

ATF/ATF2 fast feedback systems

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Oxford University

- **Status of fast feedback R&D at ATF**
- **Upstream feedback and feed-forward @ ATF2**
- **IP feedback in new final focus @ ATF2**

FONT: Feedback On Nanosecond Timescales

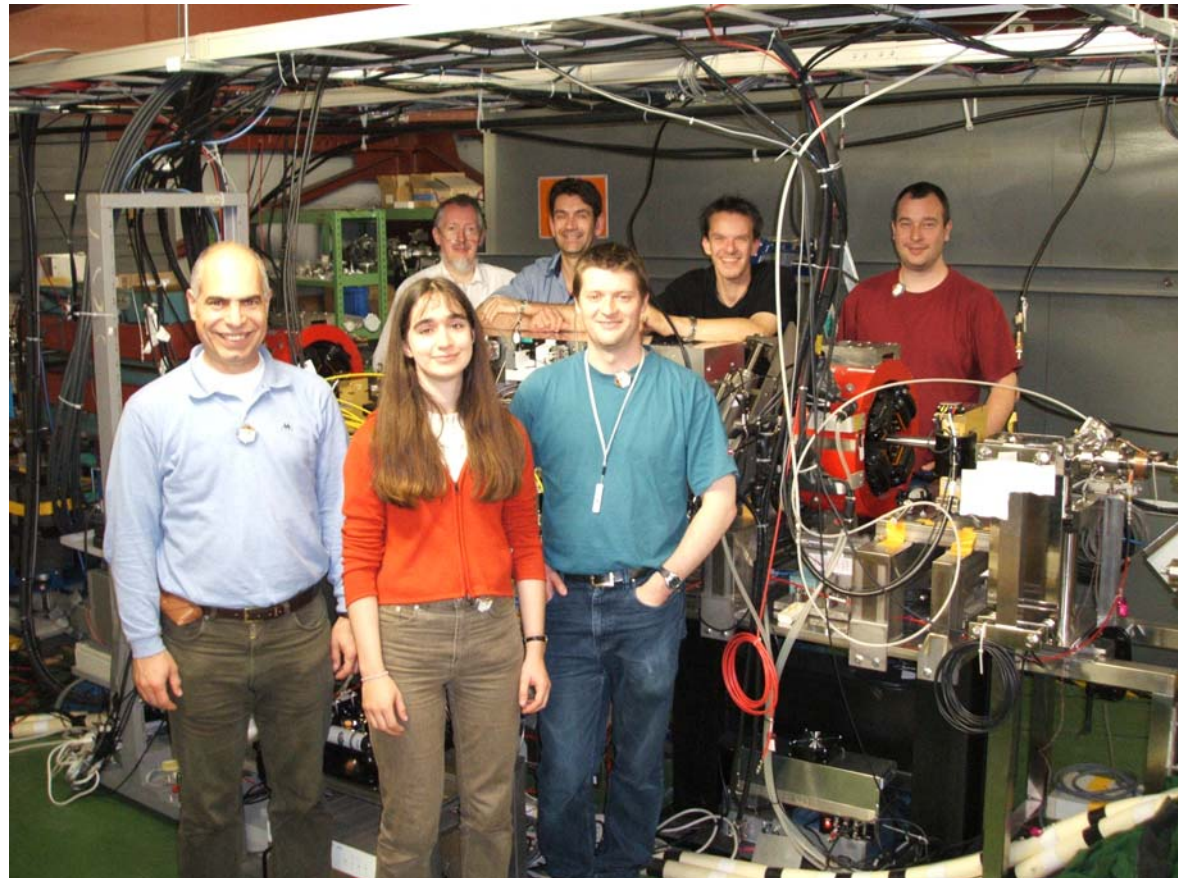
Accelerator R&D for the International Linear Collider (ILC)

Daresbury/Oxford:

Philip Burrows
Glenn Christian
Hamid Dabiri Khah
Tony Hartin
Alexander Kalinin
Colin Perry
Vice Glen White

Graduate students:
Christine Clarke
Christina Swinson
Ben Constance

KEK, Tokyo Met, SLAC,
DESY, CERN ...



Overview

Task: prototype beam-based (intra-train) feedback system

Completed: ultra-fast analogue feedback prototypes

FONT2 / NLCTA: 54ns latency

FONT3 / ATF: 23ns latency

Ongoing: ILC digital feedback prototype

FONT4 / ATF: digital FB processor tests w. 3 bunches

Design of feed-forward system (see Kalinin)

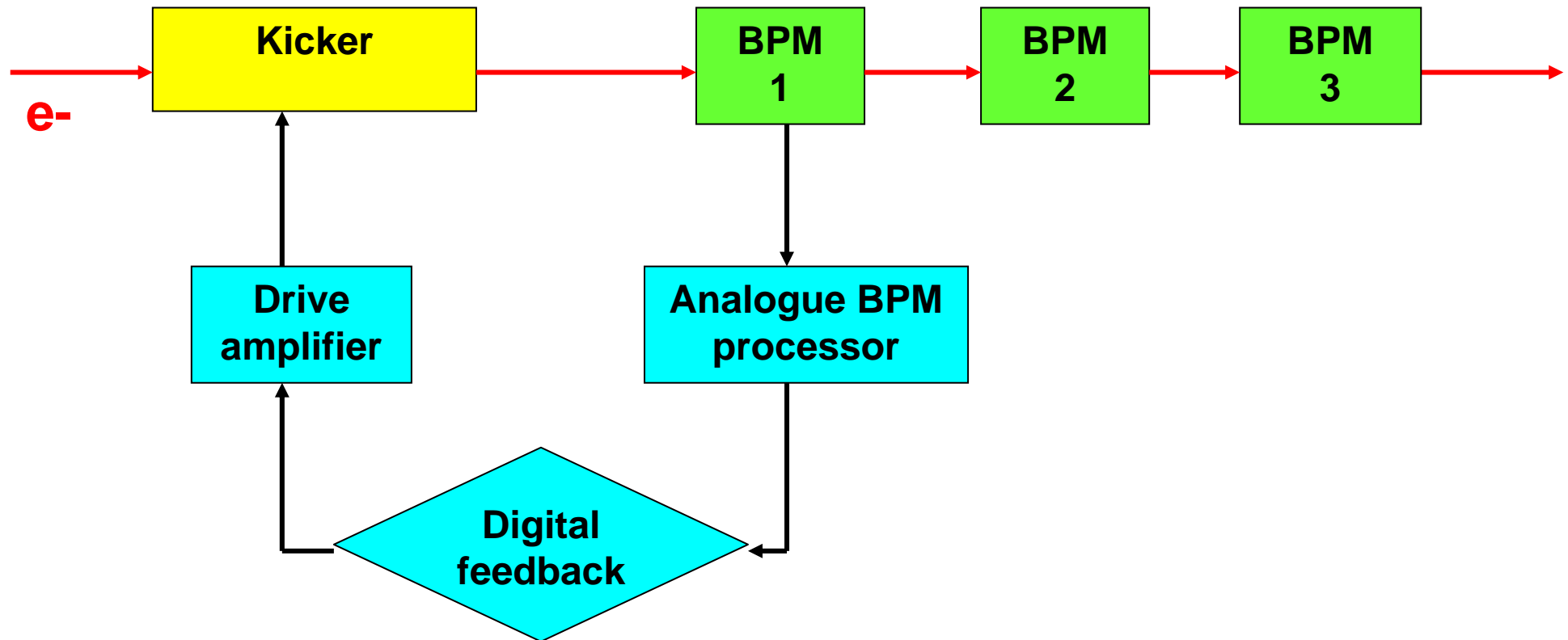
(FONT@ESA: EM background impact on FB BPMs)

