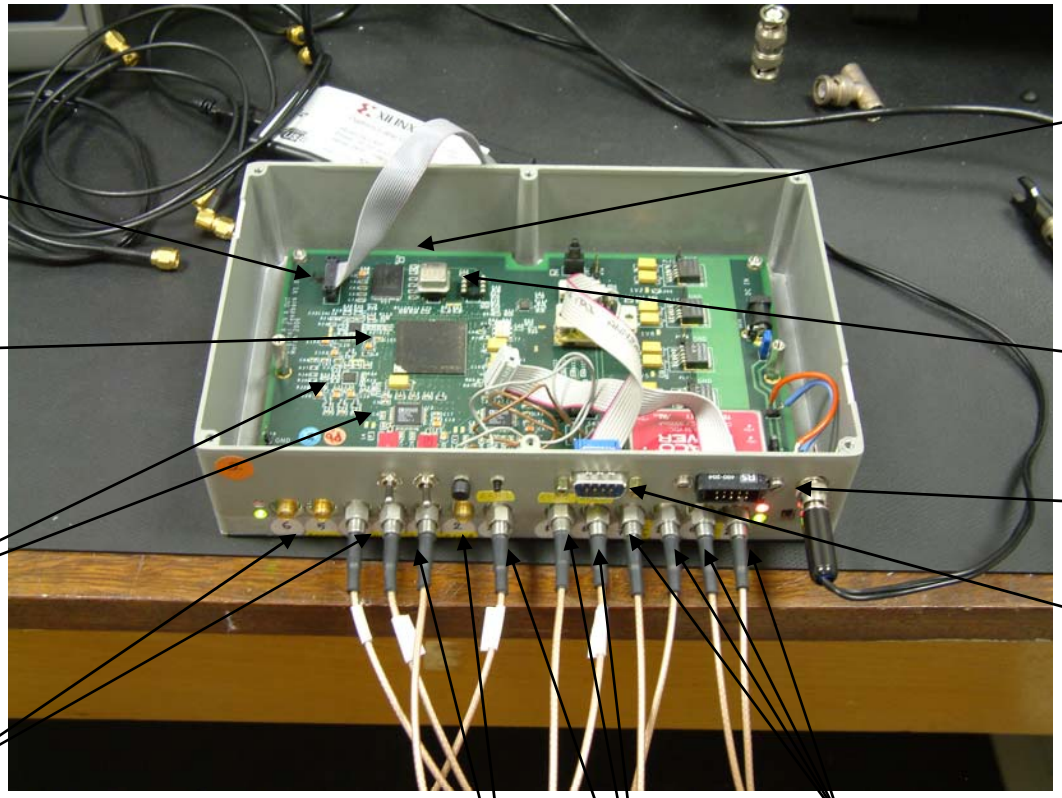


Digital Feedback Board



FONT4: latency estimate

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

  Irreducible latency: 14ns

- BPM processor: 7ns
- ADC/DAC (3.5 89 MHz cycles) 40ns
- Signal processing (8 357 MHz cycles) 25ns
- FPGA i/o 3ns
- Amplifier 40ns
- Kicker fill time 3ns

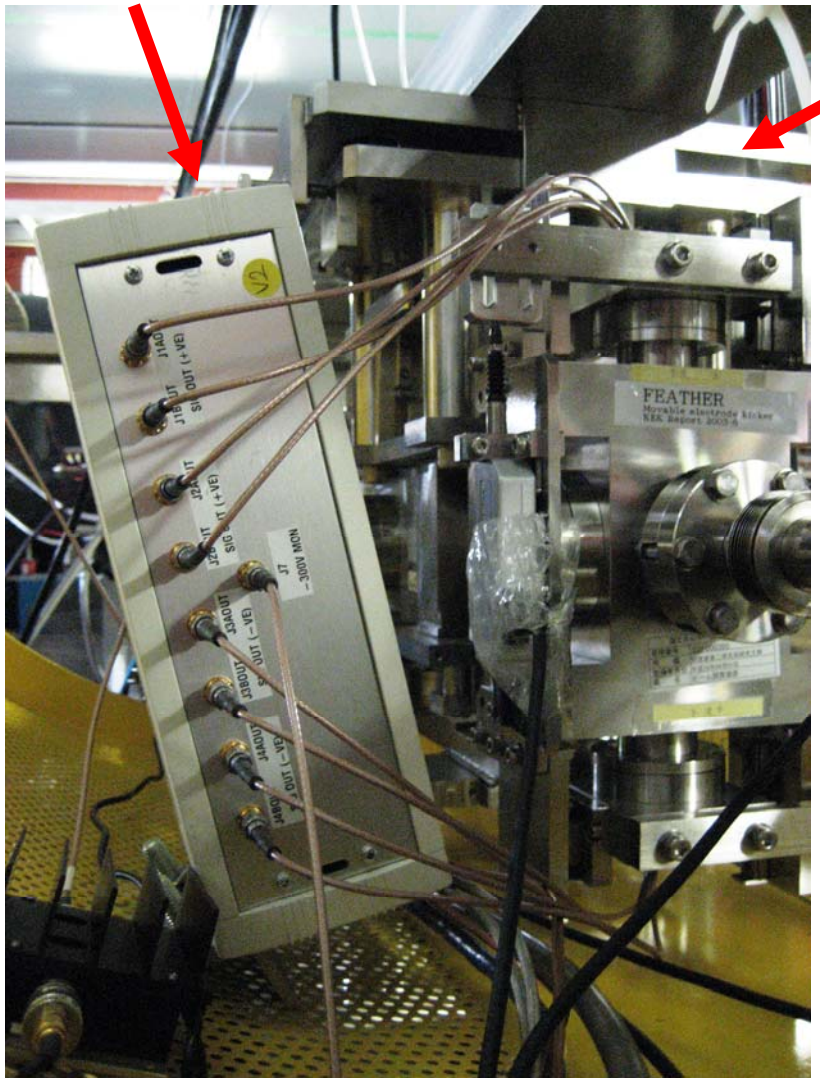
  Electronics latency: 118ns

- Total latency estimate: 132ns

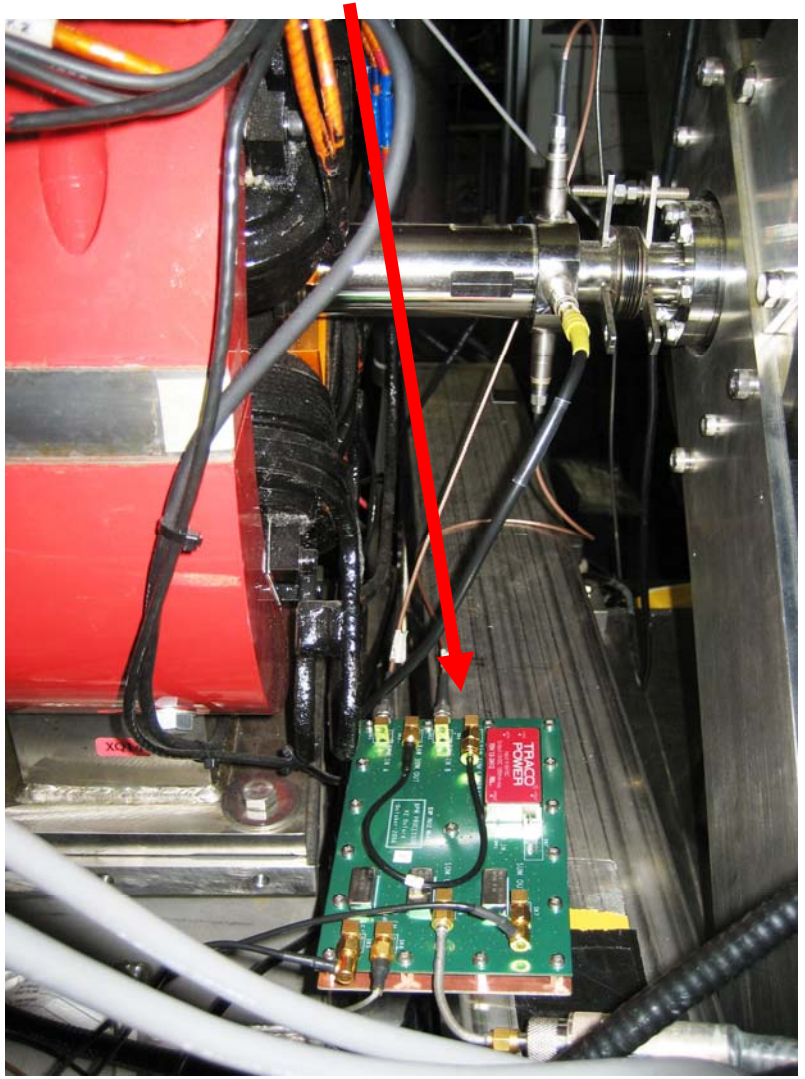
FONT4: beamline at KEK ATF (May 07)

