

# Engineering issues for IP intra-train feedback

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# Outline

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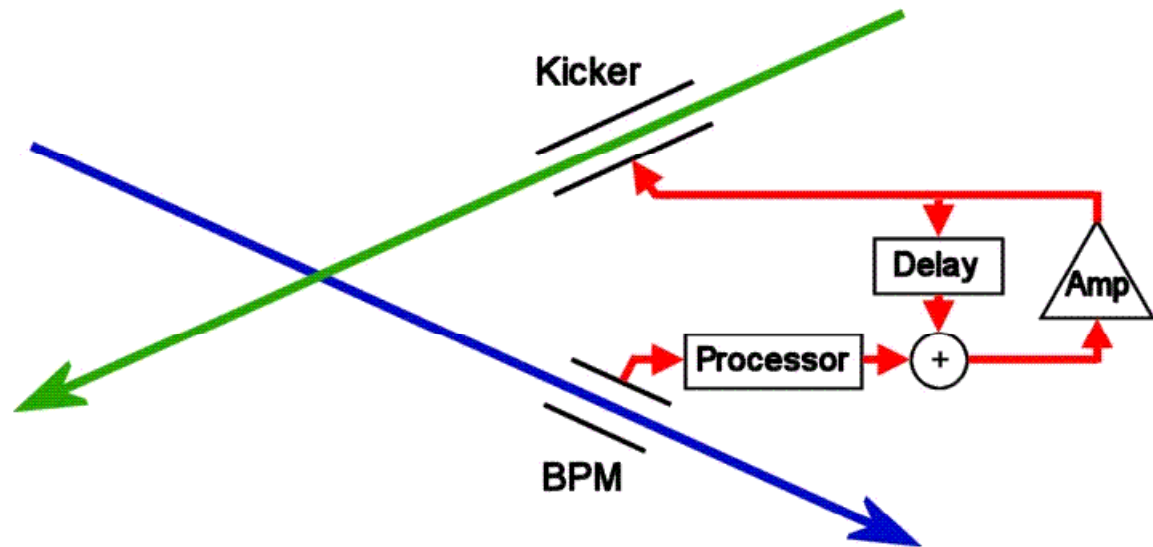
- **Reminder of IP intra-train feedback system**
- **General considerations for ILC**
- **RDR layout**
- **Prototype hardware (FONT4 system at ATF)**
- **Engineering integration issues**
- **Summary**

# IP intra-train feedback system - concept

Last line of defence  
against relative  
beam misalignment

Measure vertical  
position of outgoing  
beam and hence  
beam-beam kick  
angle

Use fast amplifier and  
kicker to correct  
vertical position of  
beam incoming to IR



**FONT – Feedback On Nanosecond Timescales**

**(Oxford, Daresbury, SLAC, KEK)**

# General considerations

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## 1. IP position feedback: hardware located near IP:

provide IP beam position correction at  $\pm 50 \sigma_y$  level  
i.e.  $\pm 250$  nm of vertical beam motion at IP

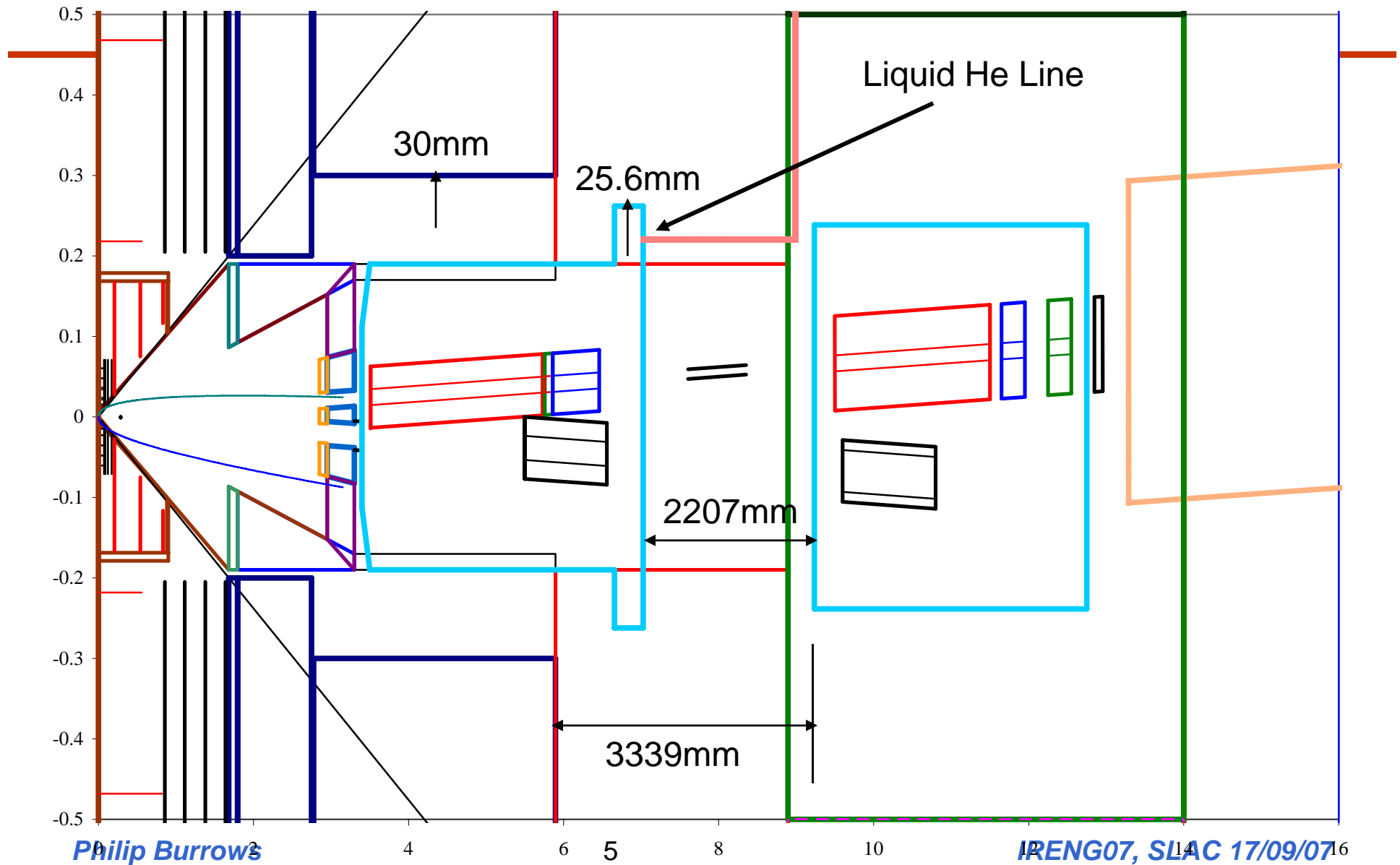
## 2. IP angle feedback: hardware located few 100 metres upstream conceptually very similar to position FB, (arguably) less critical

## 3. Additional inputs to IP FB hardware:

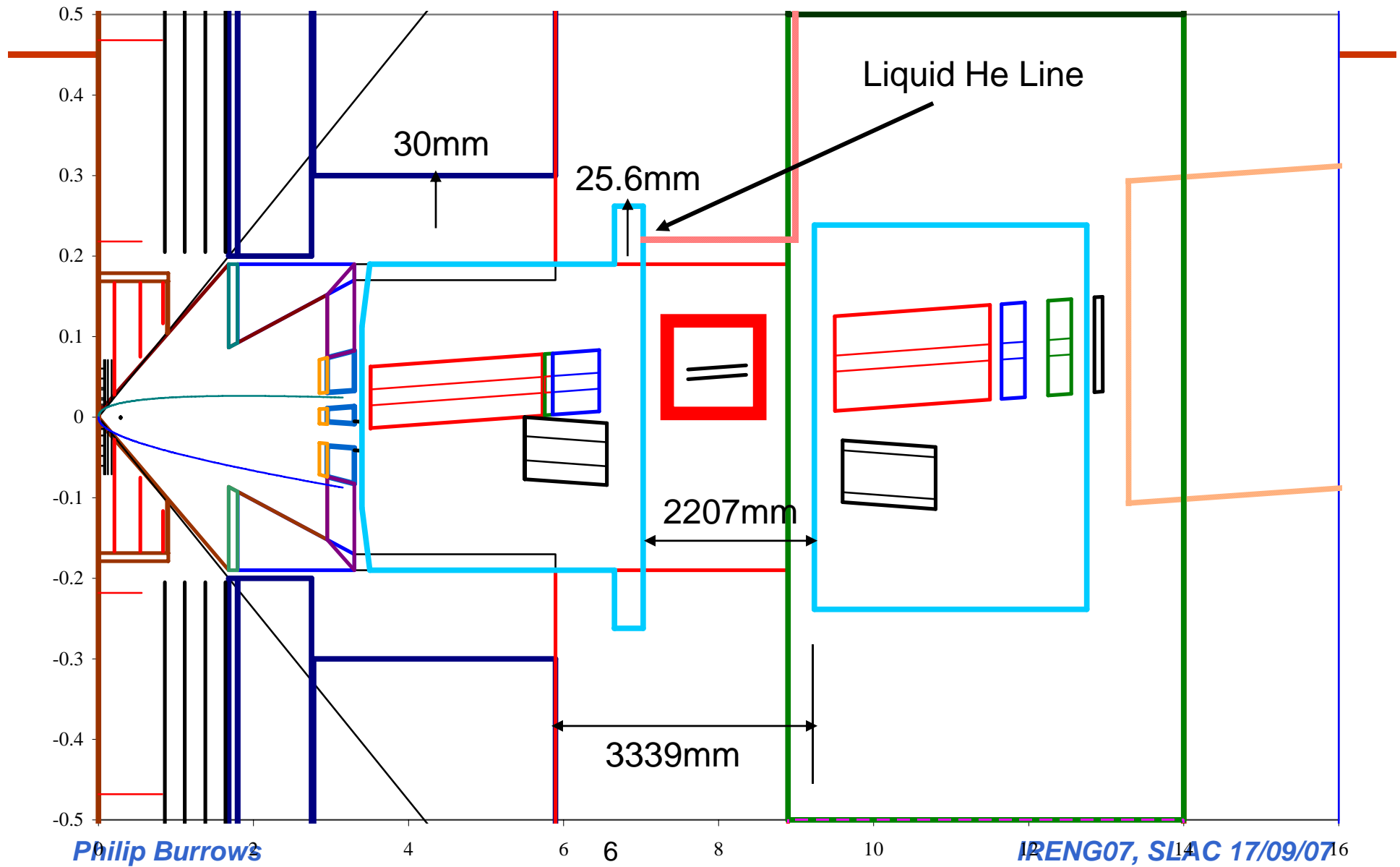
bunch-by-bunch luminosity signal (from BEAMCAL)  
information from alignment systems (eg. QD0 etc.)?  
'feed-forward' information from upstream in machine ...