Future: Multibunch (20 – 60 bunches?) operations, algorithm tests

FONT5 / ATF2

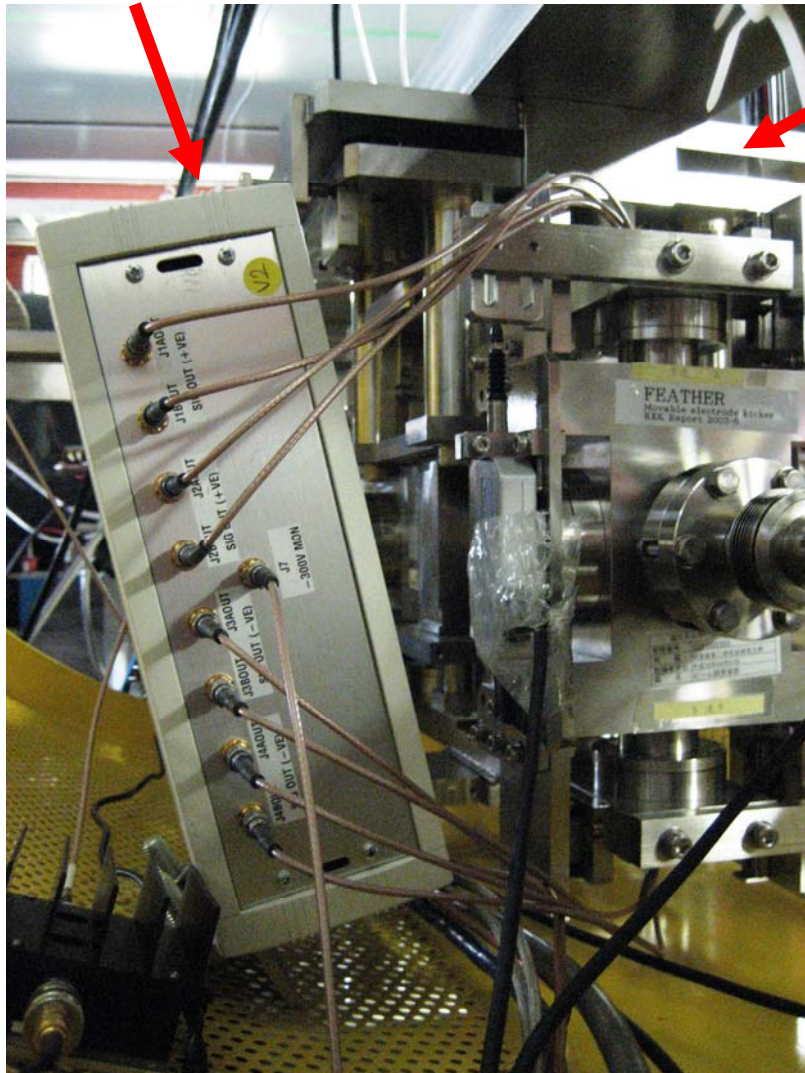
Feed-forward (see Kalinin)

ILC digital feedback prototype (FONT4)



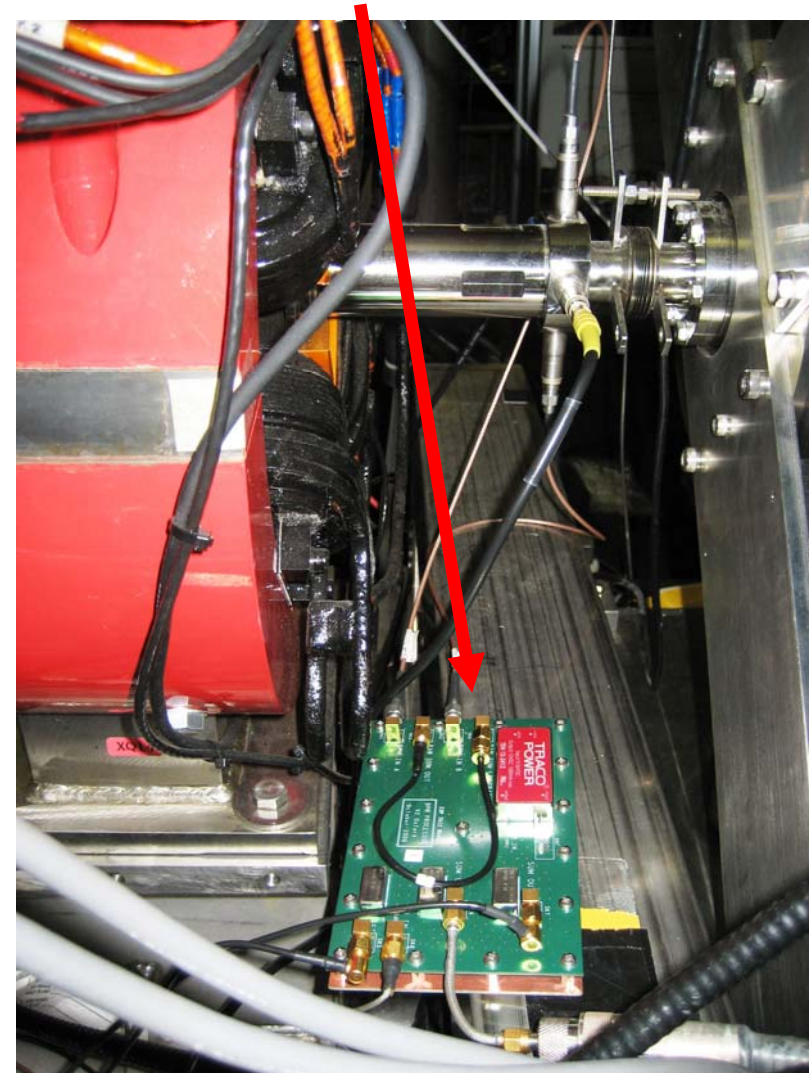
FONT4: beamline at KEK ATF (December 06)