Amplifier

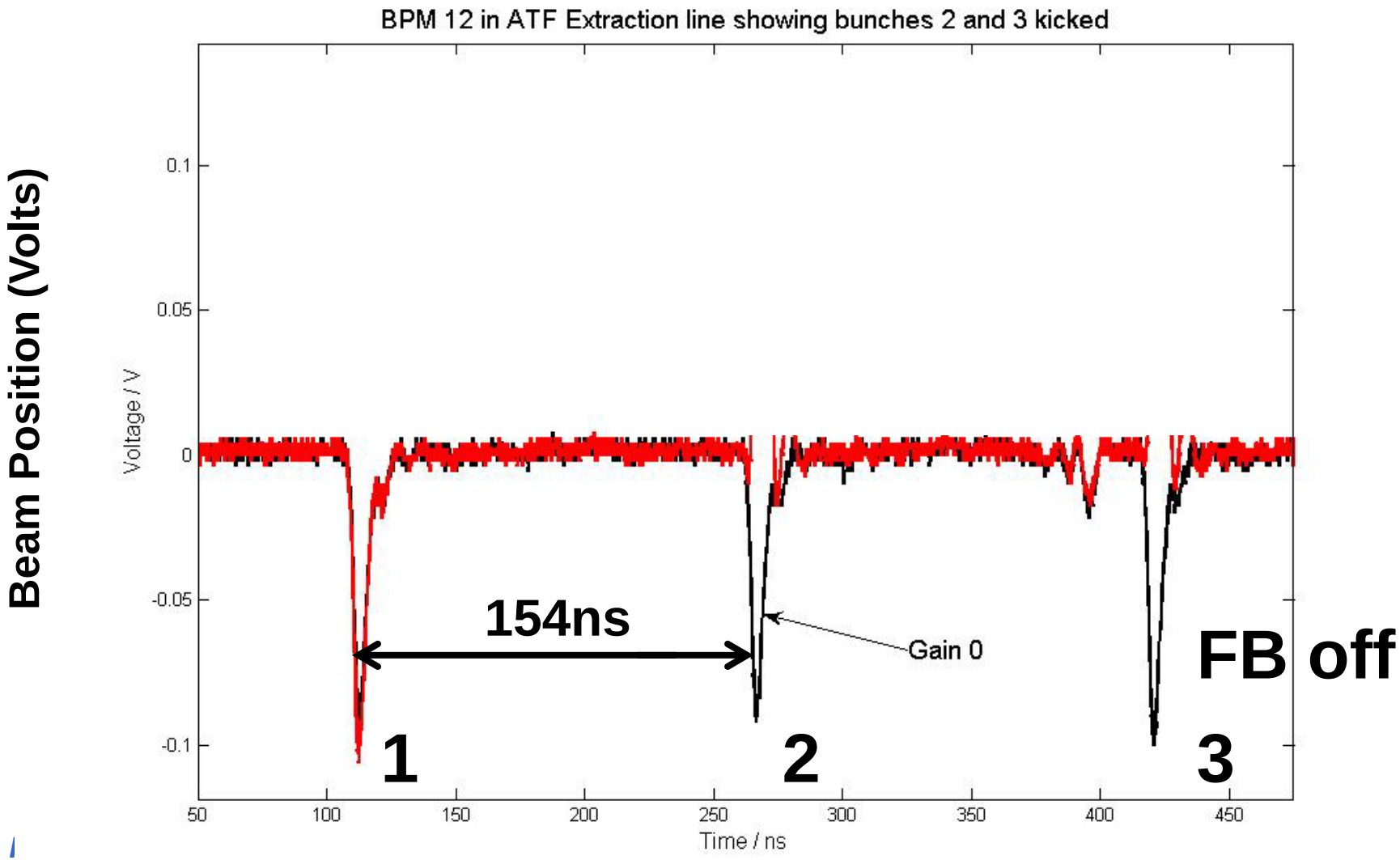
FEATHER
Kicker



BPM processor board



First closed-loop operation (Dec 06)



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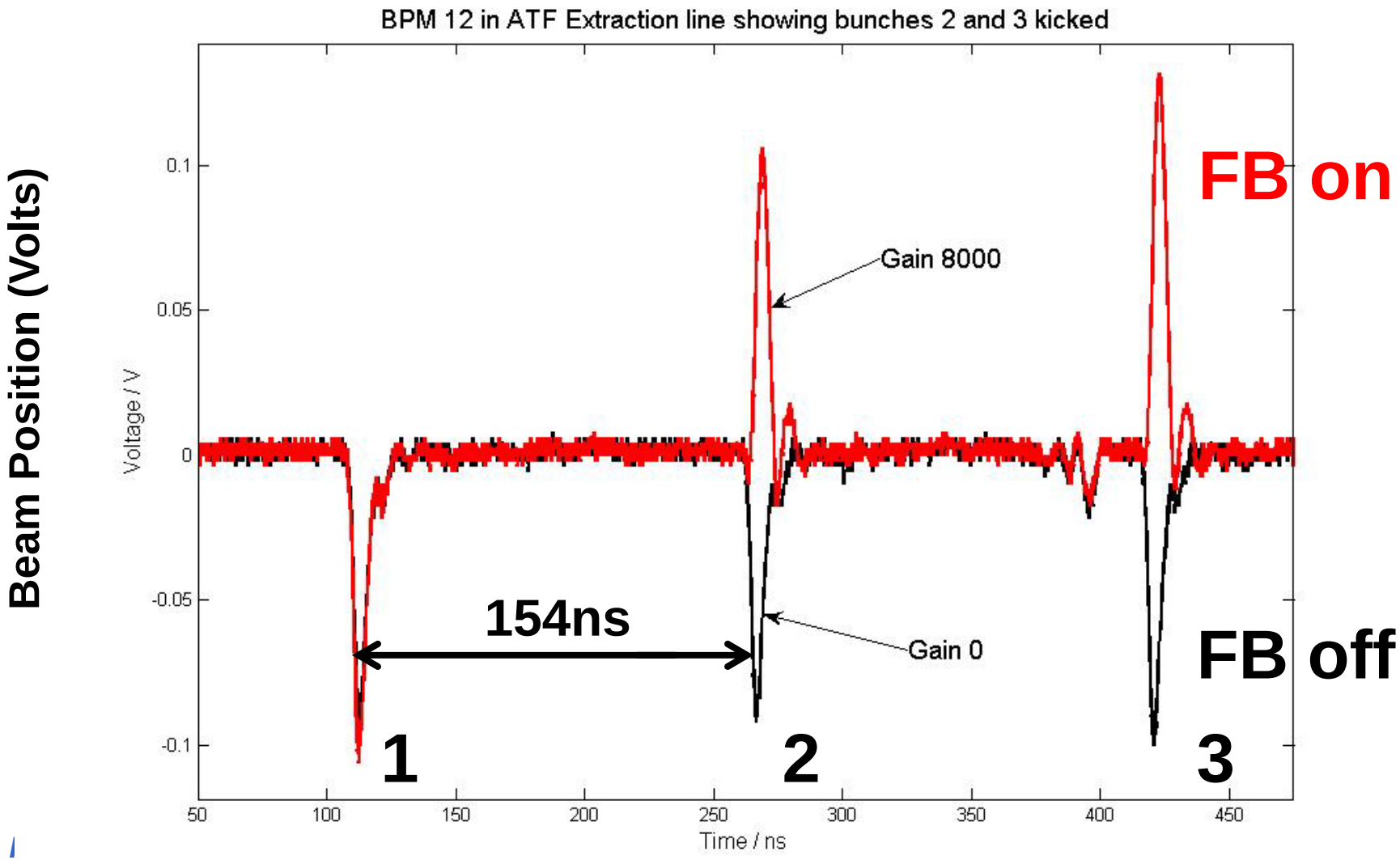
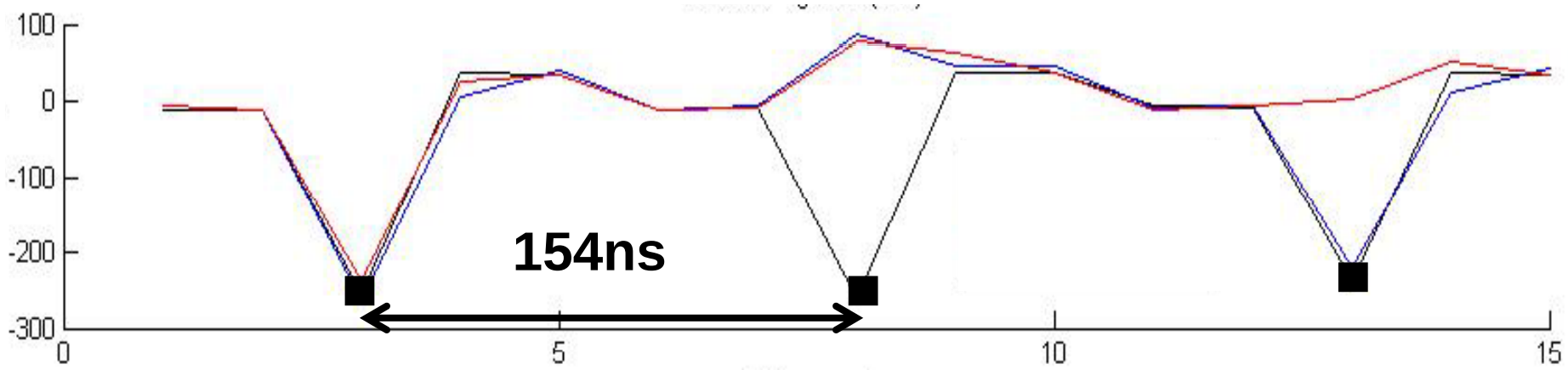