**RDR view: 'special' systems requiring dedicated hardware + data links**

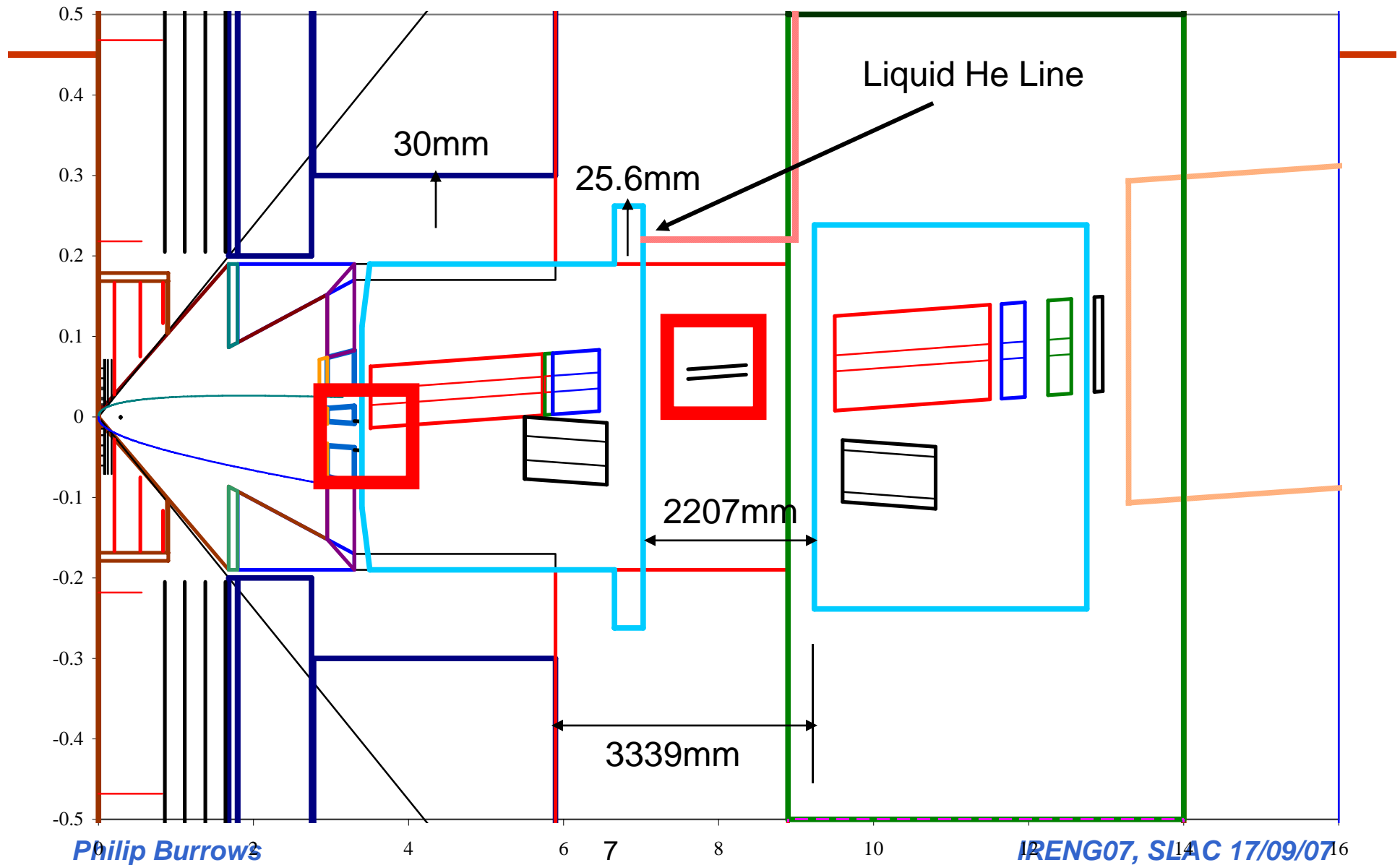
# Location of FB hardware (SiD, $L^*=3.7\text{m}$ )



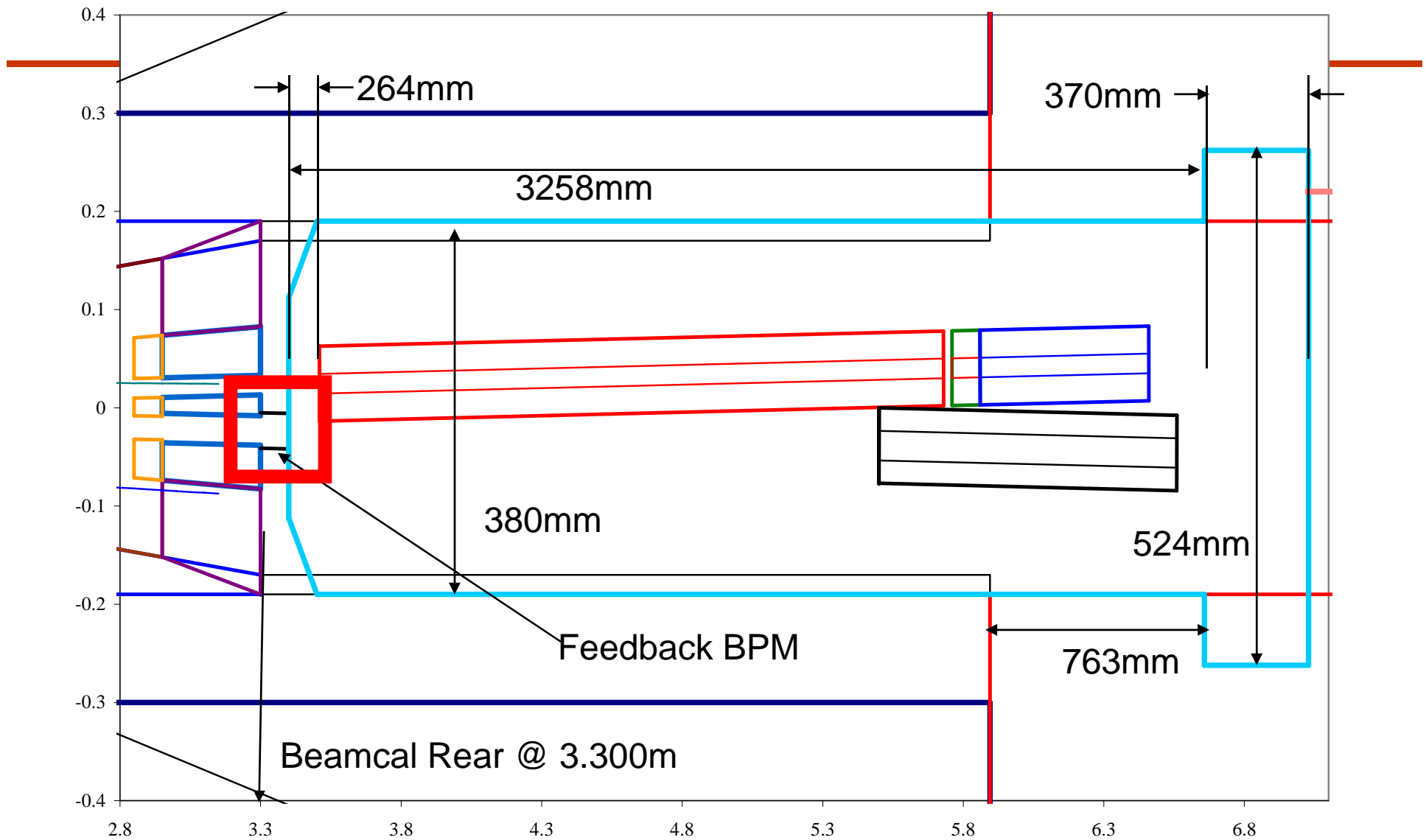
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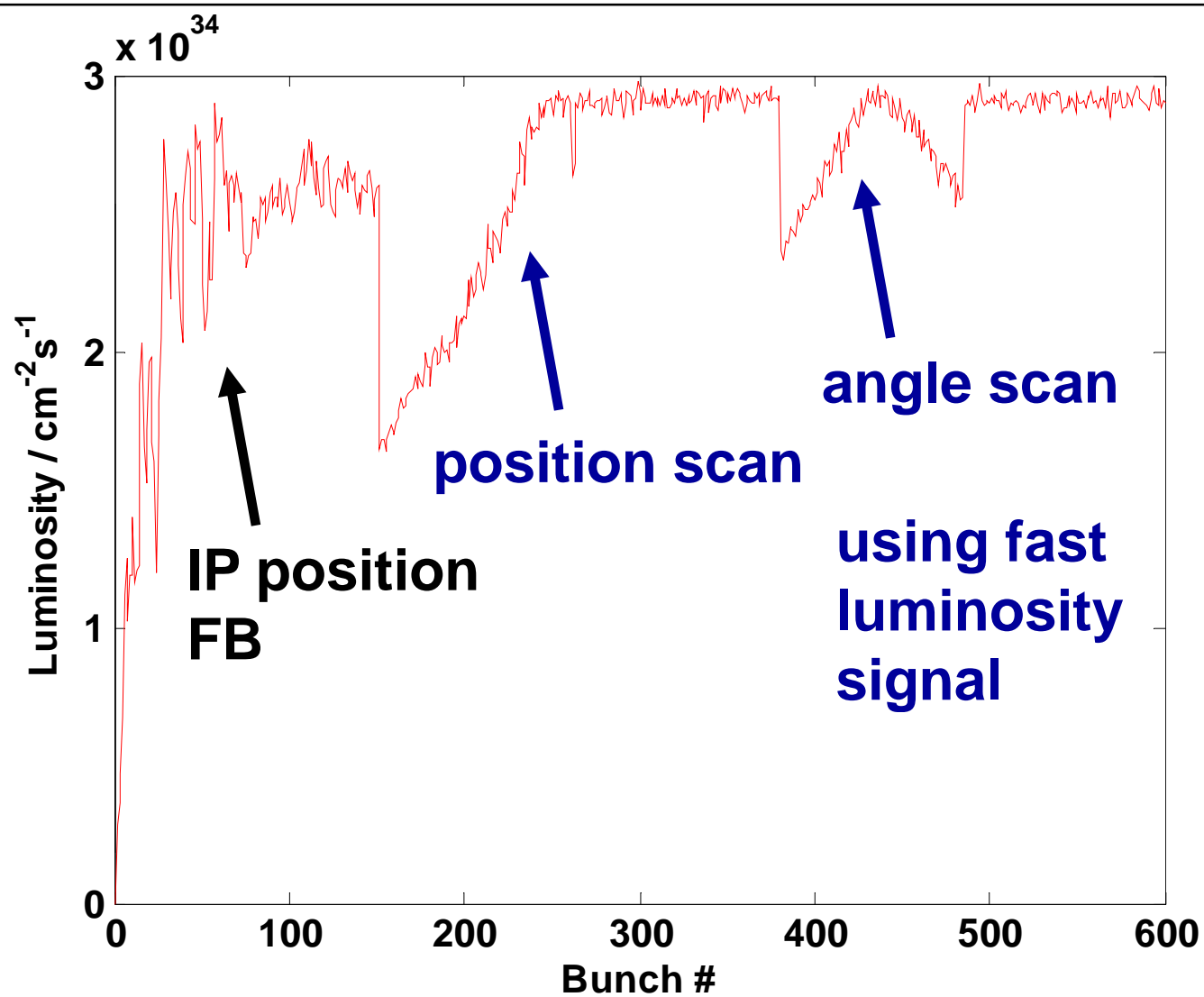