Amplifier



FEATHER Kicker

BPM processor board



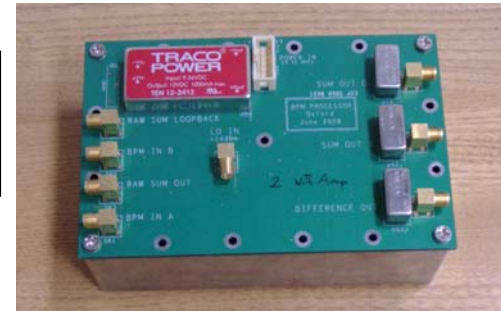
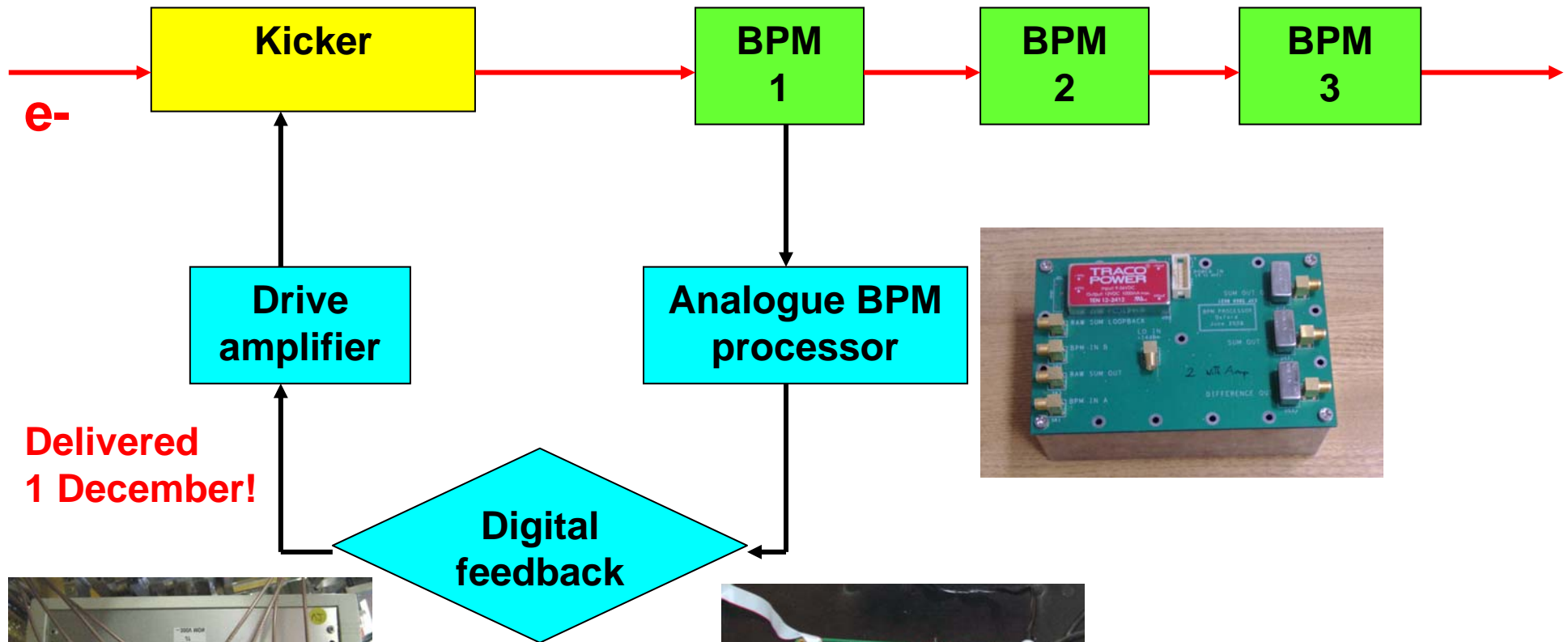
FONT4: latency budget

- Time of flight kicker – BPM: 7ns
- Signal return time BPM – kicker: 15ns
- **Irreducible latency: 22ns**

- 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 budget: 140ns**

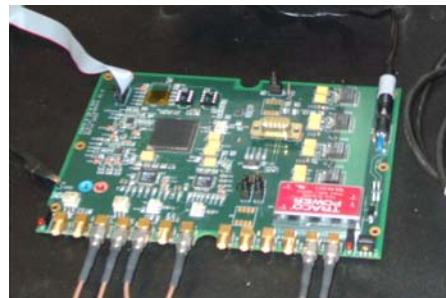
FONT4 hardware



**Delivered
1 December!**



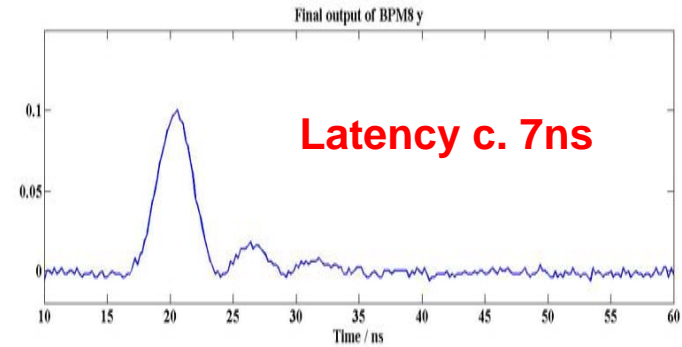
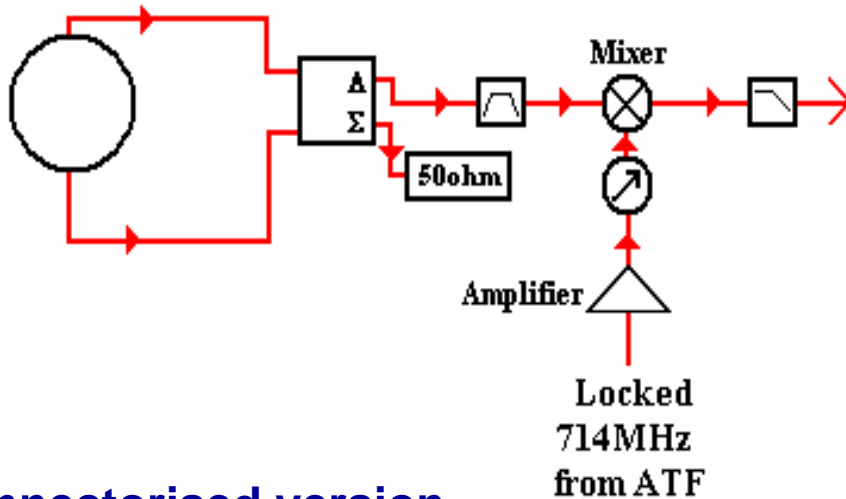
P.N. Burrows



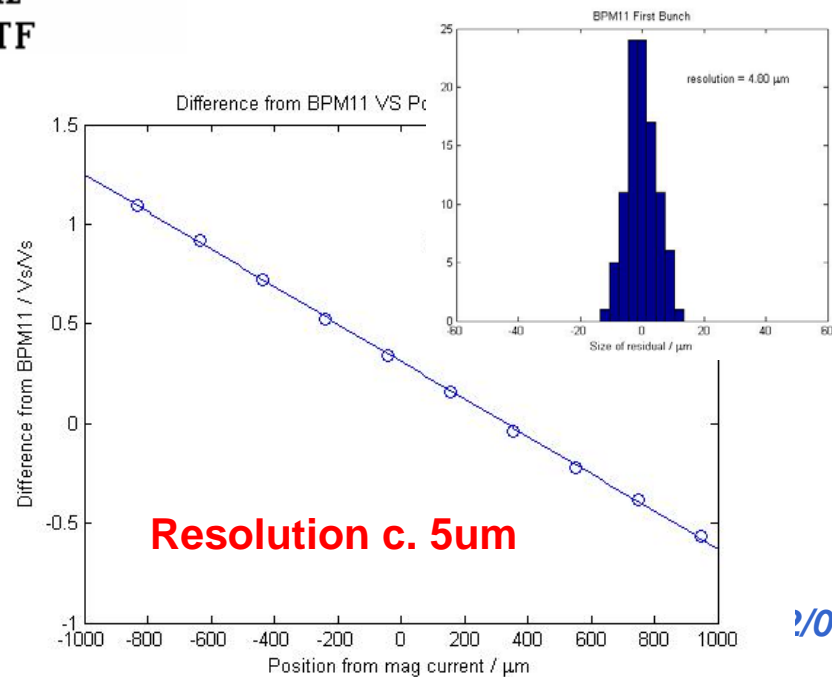
Project Meeting, KEK, 18/12/06

BPM processor

Single stage down-mix to baseband



Replaced connectorised version with custom PCB – new version tested November 2006