Feedback with delay-loop (Feb 07)

Incoming bunches

Position
(ADC counts)

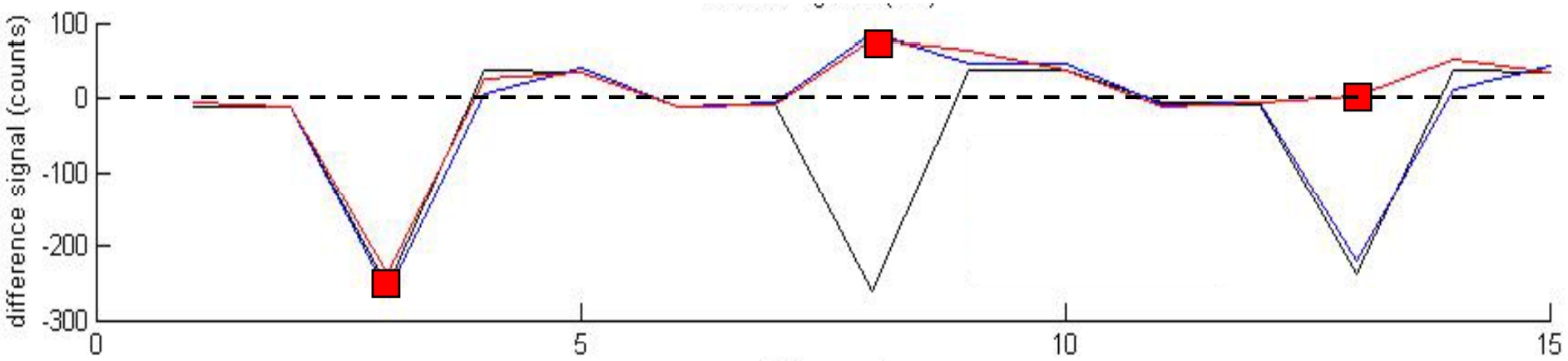


Feedback with delay-loop (Feb 07)

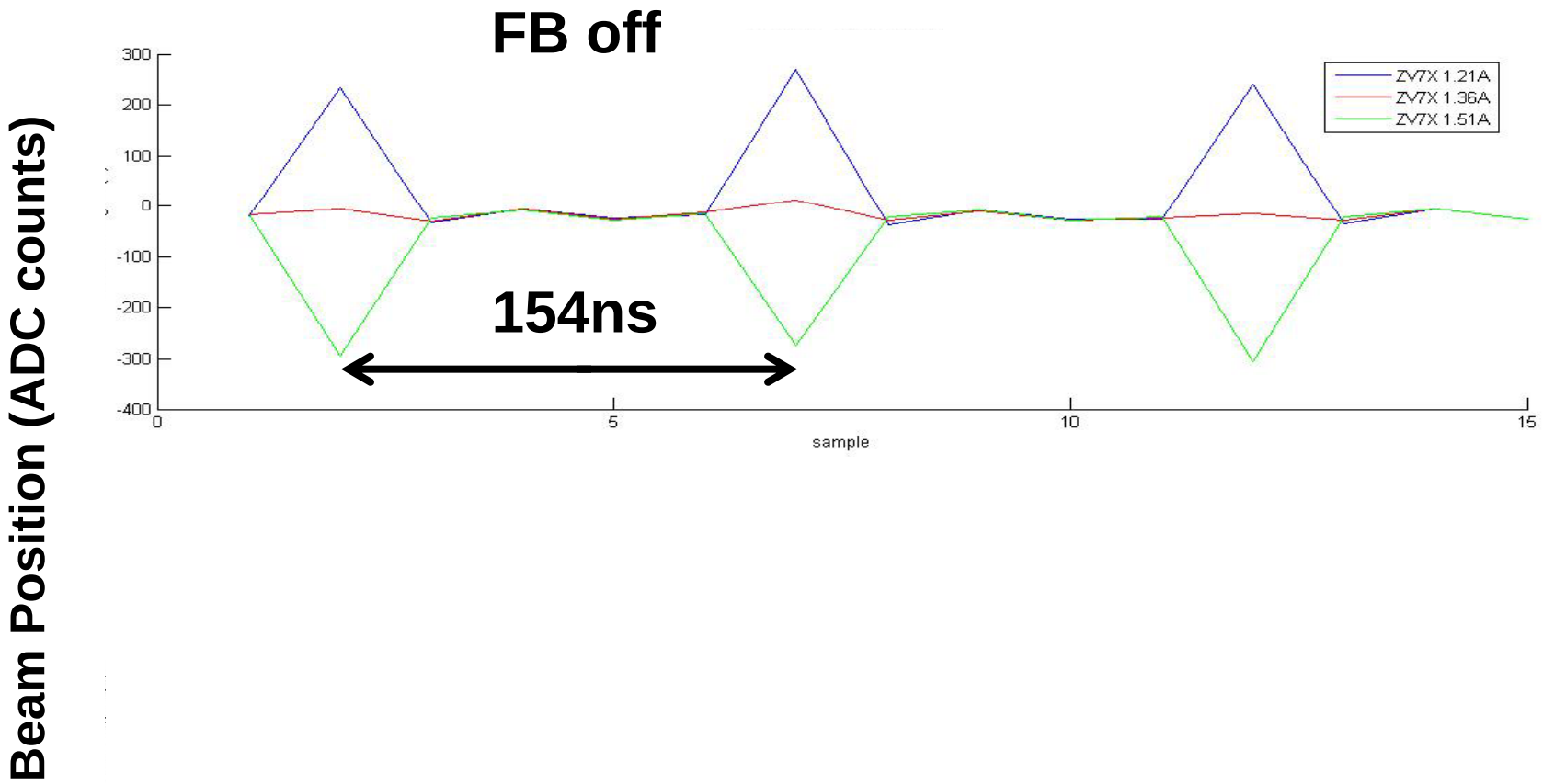
FB on, with delay loop

Latency ~ 135ns

Position (ADC counts)



With 1/Q + optimised gain (May 07)



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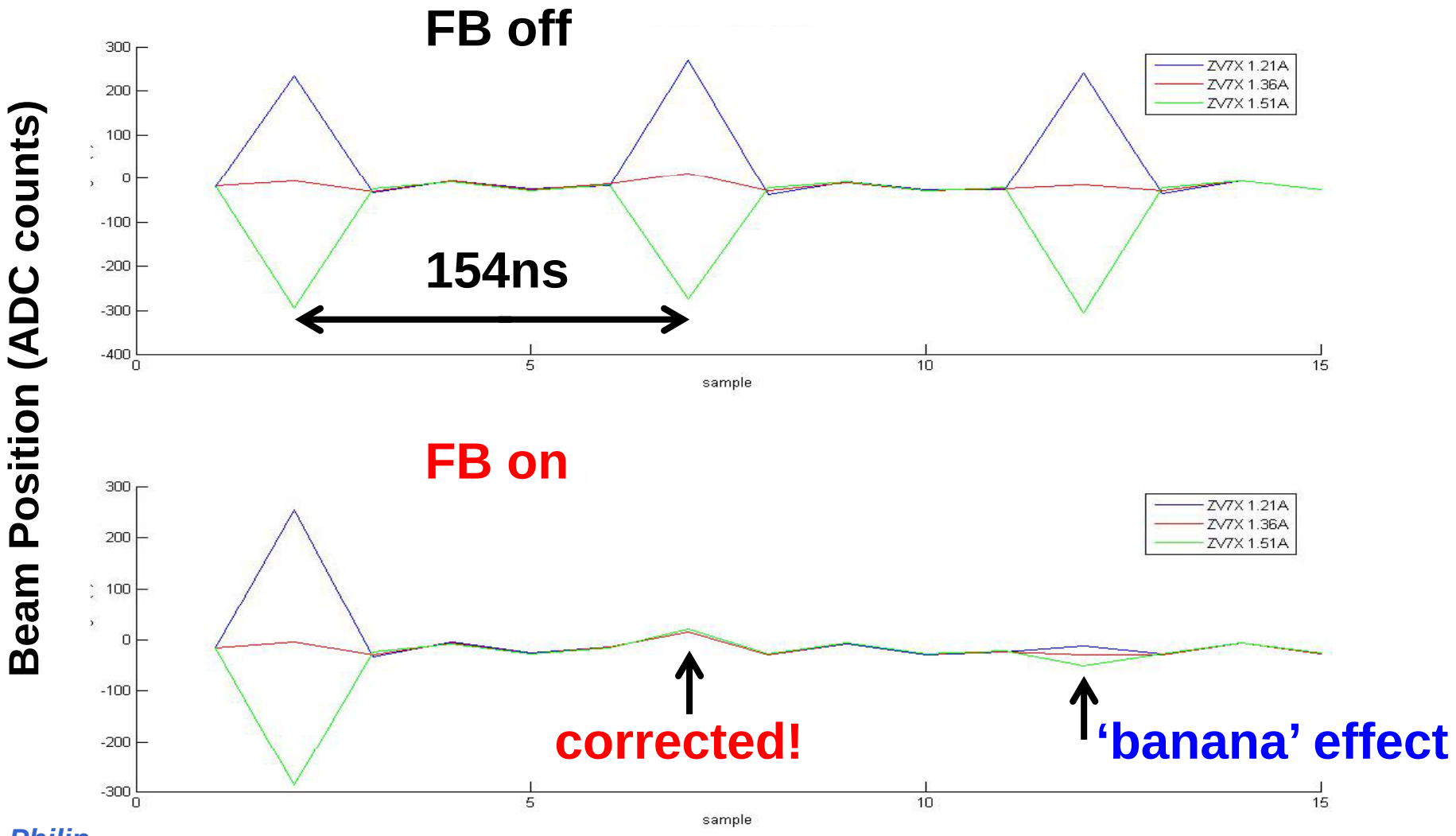

