Plans for ATF2 IP Feedback

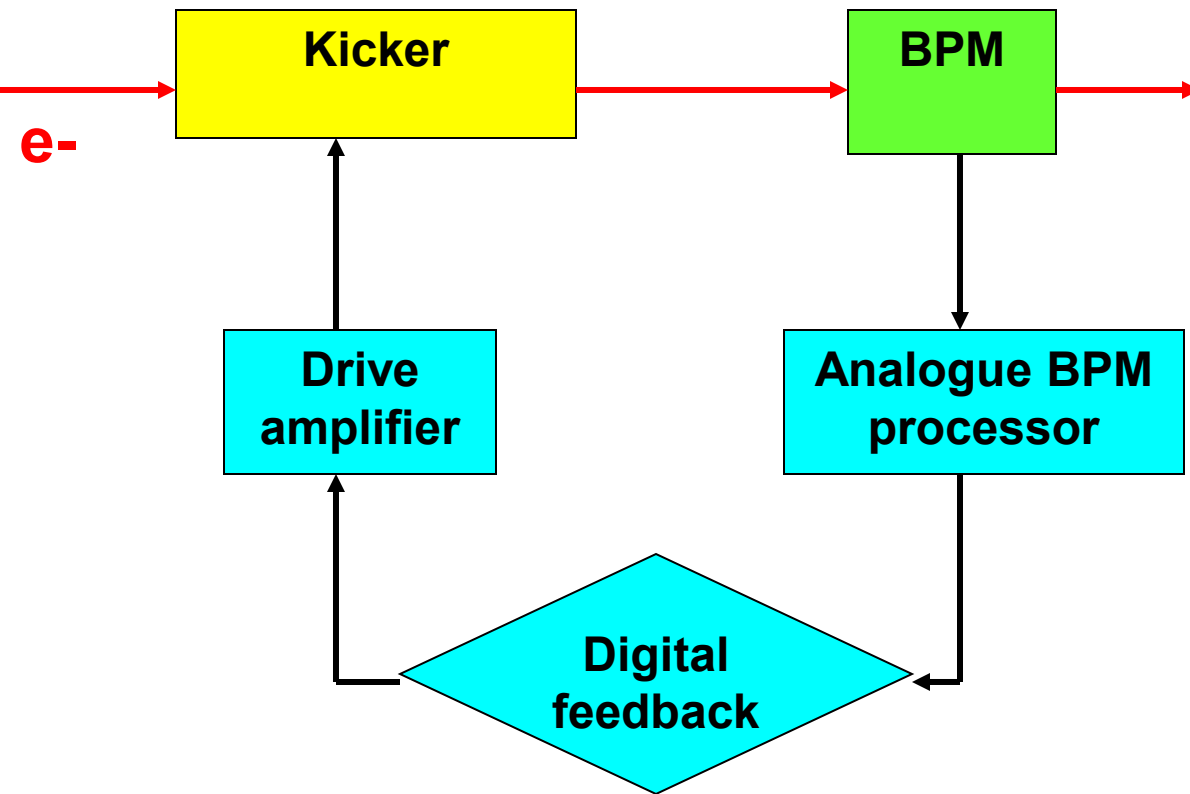## Philip Burrows, Colin Perry
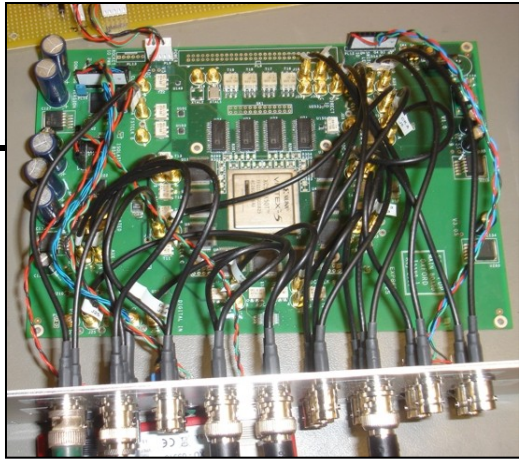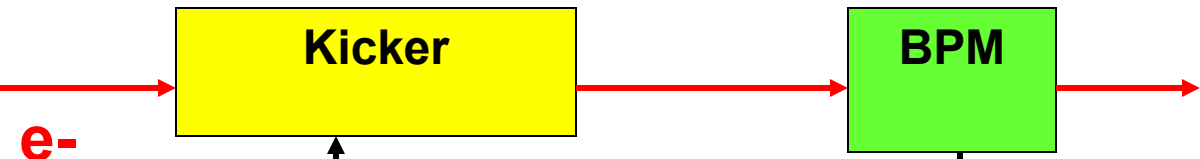
John Adams Institute

Oxford University

Outline

- **Conceptual system design**

- **General considerations for IPFB system**

- **Working assumptions**

- **Reminder of latency issues**

- **Requirements on BPM signals**

- **Summary**

FONT system loop (schematic)