# Zoom-in showing BPM location

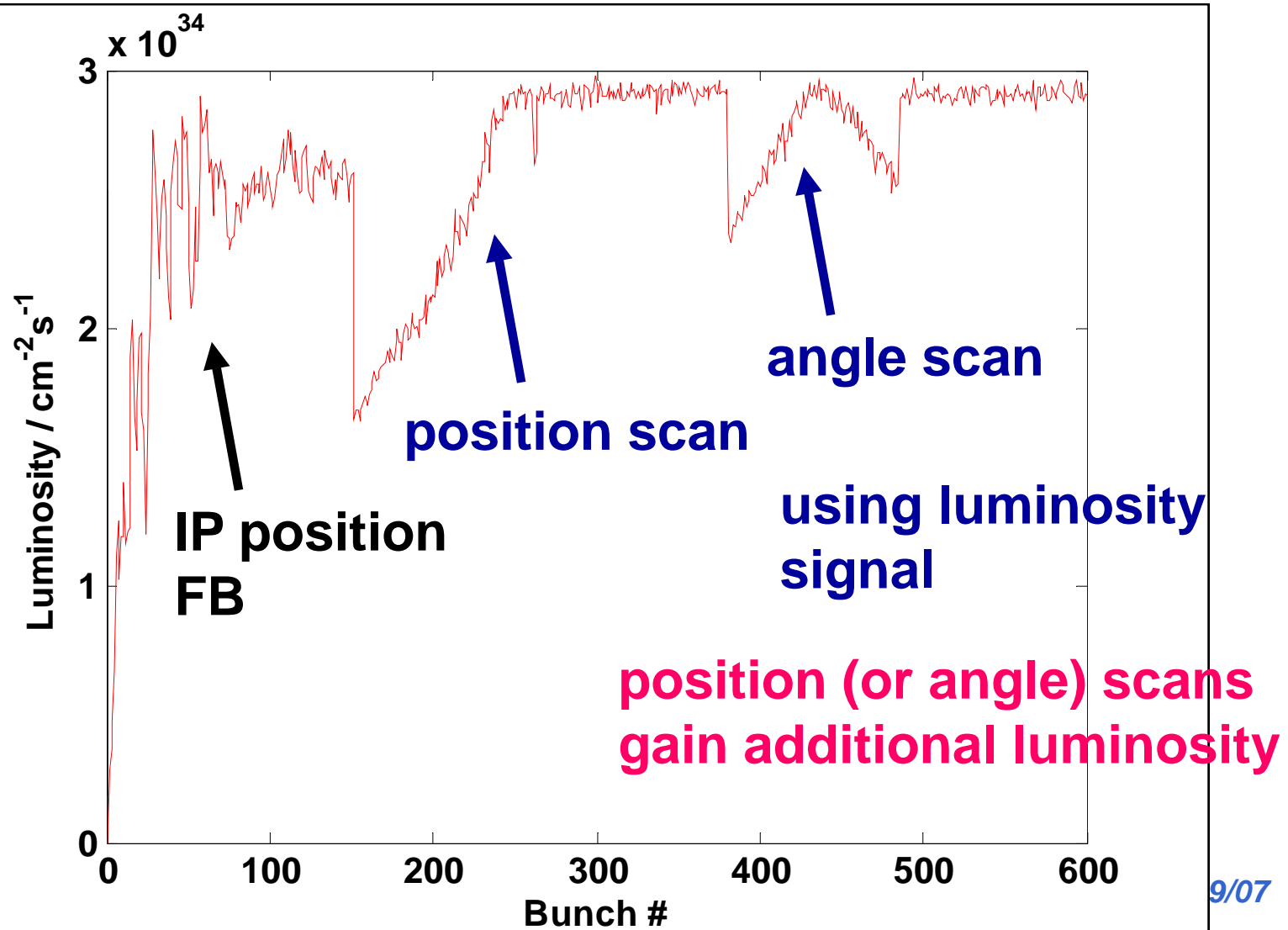




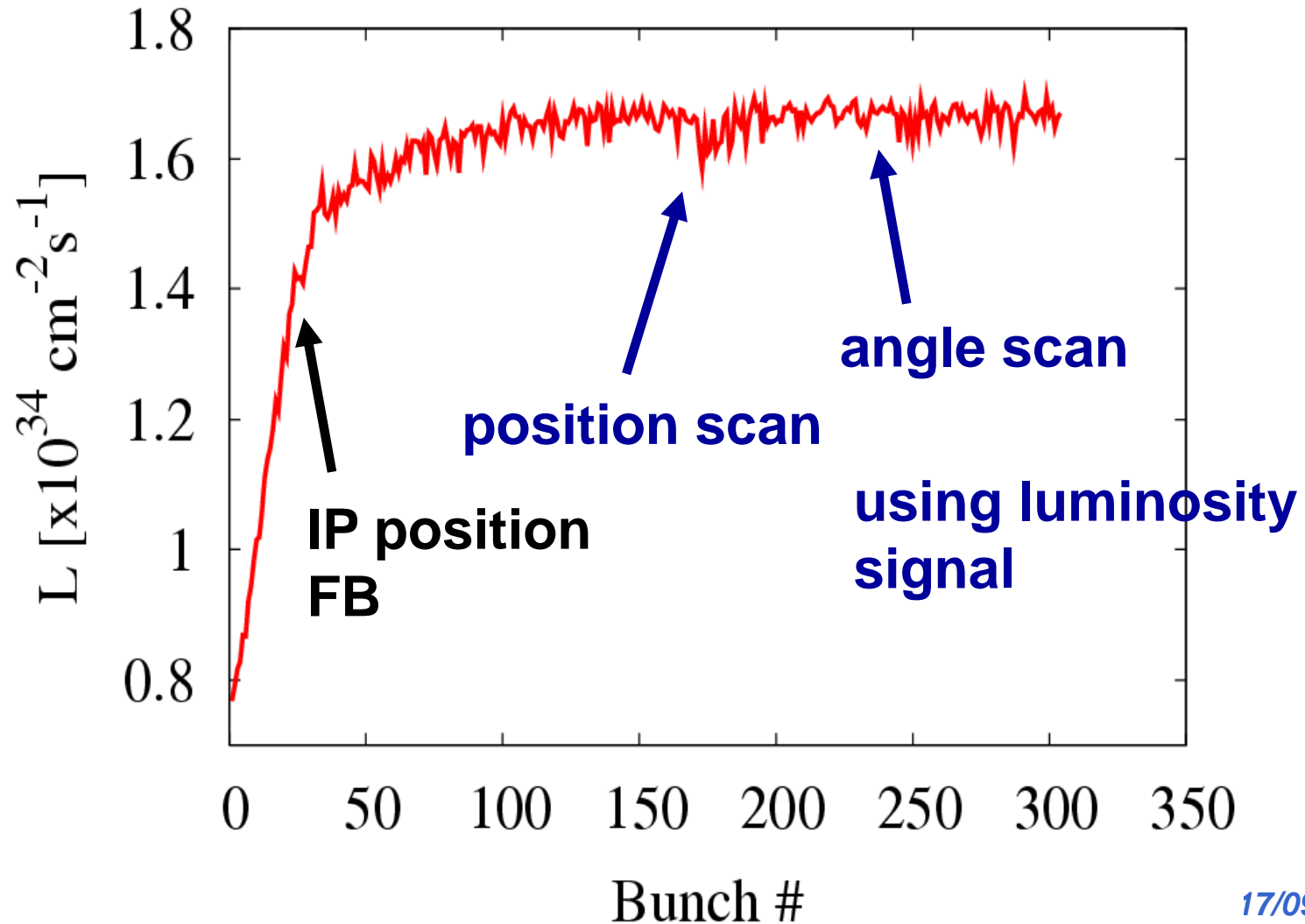
# IP intra-train FB performance (White)