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Summary of ILC IP intra-train FB

- **Built digital FB prototype + demonstrated all of the key features needed for ILC:**

  closed-loop operation

  delay-loop function

  bunch-charge normalisation of position signal

  latency c. 135ns – meets even 150ns ILC spacing

- **Key for ILC: test with long, multi-bunch trains (20 - 60 bunches at ATF2)**

  amplifier specified for 10us pulse length

Kicker driver amplifier

Specifications:

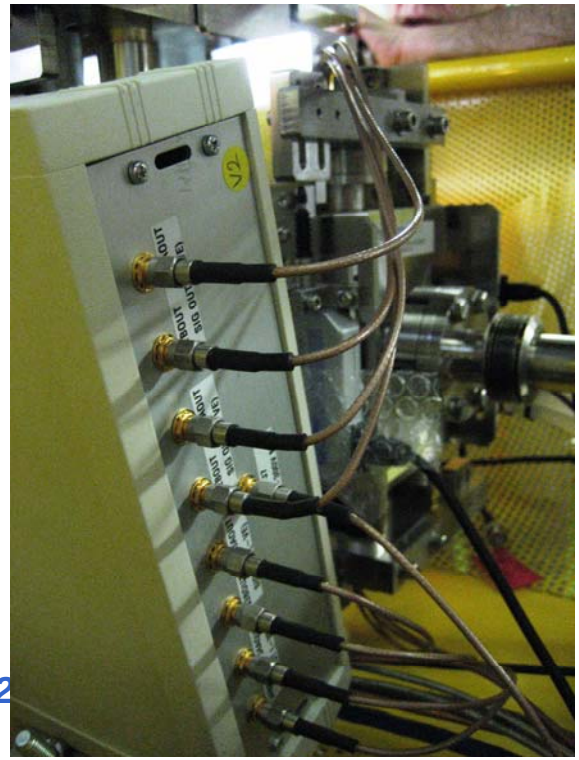
- **+- 15A (kicker terminated with 50 Ohm)**
- **+- 30A (kicker shorted at far end)**
- **35ns risetime (to 90%)**
- **pulse length 10 us (specified for 20-60 bunches)**
- **repetition rate 10 Hz**

Outline design done in Oxford

Order placed with TMD Technologies Sept 06

Two prototype units delivered Dec 06

Tested with beam at ATF Dec 06, Feb + May 07



ATF2 intra-train feedback

All of the FONT hardware can be readily deployed for intra-train FB at ATF2

Not yet a 'turn-key' system for routine operations

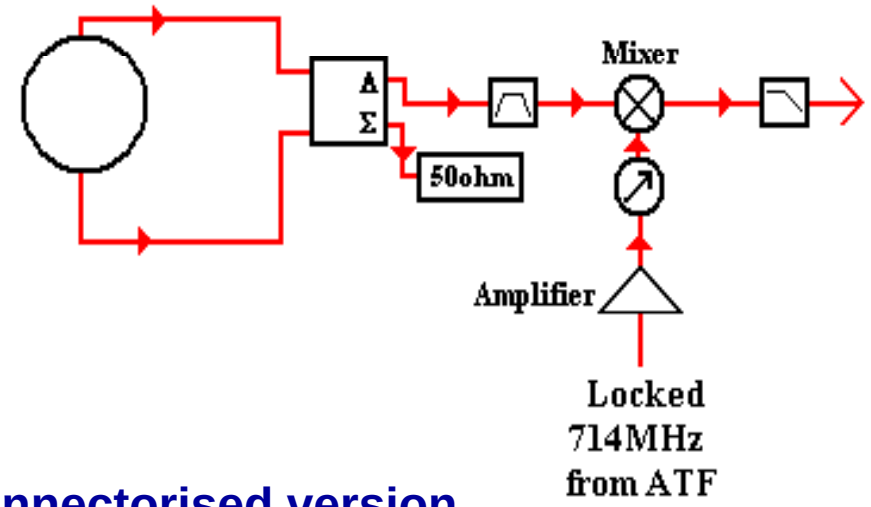
- only c. 12 shifts of beam experience so far!

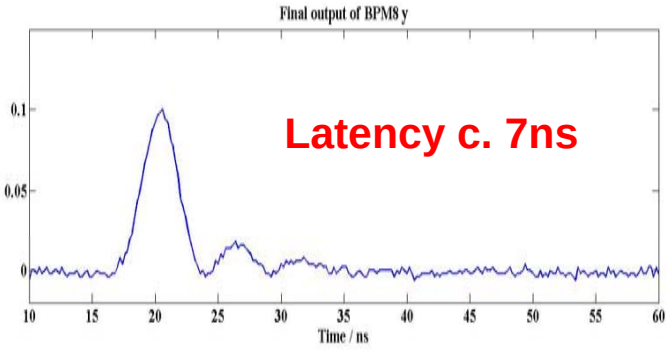
STRIPLINE BPMs used, because possible to design low-latency processor, based on phase-locked ATF Local Oscillator (LO) signal

Currently cavity BPMs NOT able to resolve multi bunches with demonstrated micron-level (or better) resolution