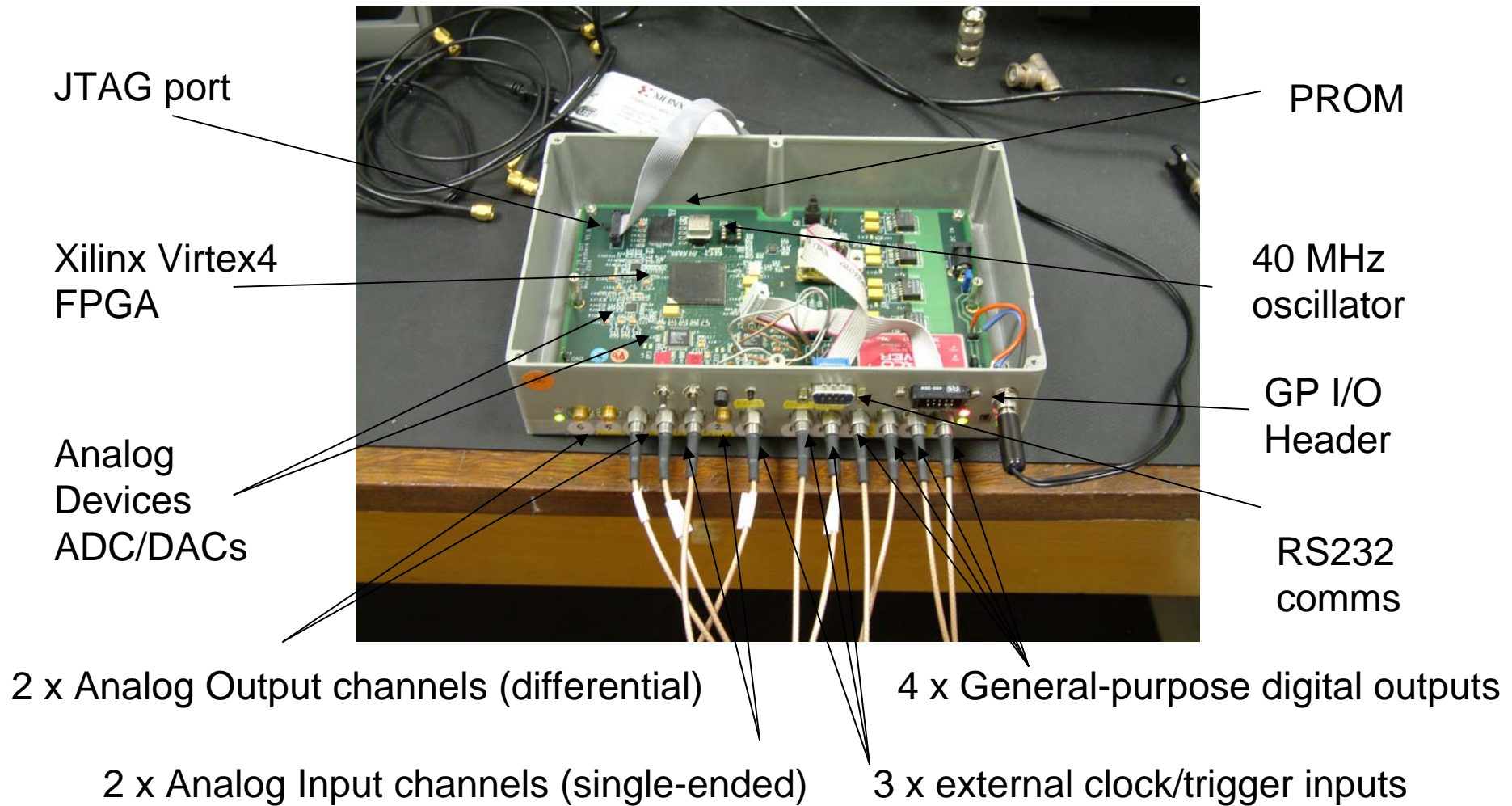


old

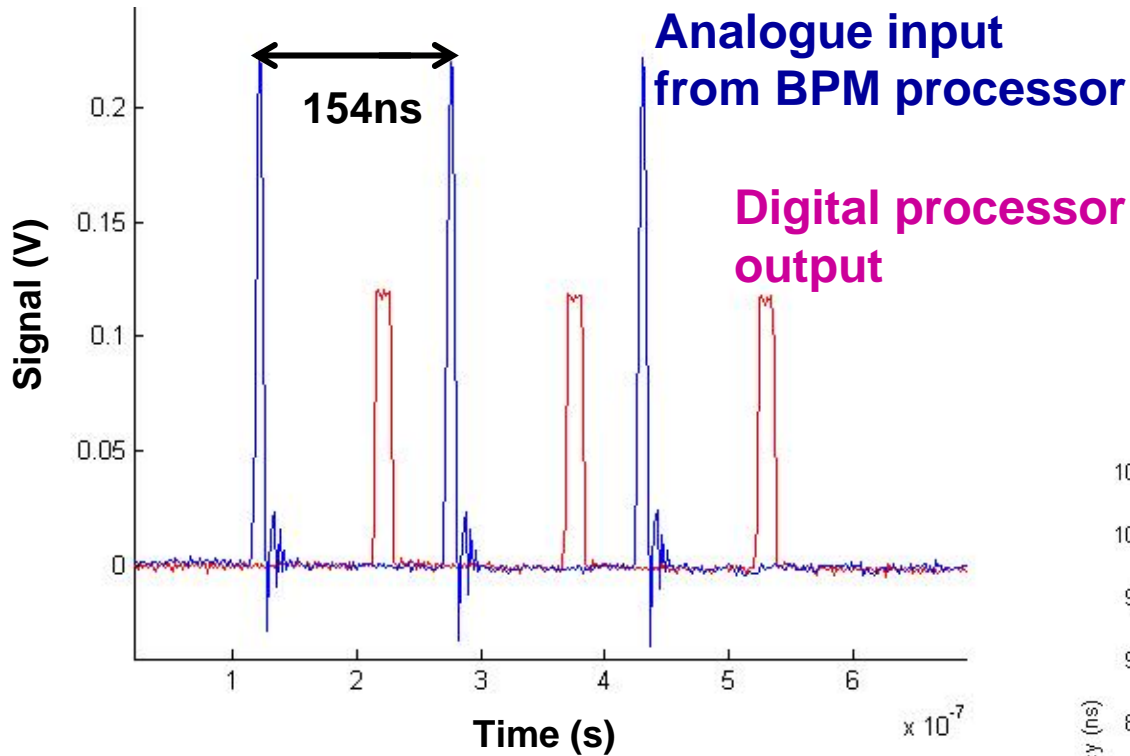


new

Digital Feedback Board



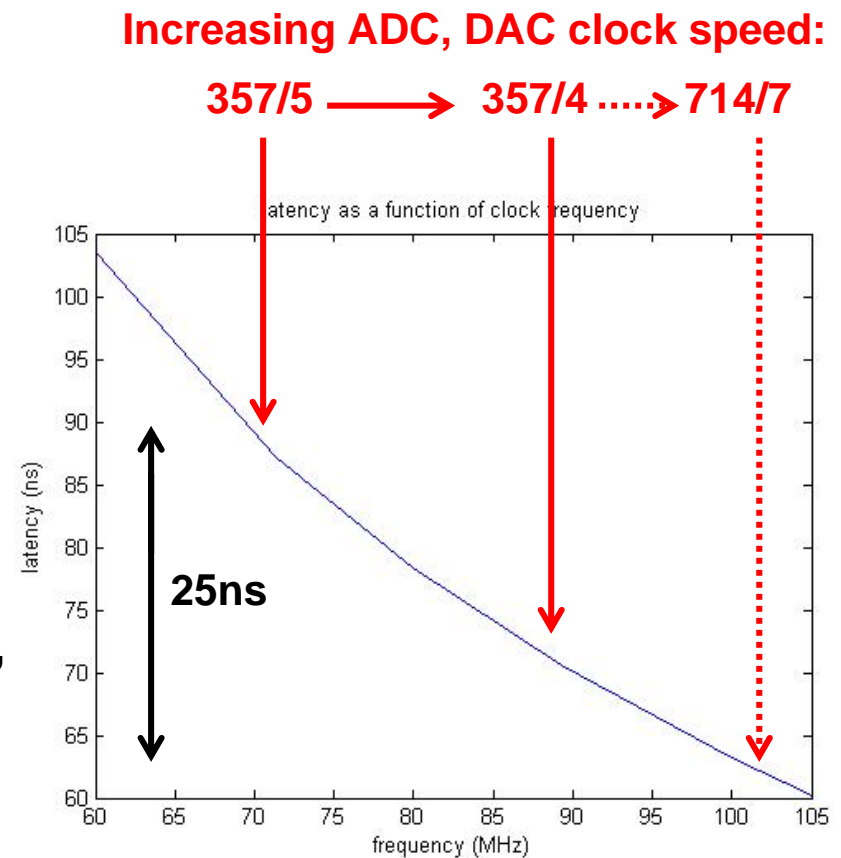
Beam test results (April – November 2006)



- Checked simple gain implementation
- Verified triggering, beam synchronisation, clocking ...