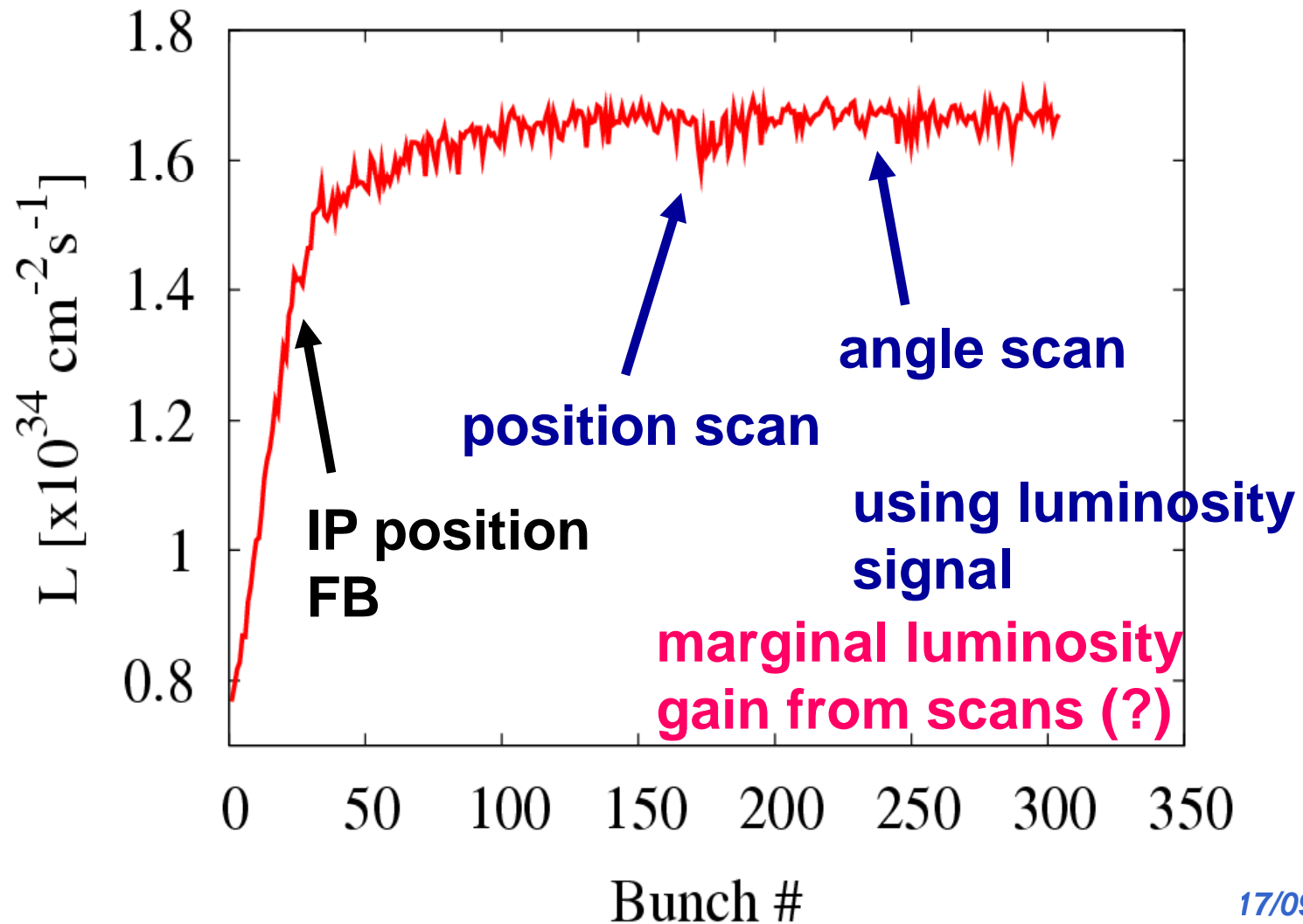
# IP intra-train FB performance (White)



# IP intra-train FB performance (Lopez)



# IP intra-train FB performance (Lopez)



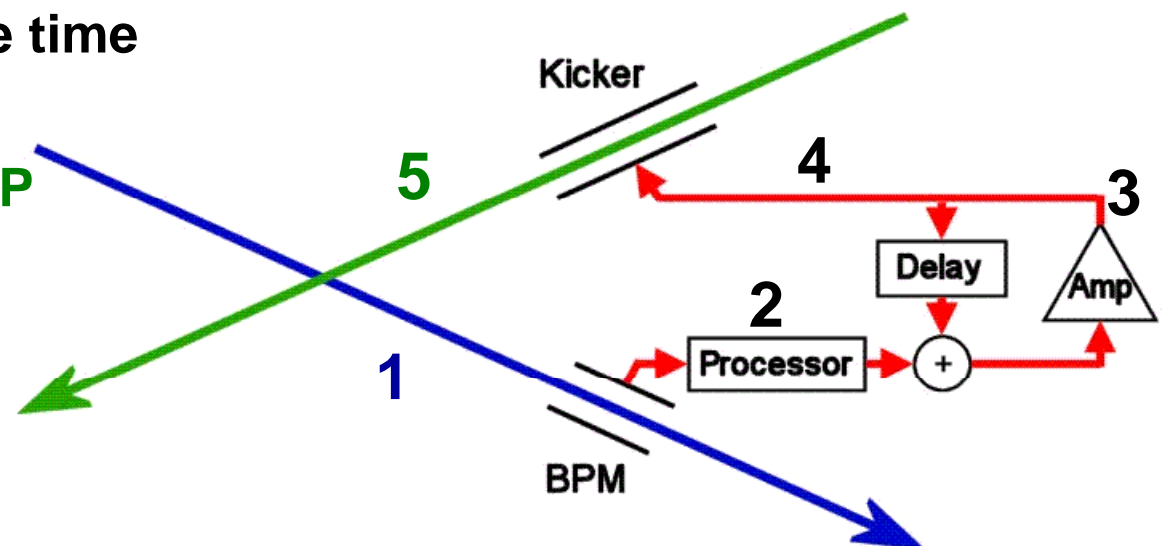
# IP position feedback

Designed for bunch-by-bunch position correction of beams at IP

→ Latency of order bunch spacing: 150ns – 300ns

Latency:

1. Beam flight time IP → BPM
2. Signal processing, FB calculation
3. Amplifier + kicker response time
4. Cable delays
5. Beam flight time kicker → IP

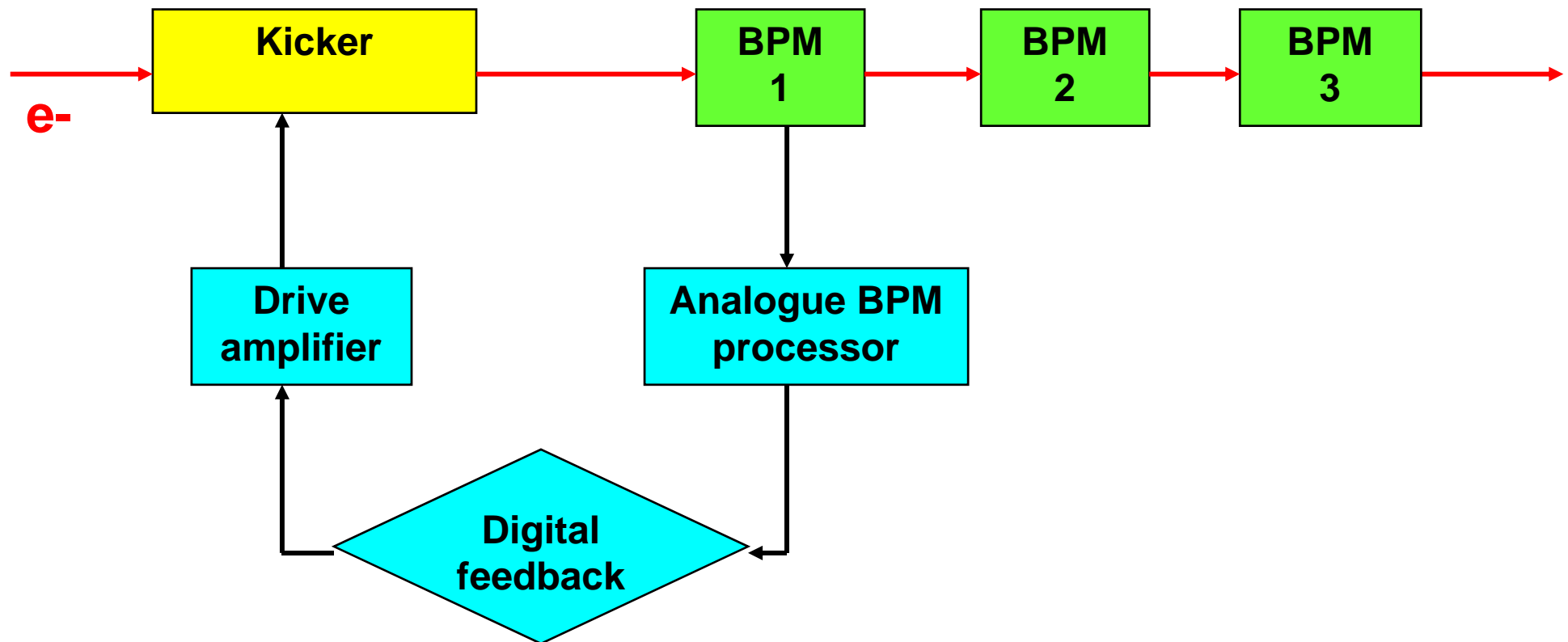


# Latency issues

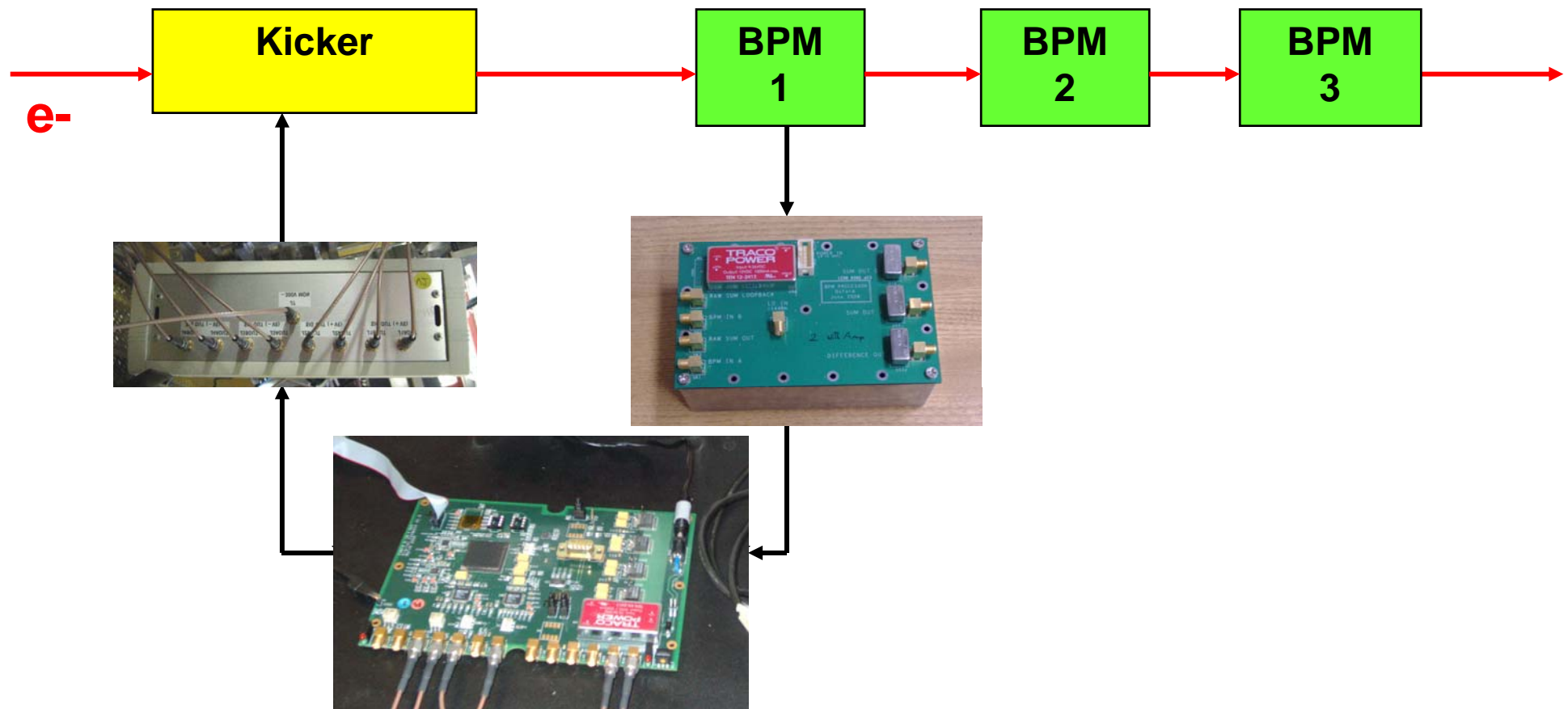
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- **BPM or kicker further from IP**
  - longer beam flight distance
  - **increase latency (3ns per metre)**
- **Electronics further from beamline**
  - longer cable runs
  - **increase latency (4-5ns per metre)**
- **FB system electronics latency: constant**