BPM processor

Single stage down-mix to baseband

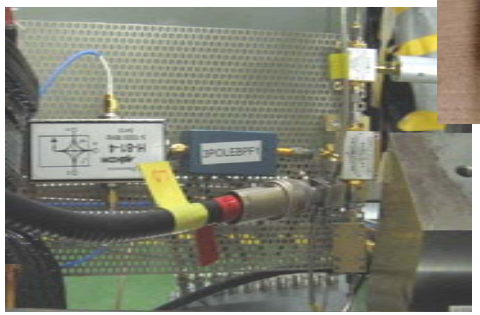


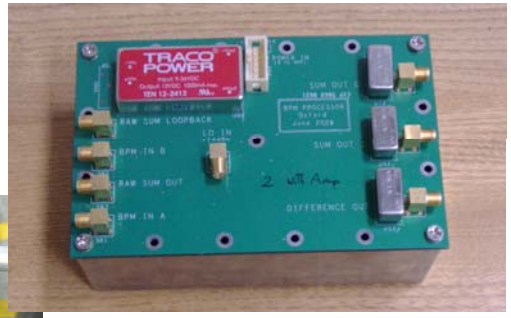


Replaced connectorised version with custom PCB – new version tested

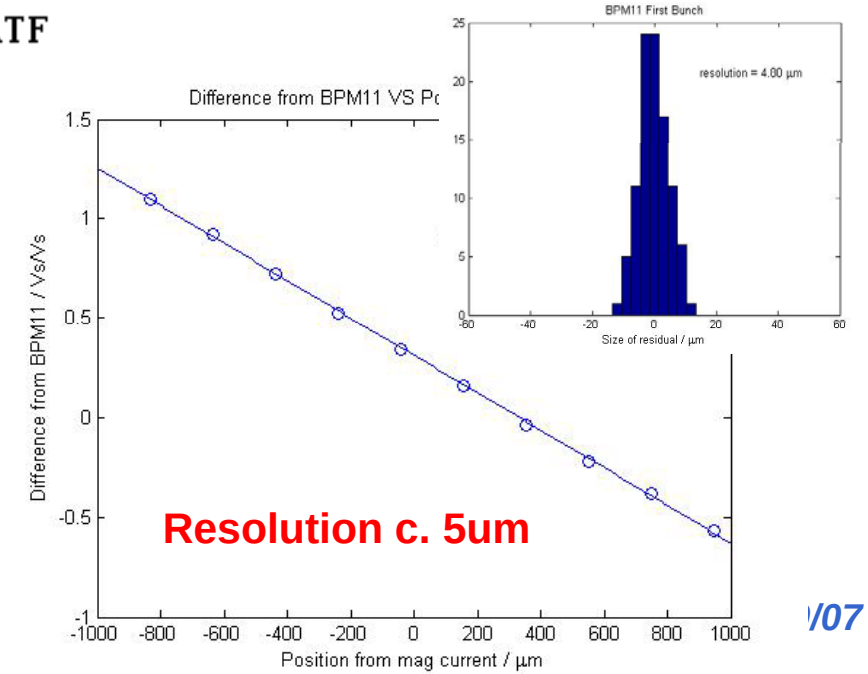
November 2006

old





new



Issues for ATF2: LO stability

Currently position resolution at best c. 3um (good days!)

- **poor LO stability (ATF 714MHz)**
- **BPM signal path lengths not matched optimally**
- **will study in October/December ATF runs**

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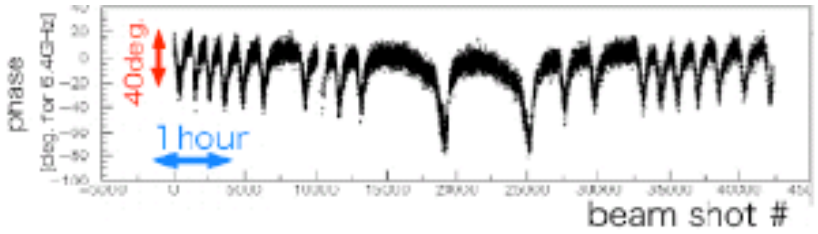
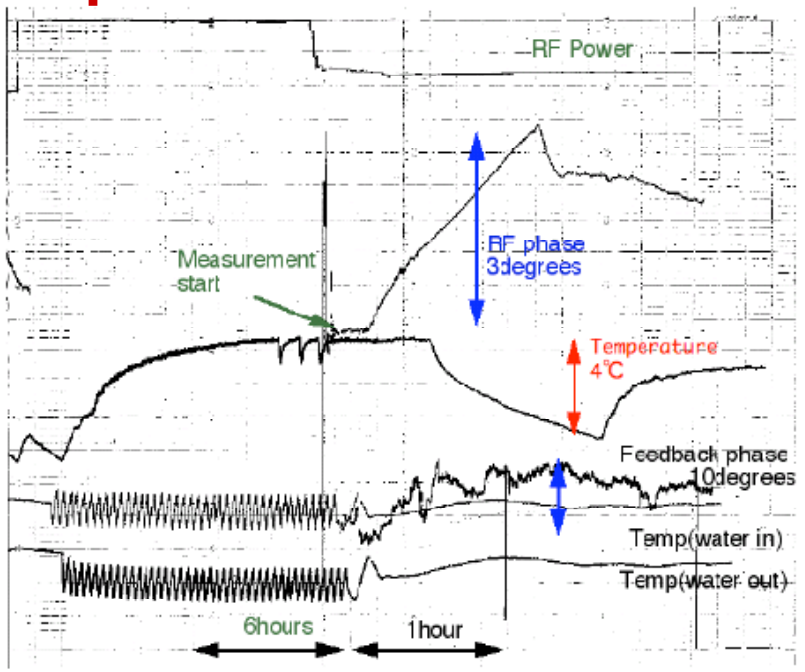
Phase stability of 9 x 714MHz



Depends on T of RF hut



Naito-san working on:
T stabilisation of RF hut
Low-expansion cables
(note 8/8/07)

Issues for ATF2: LO stability

We will study LO issues in October/December ATF runs

→ until June 2008:

improve resolution of BPM processor to c. 1um (sub-um?) for ATF2 use, gain beam experience

(Kalinin digital processor also promising)

Issues for ATF2: extraction jitter

- **Extraction kicker jitter:**

  extraction to extraction:

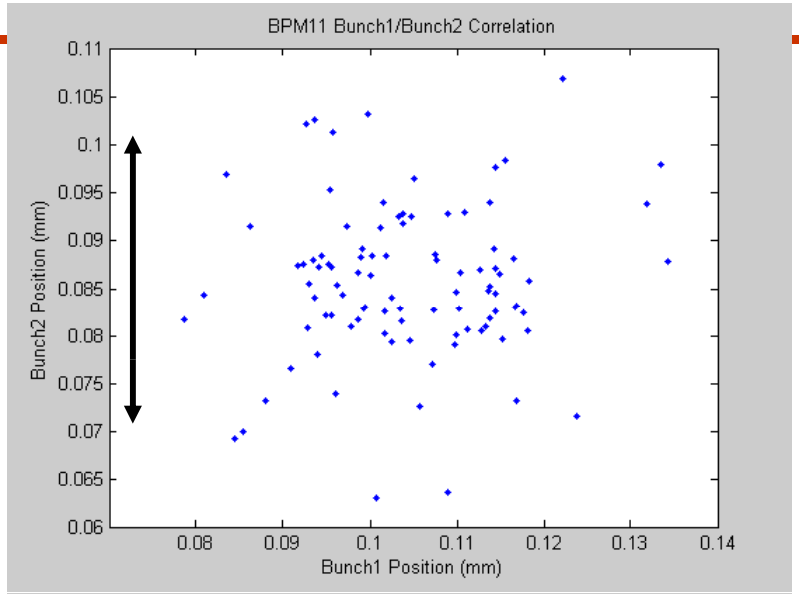
  train varies in position by c. 20-30um in y

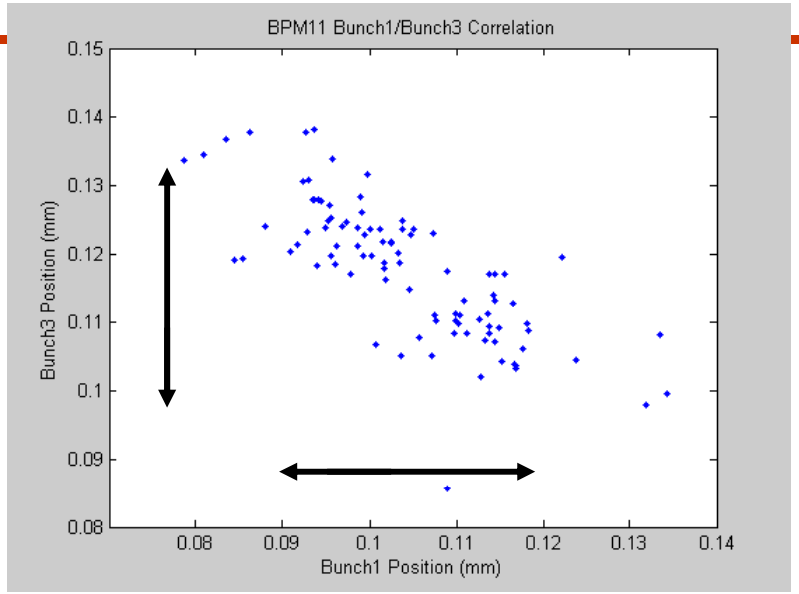
  within an extraction:

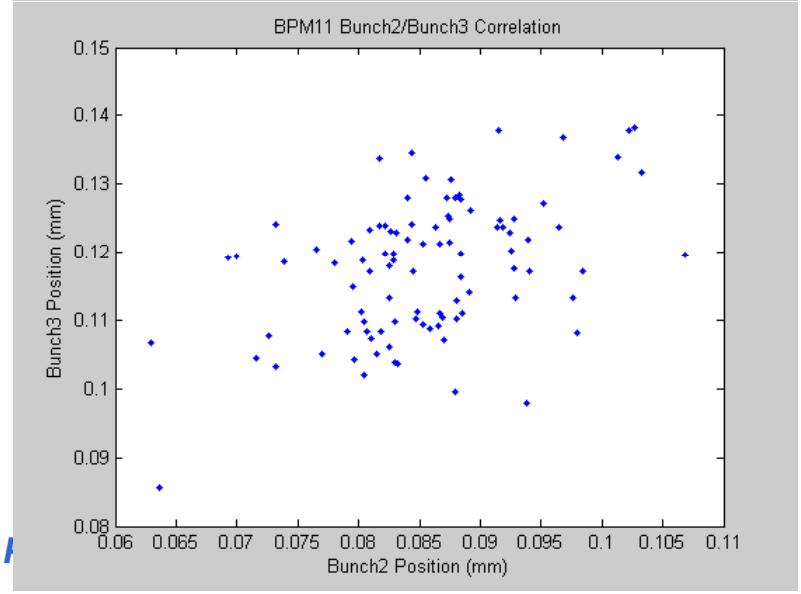
  bunches 1, 2, 3 relative jitter by c. 10um in y

  some correlations between bunches

Bunch-bunch correlations (position 151)