P.N. Burrows

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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**

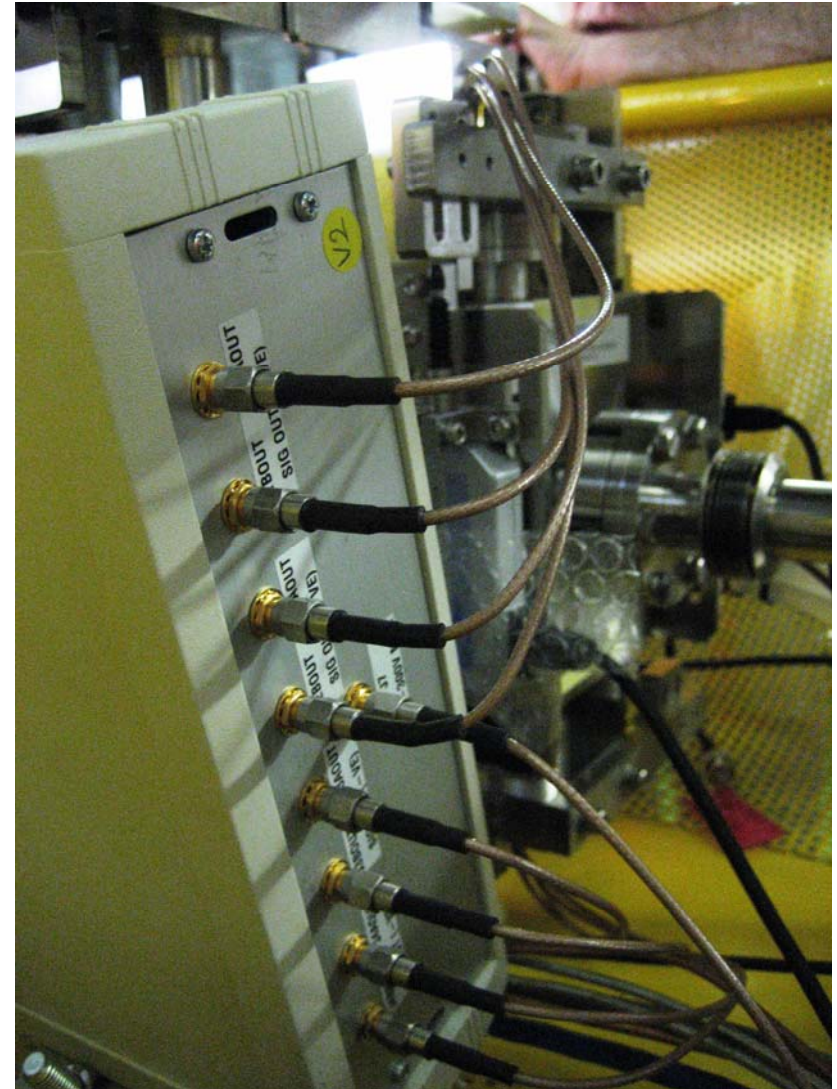
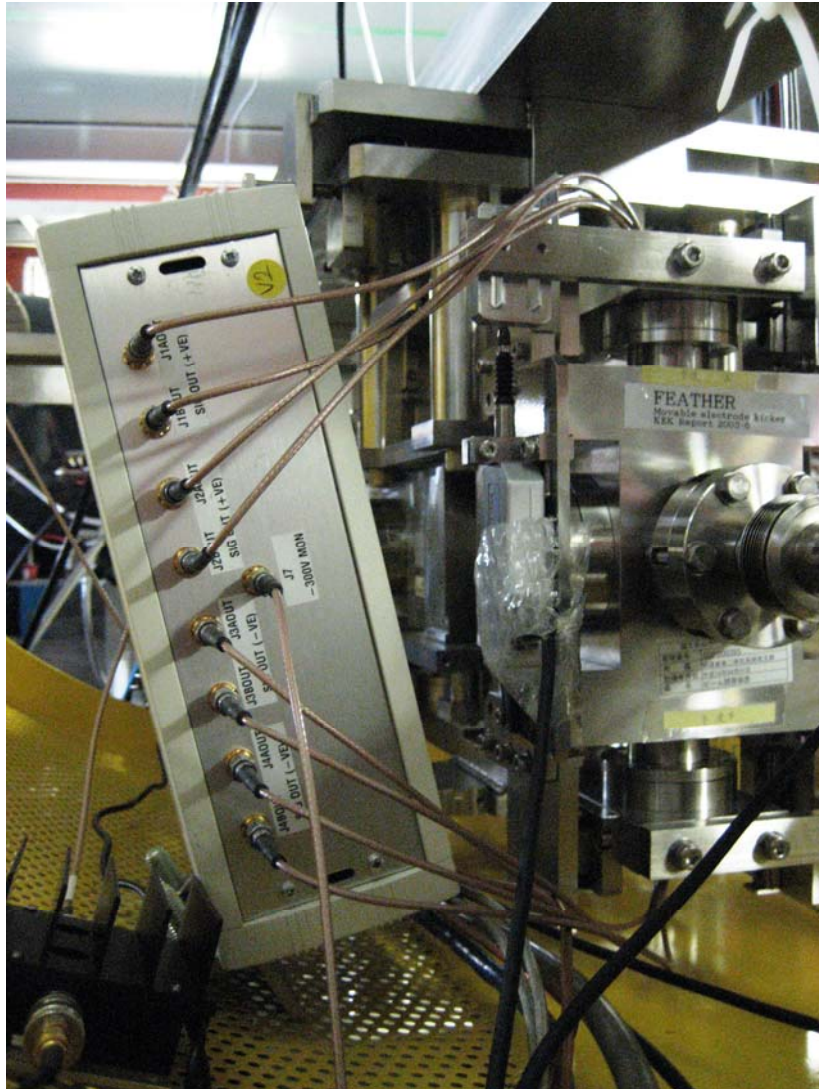
Order placed with TMD Technologies September 22