# FONT4 prototype at KEK/ATF



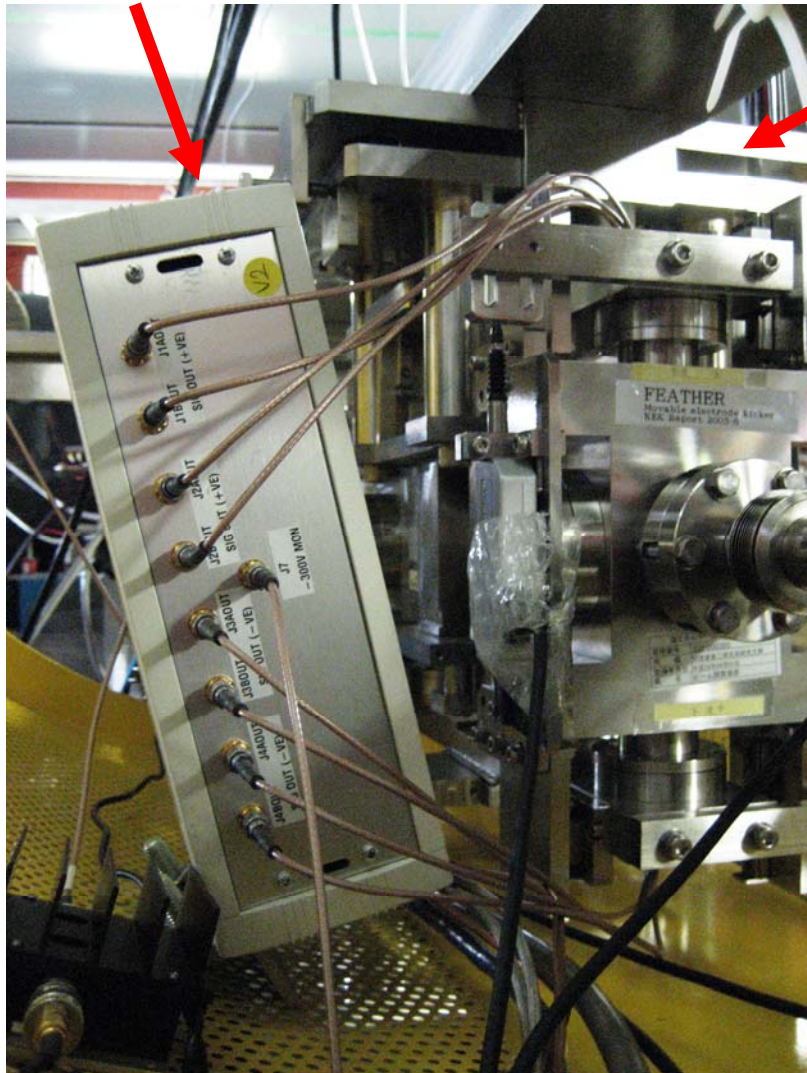
# FONT4 prototype at KEK/ATF



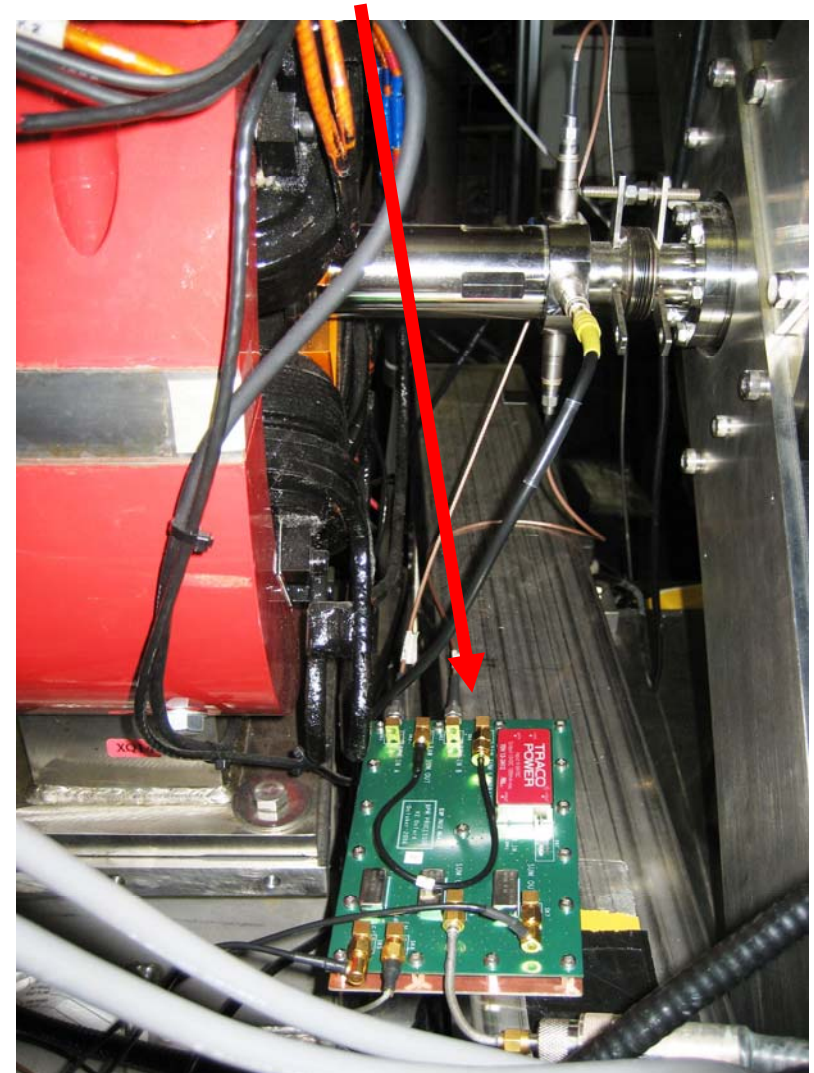


# FONT4: beamline at KEK ATF (May 07)

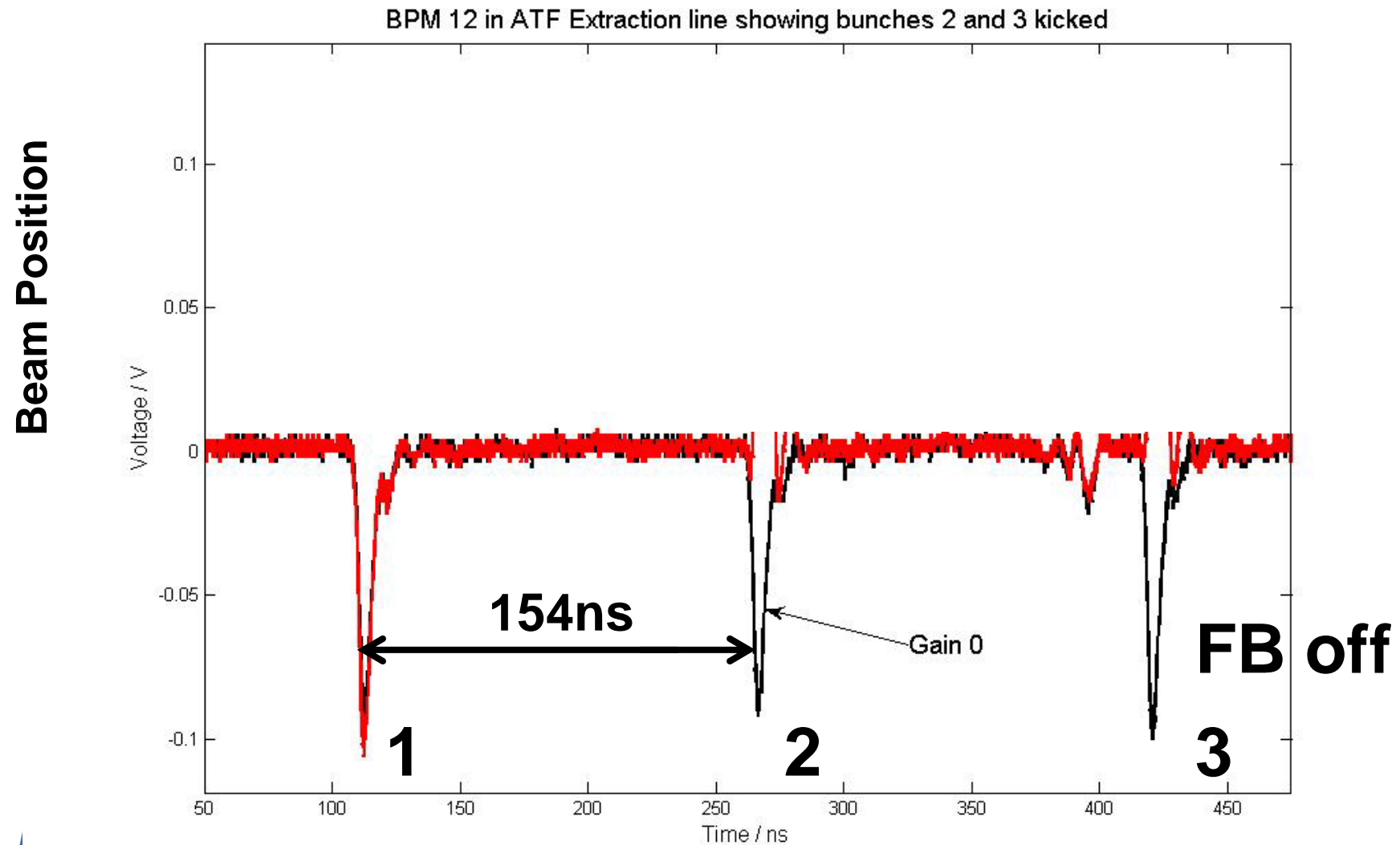
Amplifier



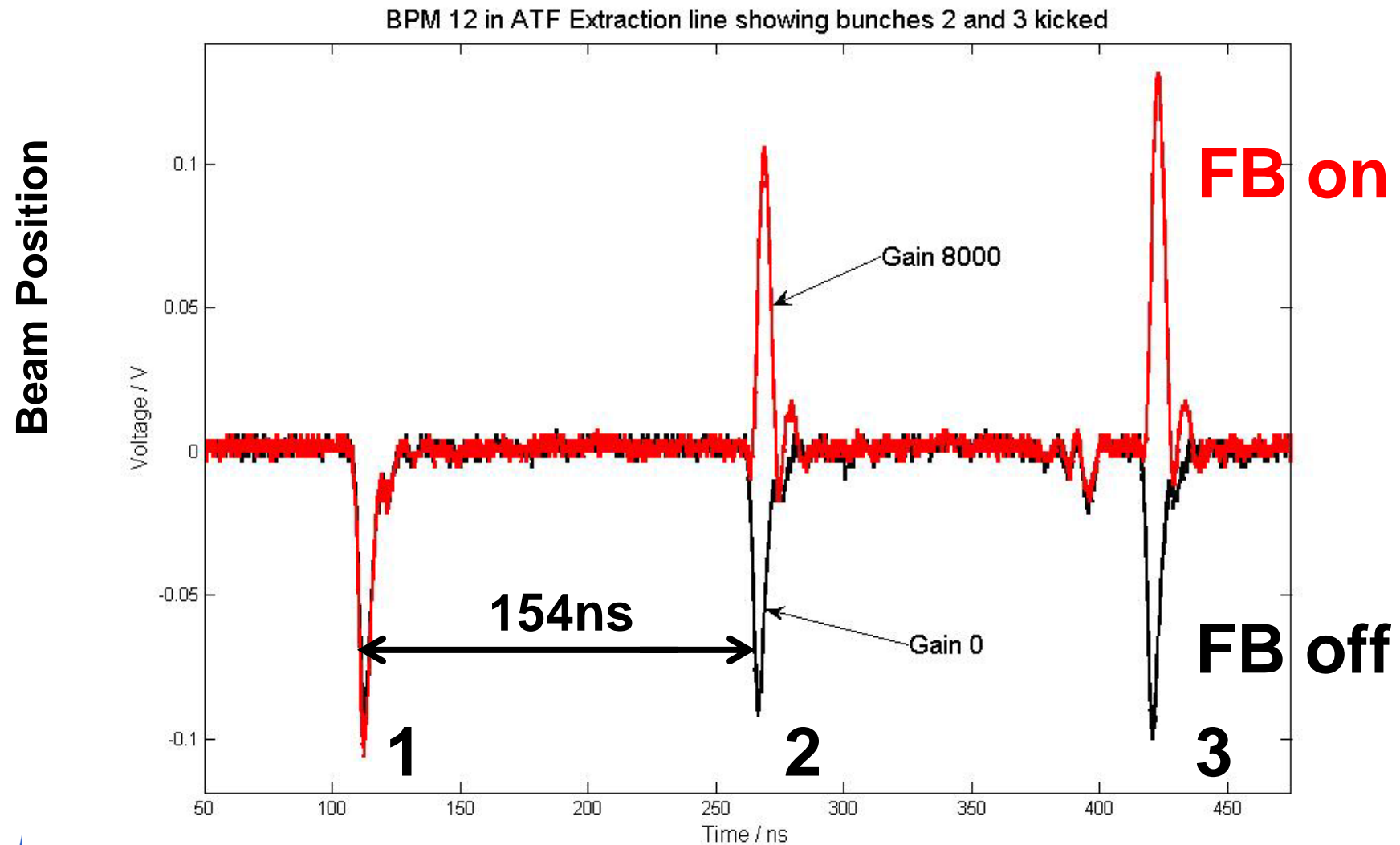
FEATHER Kicker



# Illustration of closed-loop operation



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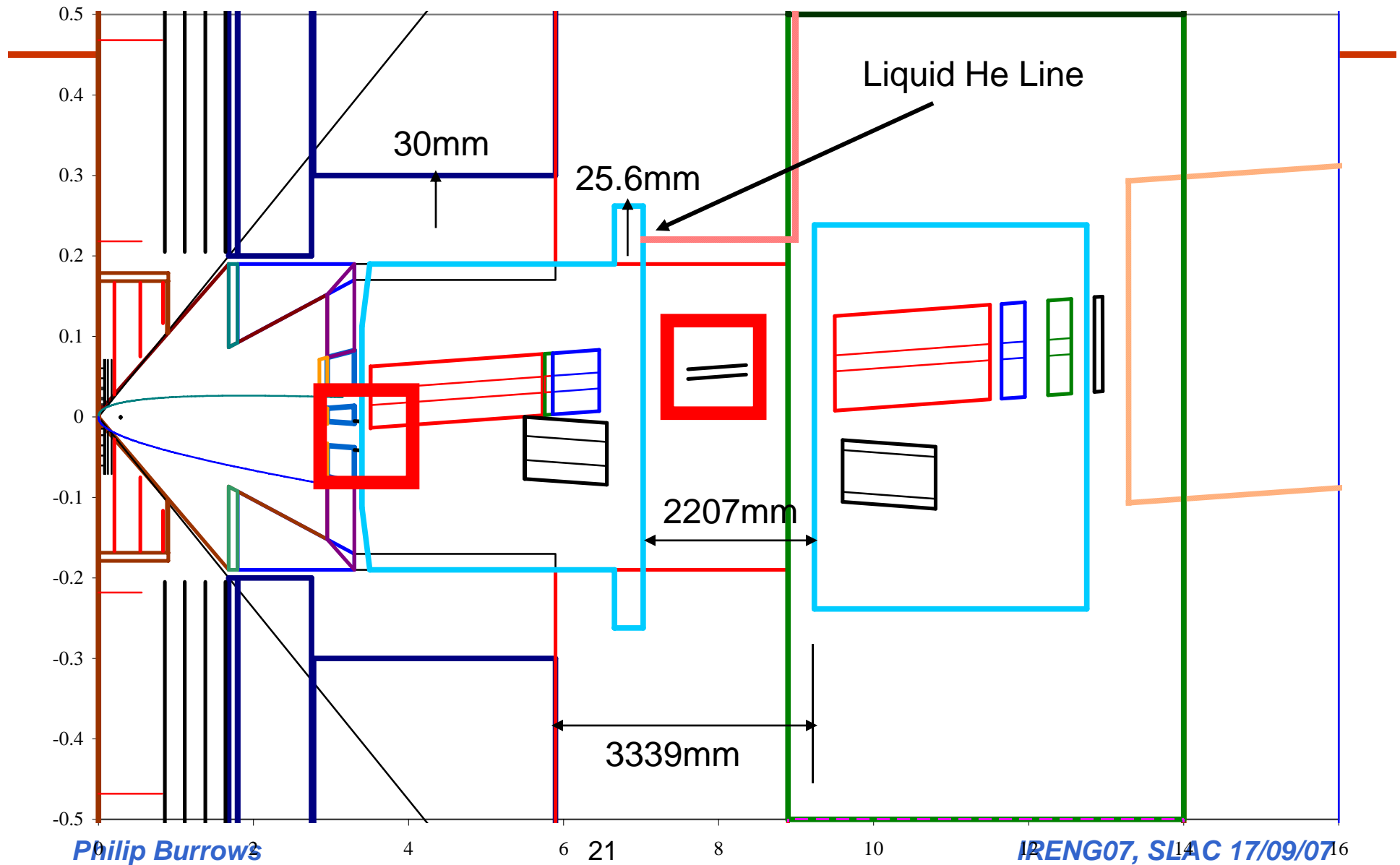


# FONT4: latency estimate

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- 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**