Arrows show 30um

Correlation Coefficients:

Bunch1/Bunch2: 0.1

Bunch1/Bunch3: -0.8

Bunch2/Bunch3: 0.5

Correlation coefficients (BPM11-witness)

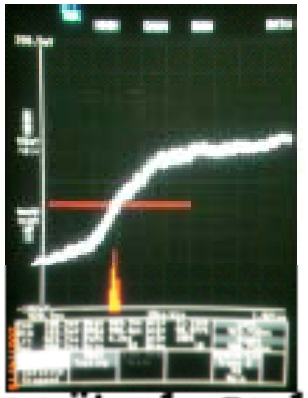
Time			
	1/2	1/3	2/3
Q151	0.1	-0.8	0.5
Q121	0.3	-0.6	0.3
Q136	0.2	-0.7	0.4

From Naito-san

Trigger Timing Feedback for the Ext. Kicker

20070702 T. Naito, A. Hayakawa

- The renewal of tyratrons were done at Feb. 2007 by helping J. Krzaszczak(SLAC).
- There is a big improvement for the pulse-to-pulse jitter. The measured jitter of the extraction kicker is ~1ns after renewal and ~10ns before renewal during a few minutes.
- The timing drift of the pulse timing which depends on the temperature change is clearly observed after reduction of the pulse-to-pulse jitter. The range of the drift is ~10ns.
- The timing drift not only deteriorates the field flatness of the kicker pulse, but affects the noise environments of the monitors of the extraction line which are needed precise measurement.



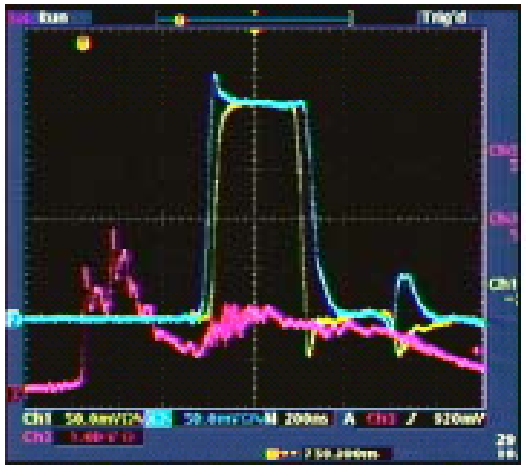
Timing jiter 1σ=~1ns

0ns at start up

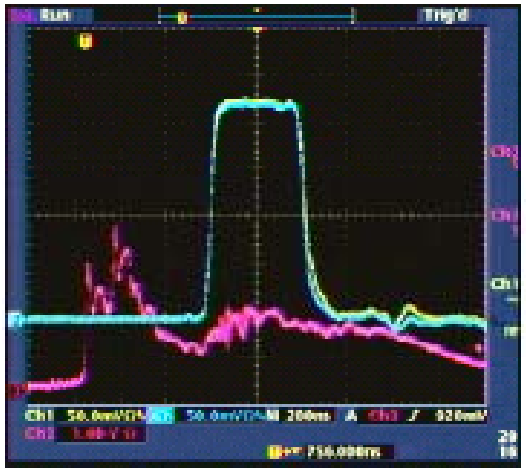
~10ns drift after 24 hours

From Naito-san

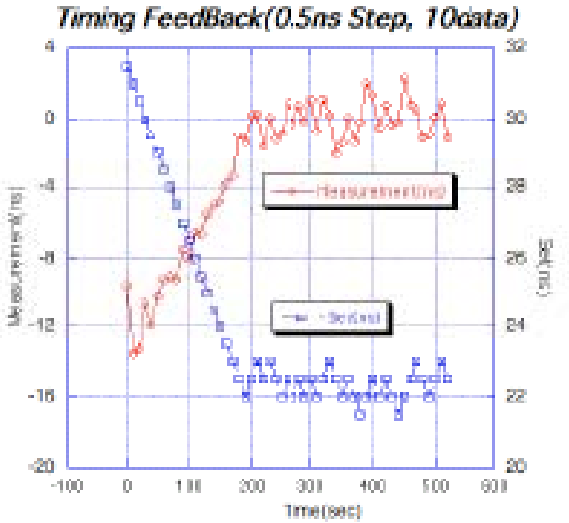
Preliminary test

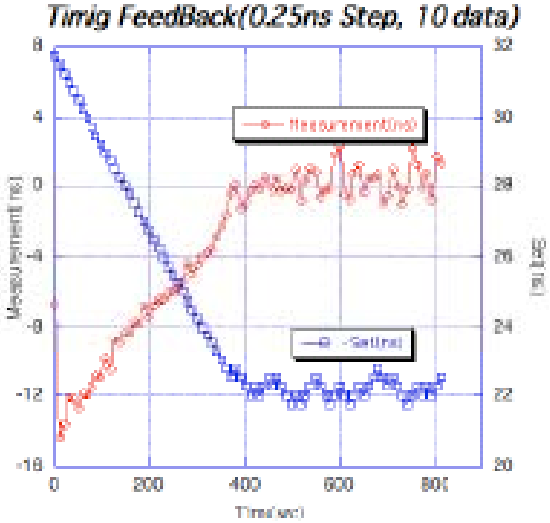


FB off



FB on





Proposal for ATF2: upstream system

1) Fast bunch-bunch feedback for multibunch mode

2) Slow pulse-pulse feedback (uses same hardware as 1)

3) Feed-forward from DR to extraction line

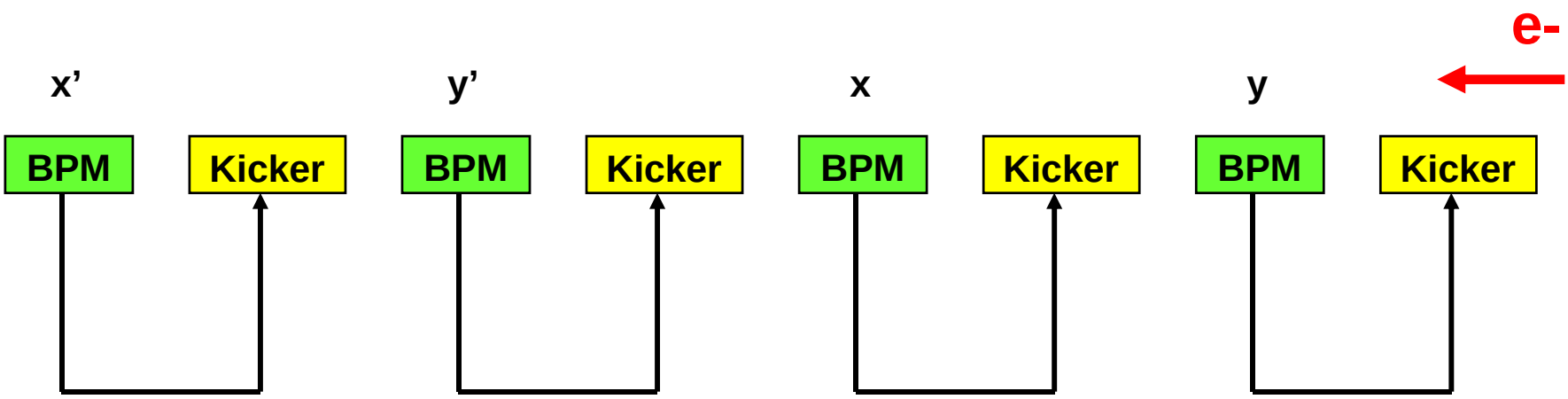
Feedback system:

Assuming x,x', y,y' correction:

minimal setup requires 4 BPMs and 4 kickers

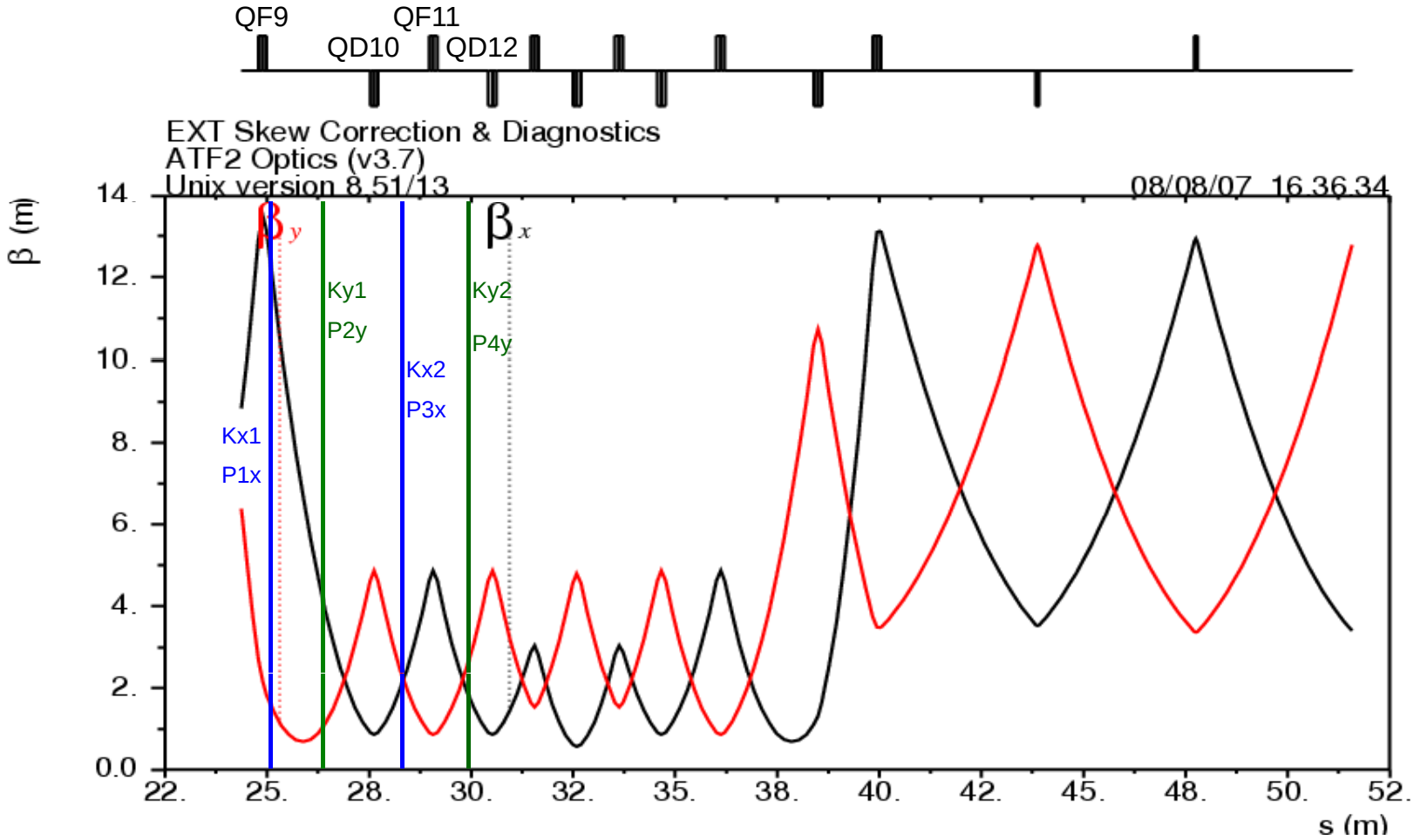
(or 2 combined x-y kickers)

Schematic ATF2 feedback

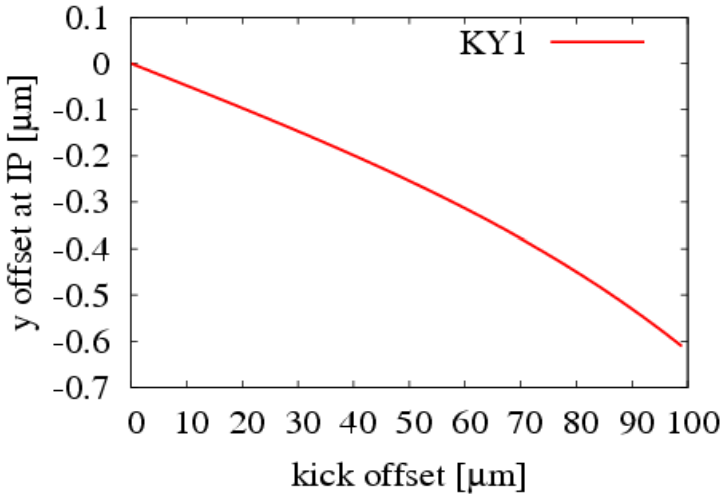


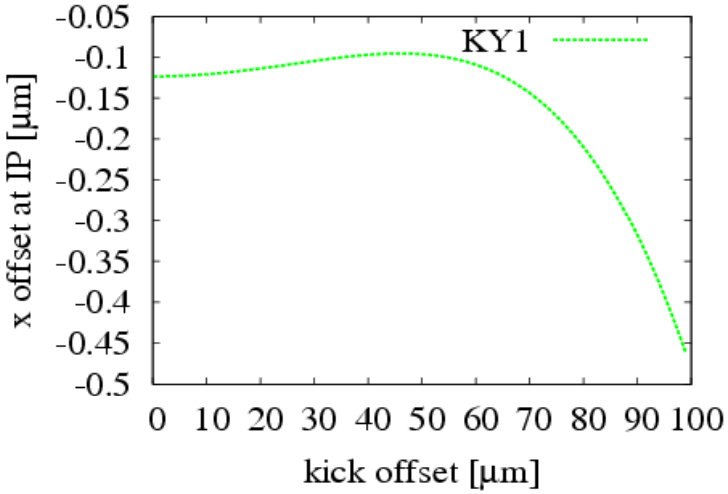
FONT kickers position (Kalinin)

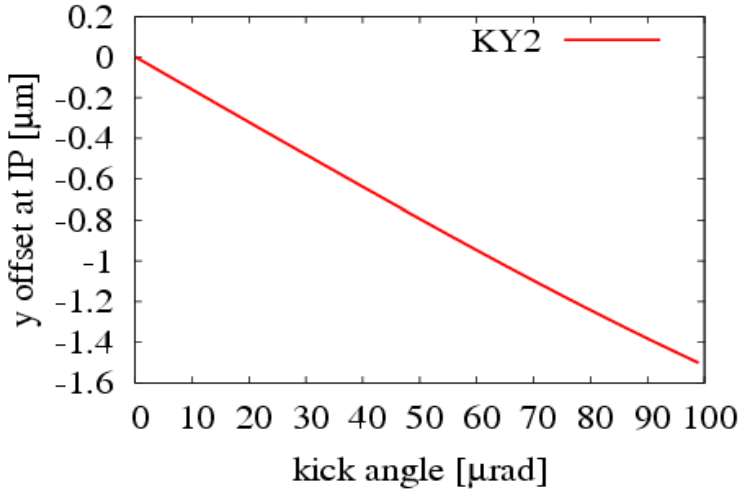
Extraction line: diagnostic and coupling correction

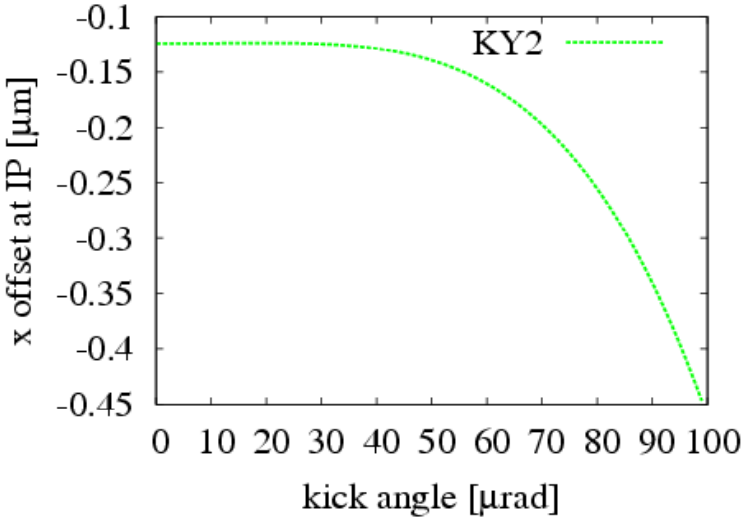


KY1 & KY2: transverse average offset at the IP (Resta Lopez)