1st prototype unit delivered December 1

2nd prototype unit delivered December 8 (5ns faster)

Tested with beam at ATF last week!

Kicker driver amplifier in beamline



FONT4 test plan – same slide as 30/5/06!

June 2006:

1st test of PCB version of analogue BPM processor

2nd tests of digital FB: timing, synchronisation, triggering,
gain adjustment in FPGA
(ADC clocking @ $714/10 = 71$ MHz)

December 2006:

1st test of FONT4 amplifier

3rd tests of digital FB: ADC clocking @ $357/4 = 90$ MHz

2nd tests of PCB BPM processor

Closed-loop FB

March/April 2007:

Closed-loop FB

FONT4 test plan – same slide as 30/5/06!

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Closed-loop FB 

March/April 2007:

Closed-loop FB

FONT4 test plan (contd.)

January 2007 - Mid 2008: Continue closed-loop FB tests

Up to June 2006:

- Specify any modifications to TMD amplifiers
- Close loop 'properly'
- Optimise FPGA firmware programming

Until ATF shutdown for connection to ATF2:

- Improve performance in preparation for ATF2:

Improve BPM resolution to 1 μ m level:

- striplines: can it be achieved?
- cavities: can multibunch be done?

Beam jitter improvements in multibunch extraction?

FONT5 test plan

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)

- Depends on success of fast-extraction kicker tests, **2008/9??**
- Would allow us to make FB algorithms robust:
 - take into account bunch-bunch correlations along train
 - adaptive gain as beam conditions change (drift)
 - incorporate feed-forward information from upstream
 - add beam-related 'luminosity' signal for fast scanning?
- **Could in principle be done at FLASH?**

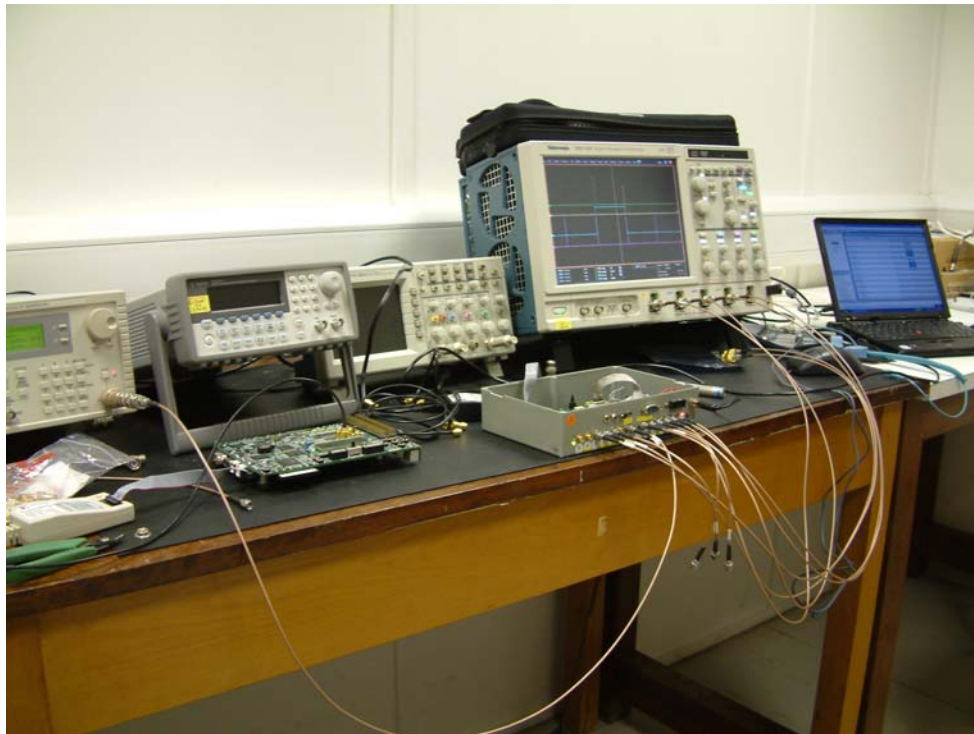
FONT bench test system

Manufacture synchronised ILC bunch-train, clocks, and trigger

Develop algorithms and program FPGA

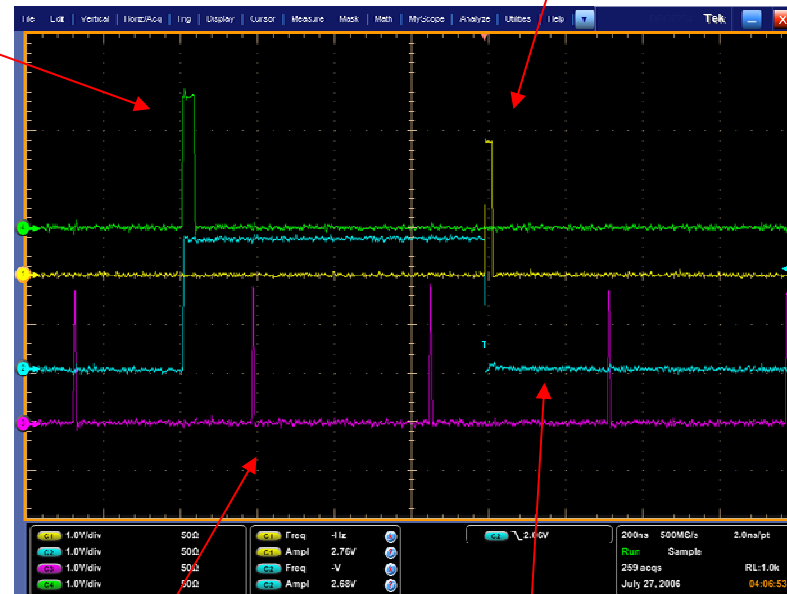
Close loop

(Include amplifier and dummy kicker also!)