# Location of FB hardware (SiD, $L^*=3.7\text{m}$ )



# ILC IP feedback engineering

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**System component locations + specs listed in RDR**

**No detailed engineering work done in terms of:  
actual designs of BPM and kicker  
integration into beamline design**

**However, components are envisaged to be 'standard':**

**Stripline BPM c. 10-20cm long (ATF: 12.5cm)**

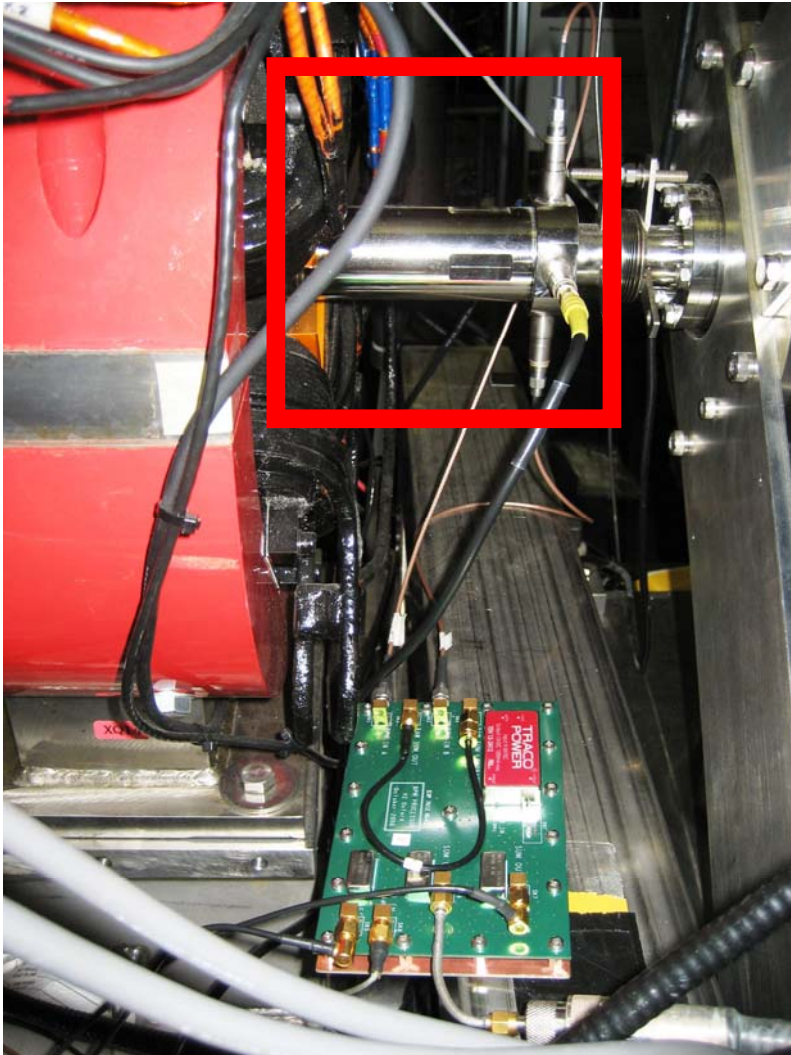
**Stripline kicker c. 30-60cm long (ATF ~ 40cm)**