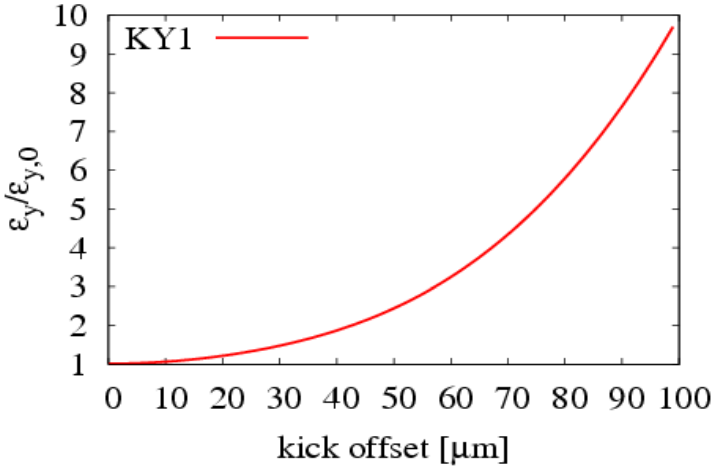


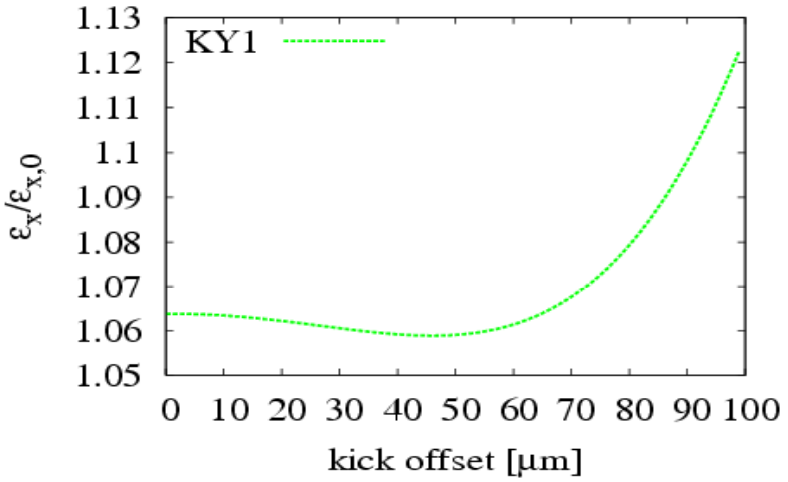


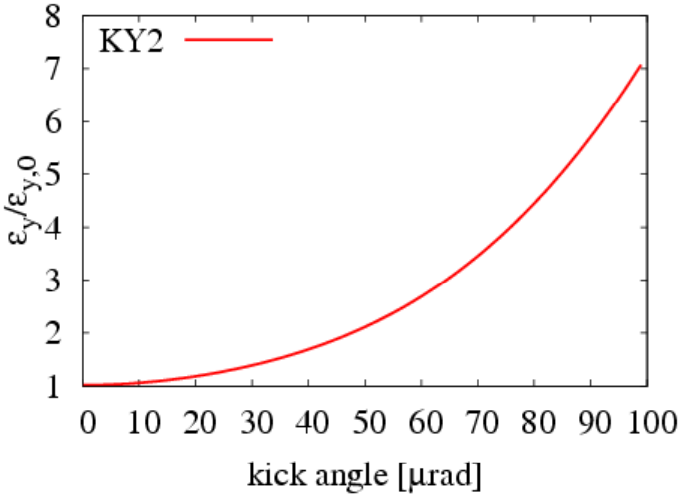


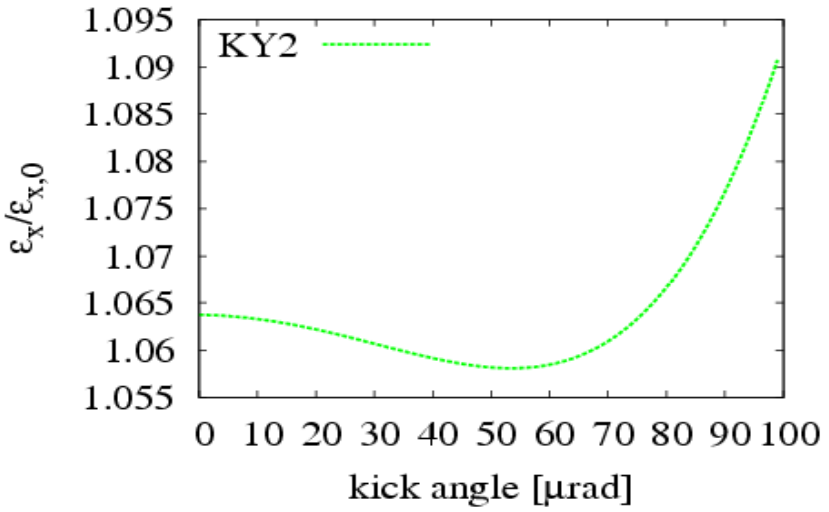
KY1 & KY2: emittance growth at the IP

(Resta Lopez)





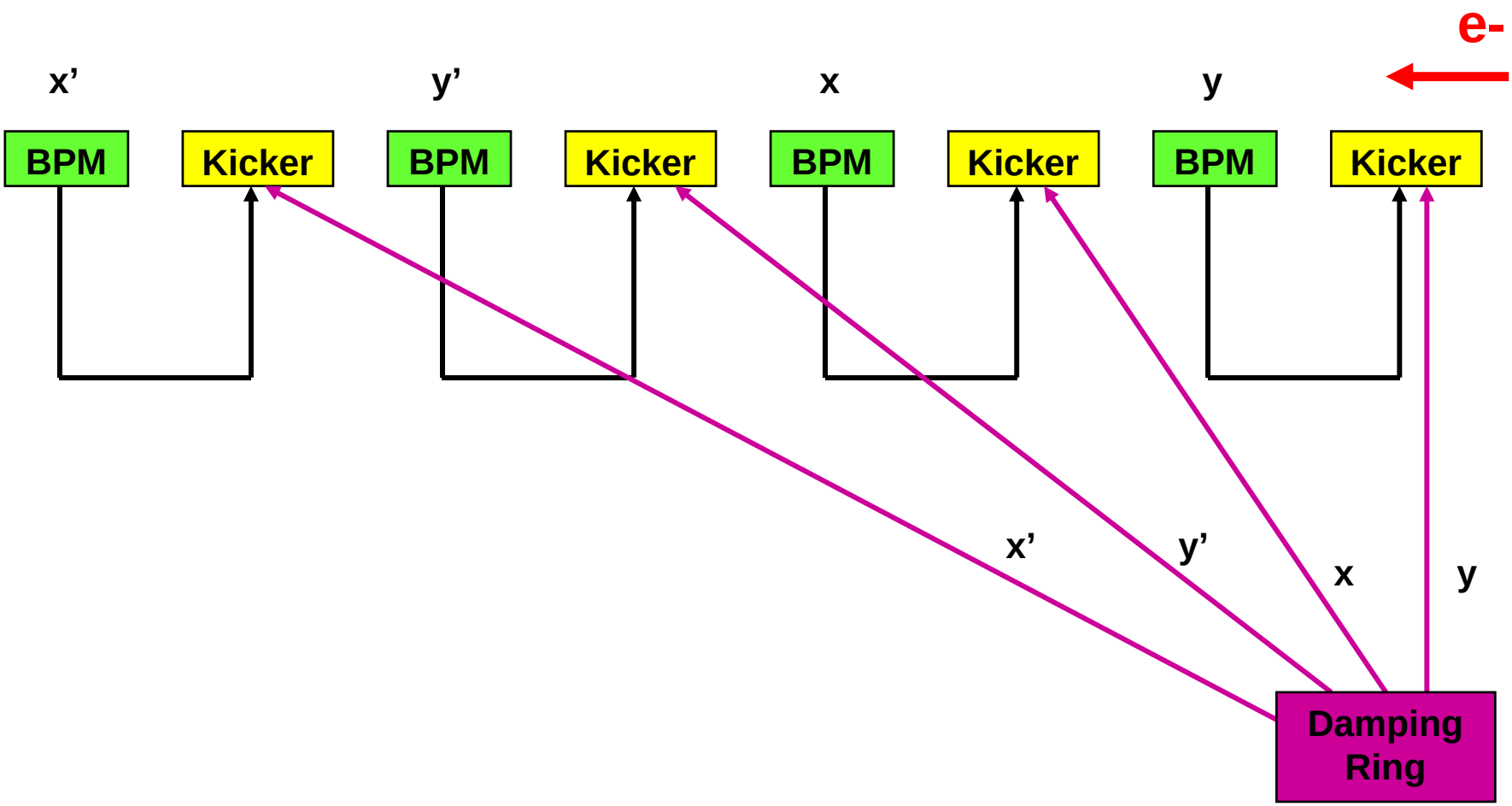




Plans / schedule

- Meeting 9 May 2007: Urakawa, Tauchi, Burrows
- Until June 2008: optimise FONT4 system at ATF
- By ATF2 meeting December 2007:
  define location of BPMs and kickers in extraction line,
  specify kicker design
- By mid 2008: build kickers
- 2008 shutdown: install BPMs + kickers in extraction line
- October 2008: ready to start commissioning with beam
- 3-bunch trains Ok at start
- Move to multibunch (20-60) trains when available

Schematic ATF2 feedforward



Proposal for ATF2: integrated approach

- **‘Slow’: pulse-to-pulse (or slower)**
  LAL Group
- **‘Upstream’ intra-train + feed-forward**
  FONT Group
- **IP intra-train based on IPBPM (Honda-san)**