Trigger

Bunch



2.16 MHz

Diagnostic

ATF2 Project Meeting, KEK, 18/12/06

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:

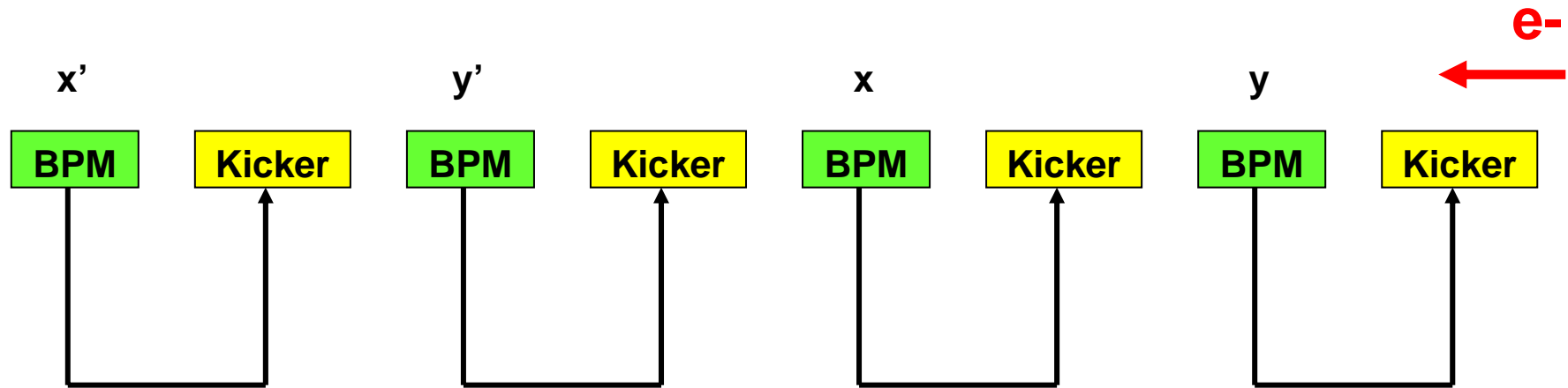
Assuming x, x', y, y' correction:

minimal setup requires 4 BPMs and 4 kickers
(or 2 combined x-y kickers)

Feed-forward system:

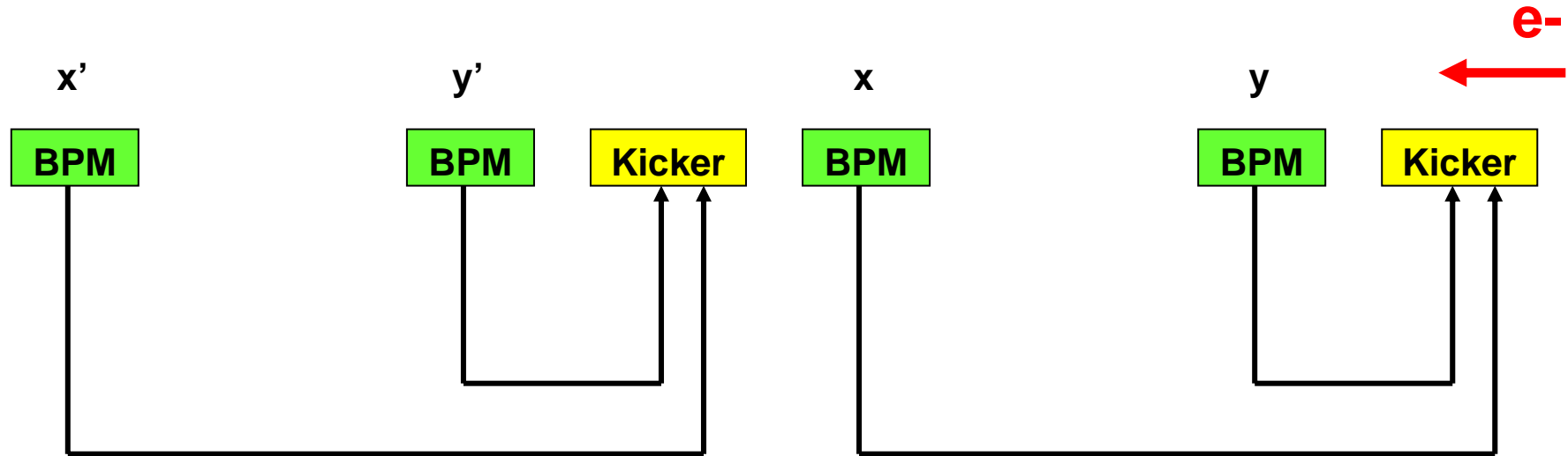
4 BPMs in ring, 'piggy-back' on feedback kickers in extraction line?