**Stripline radius c. 1-2cm (ATF ~ 1cm)**

**Possible want to customise design to fit into tight beamline environment**

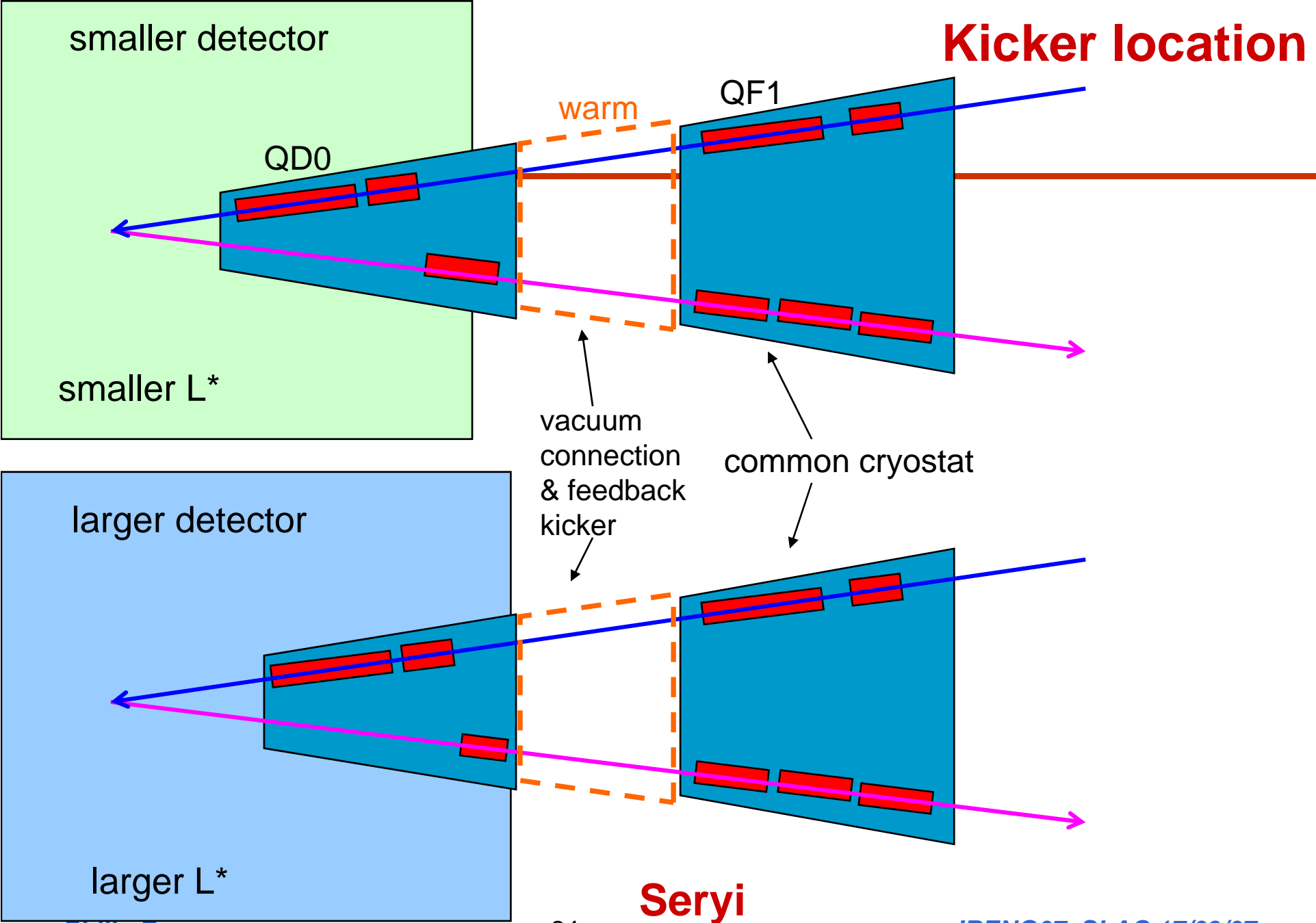
# BPM engineering issues

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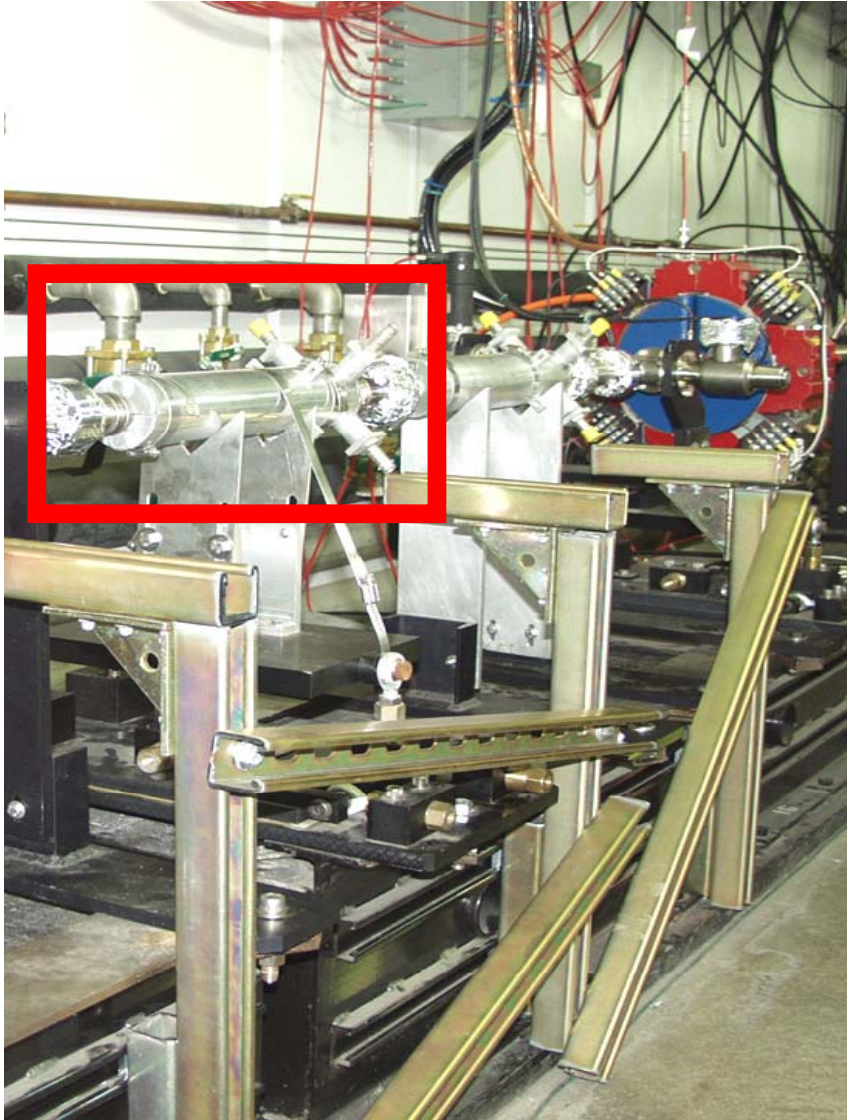
- **Connections to BEAMCAL, QD0 cryostat?**
- **Bellows, at both ends?**
- **Shorten pickoffs?**
- **Electronics off to side and shielded?**
- **Define cable runs: door opening, push-pull?**

# Kicker location





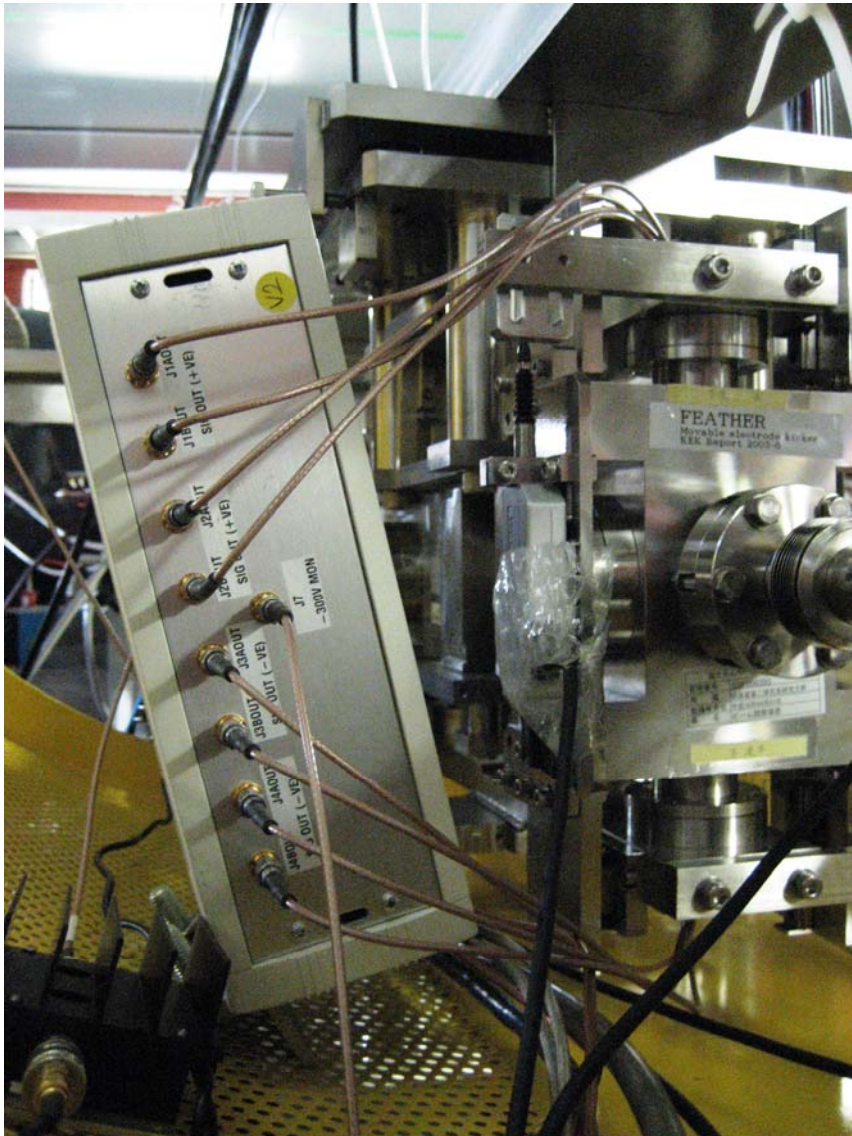
# Kicker engineering issues



**Real-estate more generous**

- **Does warm section move with detector in push-pull?**
- **Amplifier detector-side or machine-side of break?**
- **Flanges, bellows, at both ends?**
- **Shorten pickoffs?**