Schematic ATF2 feedback layout: 1

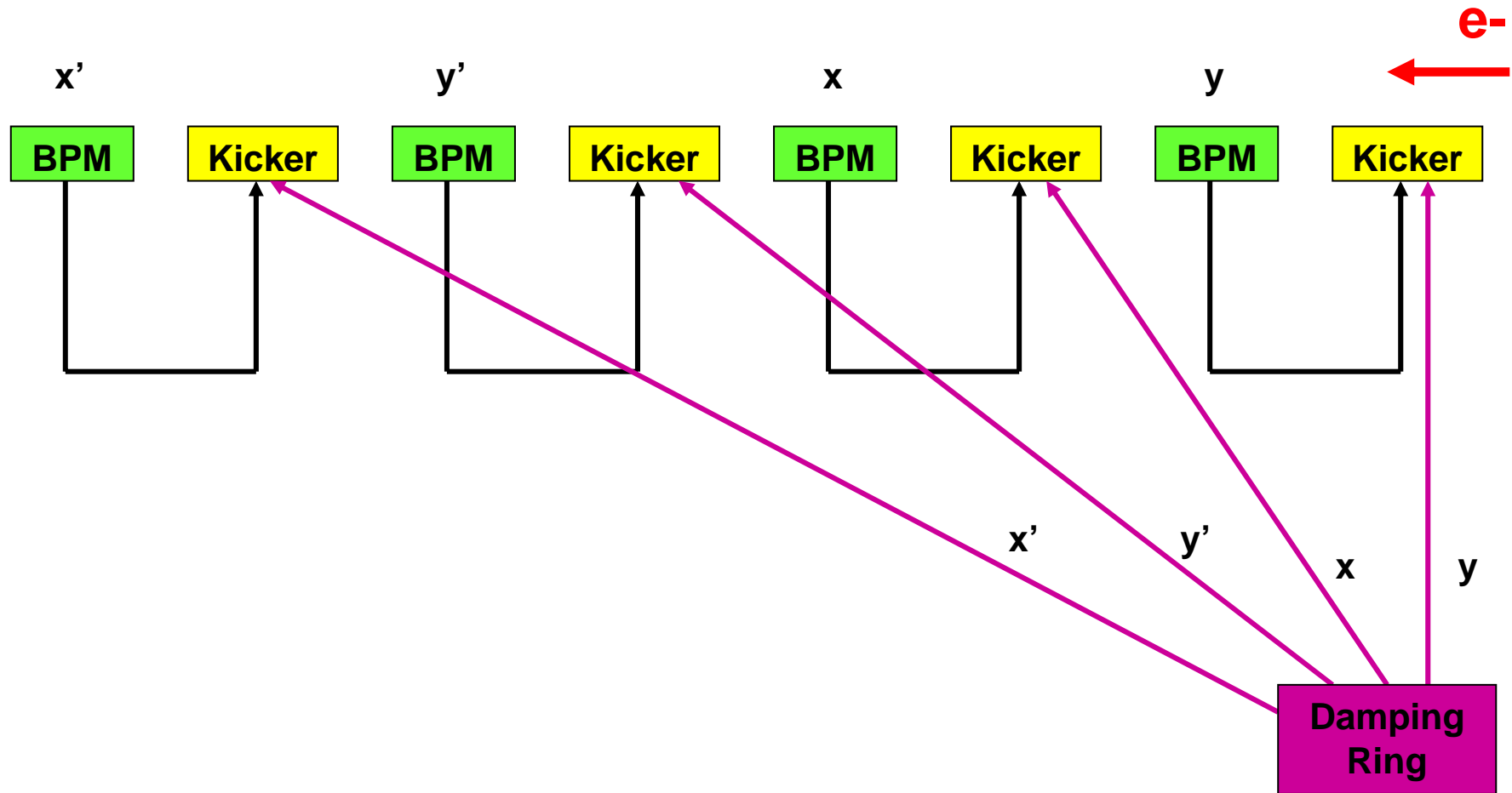


Schematic ATF2 feedback layout: 2

combined x-y kickers

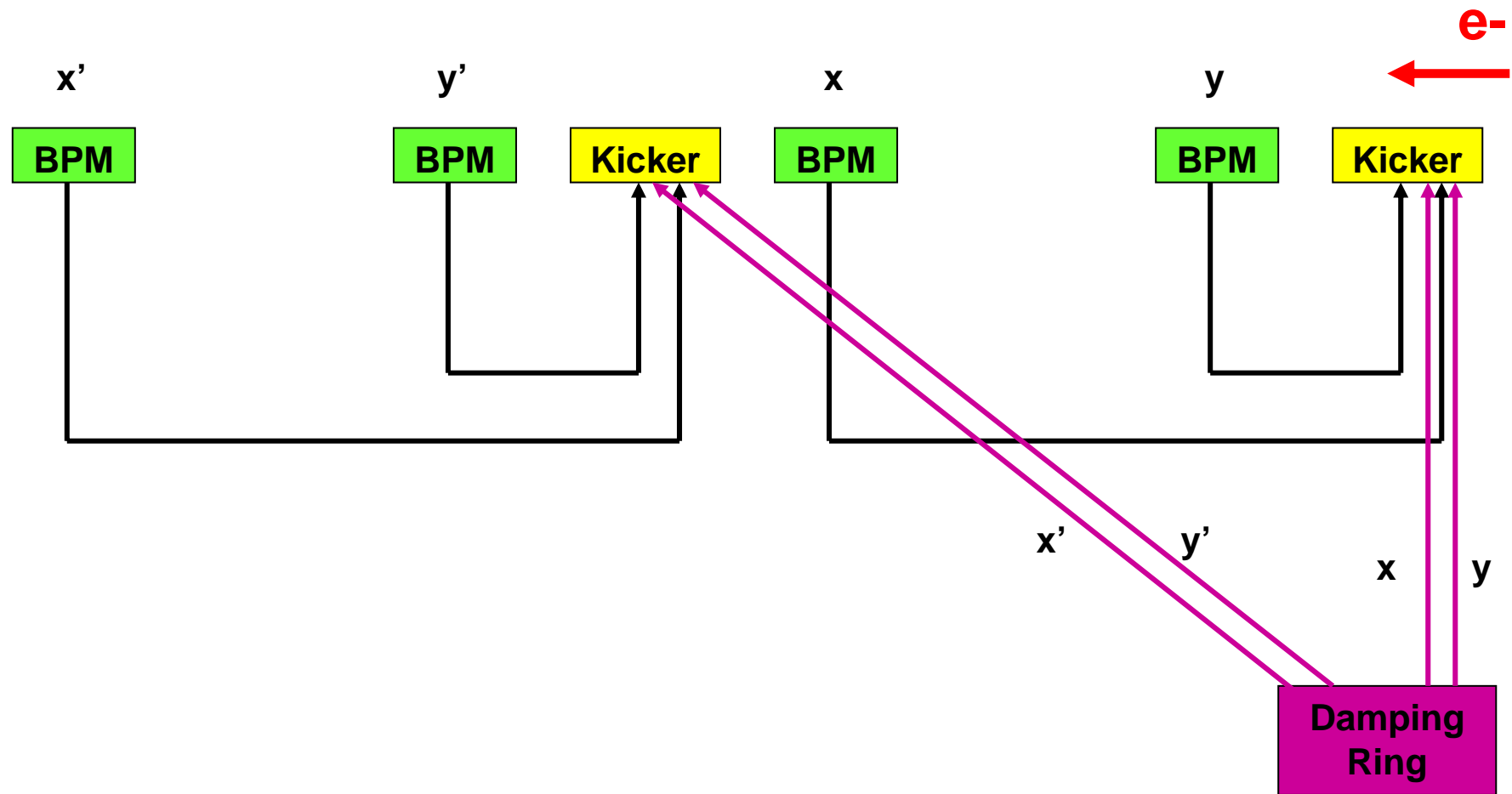


Schematic ATF2 feedforward layout: 1



Schematic ATF2 feedforward layout: 2

combined x-y kickers



Issues – for discussion

- **Location of BPMs and kickers in extraction line:**
 - See Honda-san's earlier presentation
 - Need appropriate $\pi/2$ phase differences between BPMs and kickers
- **Type of BPM:**
 - If we can obtain 1 μ m resolution, striplines OK
 - can we use planned striplines, or need to add extras?**
 - If not, we will need to use cavity BPMs
 - probably needs new low-Q BPMs for multibunch**
- **Kicker design:**
 - FEATHER style ideal, but expensive! **Fixed gap?**
- **Identify appropriate BPMs in ring for feed-forward**

Proposal for ATF2: IP FB system

It would be prudent to plan for possible use of the IPBPM to drive an upstream kicker for correction of the beam position in y at the ATF2 final focus

Since the IPBPM program is in development, this would probably not be ready to try until much experience has been gained with the new final-focus

Suggestion:

identify and reserve space within the final focus for a kicker at the correct phase for y @ IP – it can be added when needed

Schedule considerations

- We plan to demonstrate 1-d FB system (y) in ATF in 2007
- Pursue 1 μ m stripline resolution by simulation + prototype
Decide whether striplines viable mid 2007:
 - if yes: prototype and test BPM processor @ ATF
 - if no: need to develop multibunch cavity r/o system
 - start with E-spectrometry cavity BPM?**in both cases we will need beamtime @ ATF**
- **Provided BPMs + kickers are in ATF2 beamline, or sections with bellows are 'reserved', FB + FF hardware can be added later**
 - details NOT critical for scheduling at this time**