# Amplifier engineering issues



**FONT4 amplifier performance:**

**Kicker 30cm long, 1cm aperture, 1kW drive**

**50 nrad deflection  
(500 GeV beam)**

**lever arm 8m**

**+ - 400 nm at IP  
(c. 50  $\sigma_y$ )**

**Kick  $\sim I, 1/r, \text{sqrt}(P), 1/p \dots$**

# Summary / issues

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**Detailed mechanical/integration engineering needs to be done for EDR**

**Radiation environment for BPM electronics, feedback electronics, kicker amplifier:**

**radiation tolerance, locations, shielding ...**

**EM interference:**

**Pickup on BPM or kicker**

**Broadcast RF (to detector)**

**Ground loops**

**Interface to BEAMCAL?**

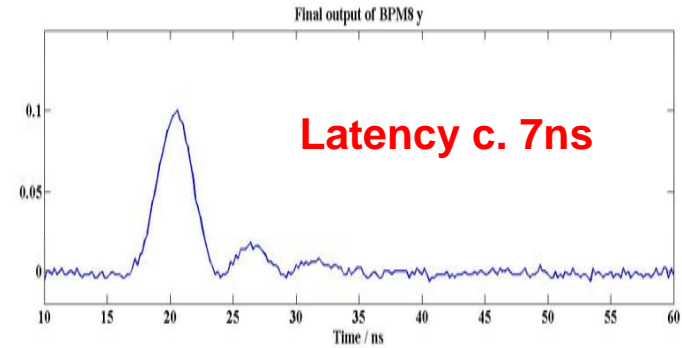
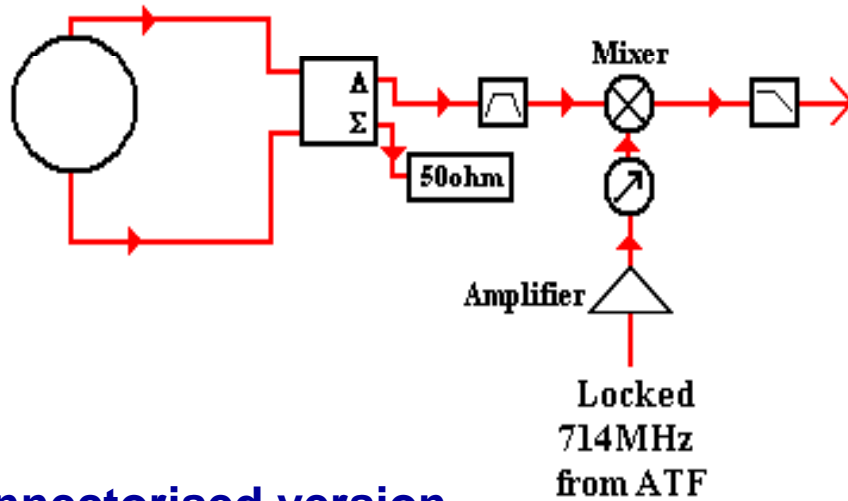
**UK group ready to do this**

# Extra material

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# BPM processor

Single stage down-mix to baseband



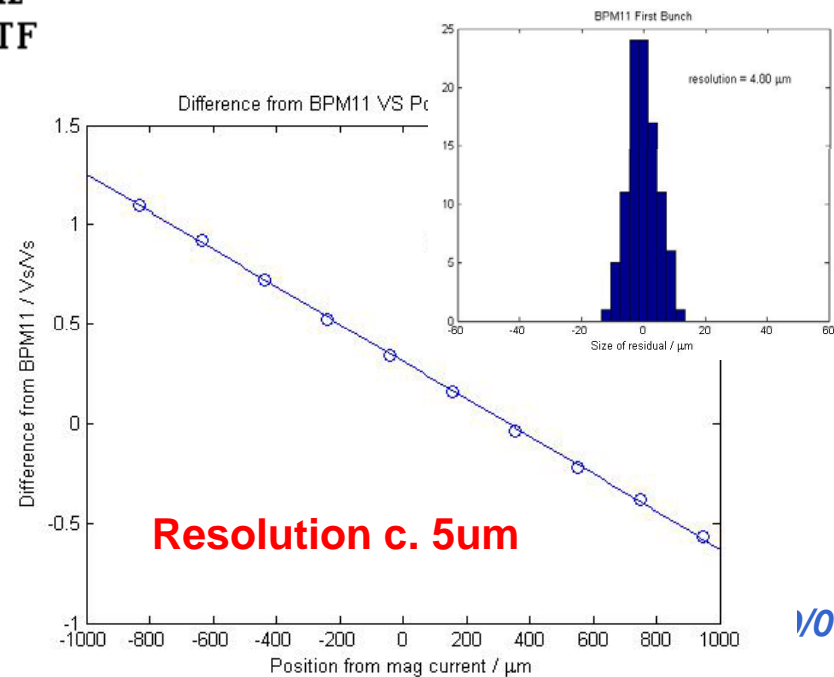
Replaced connectorised version with custom PCB – new version tested

November 2006

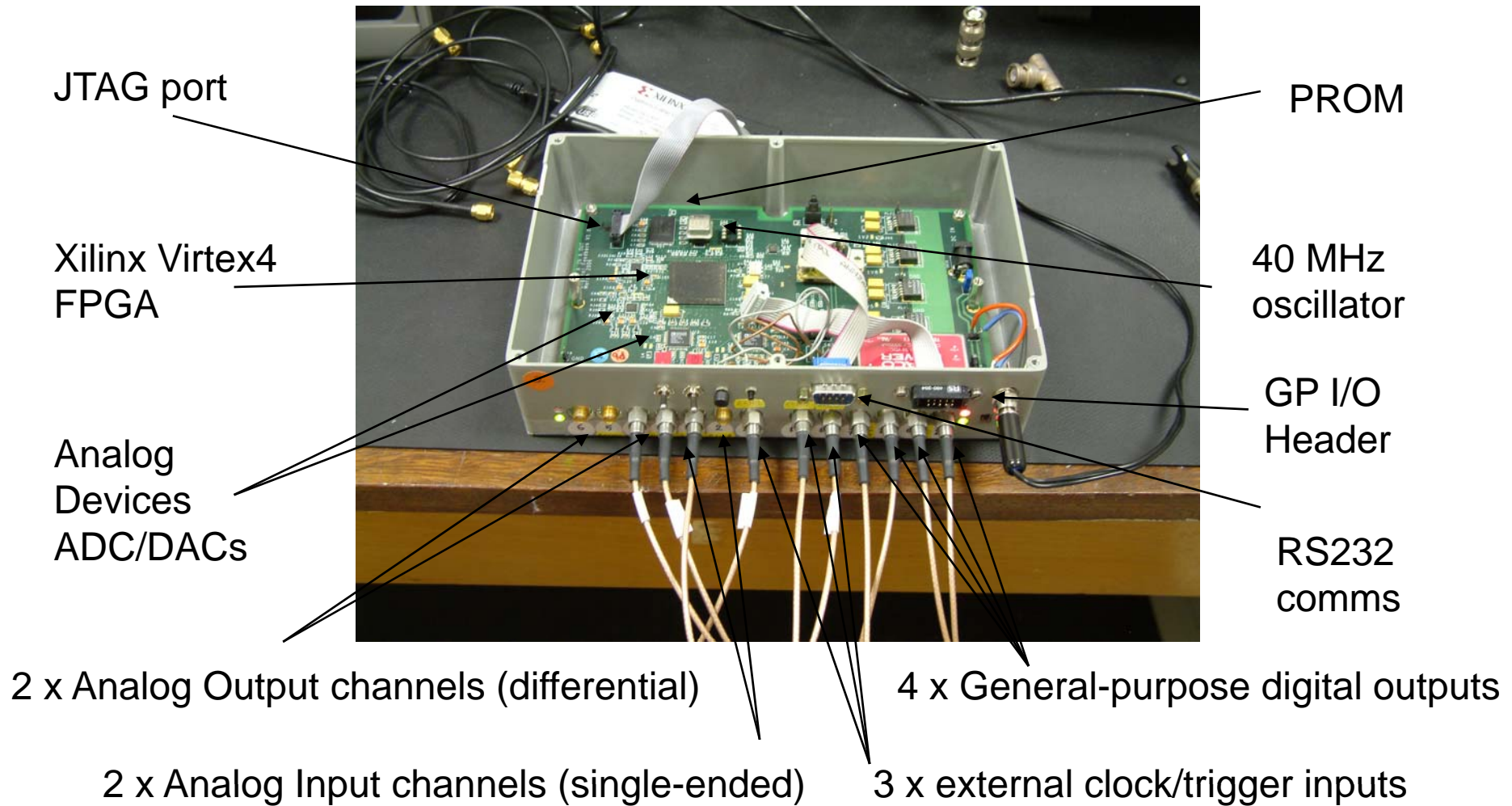
old



new



# 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**

**Order placed with TMD Technologies Sept 06:**

**1<sup>st</sup> prototype unit December 1**

**2<sup>nd</sup> prototype unit December 8 (5ns faster)**

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