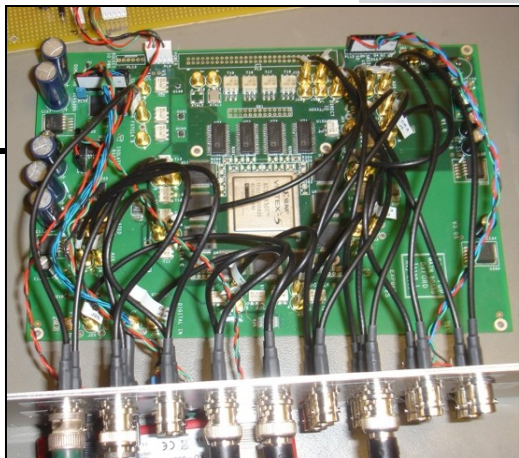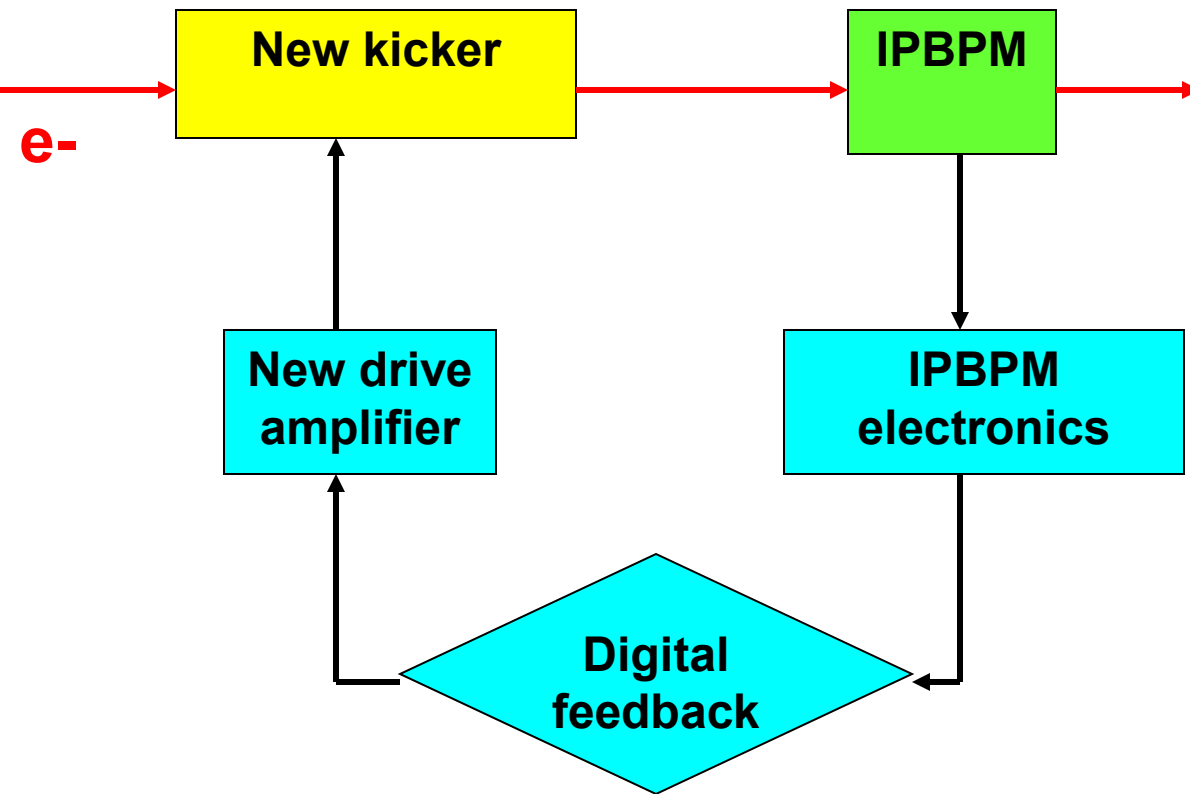# FONT5 system loop (schematic)

e-

Kicker

BPM

FONT5 system loop (schematic)

e- → Kicker → BPM →
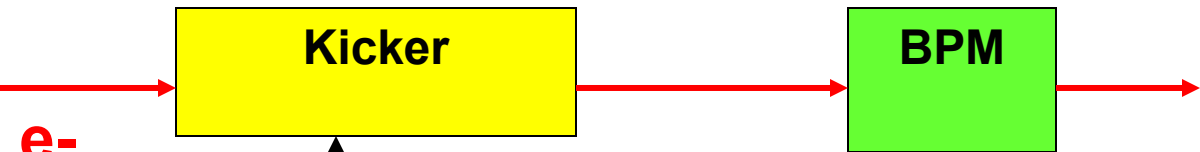
There should be no problem (in principle) to build a similar system for operation at the ATF2 IP

IP system loop (schematic)

Major challenge

From our perspective, the feedback should be straightforward!

Biggest challenge will be to obtain a 1-nanometer-level position signal from the IPBPMs, in multi-bunch mode

Current 'world record' is about 8nm in single-bunch mode (Honda-san)

→ see Boogert's + Joshi's talks of yesterday,

and next talk from Kim-san

General considerations

Many details need to be worked out:

- **Configuration of IP BPMs**

- **Location (lever arm) and length (kick) allowed for kicker**

- **Kicker aperture (amplifier power)**

- **Dynamic correction range required (amplifier power)**

- **Details of cabling (latency):**

    IPBPM → IPBPM electronics → FONT

- **Output signal of IPBPM electronics (latency, digitisation)**

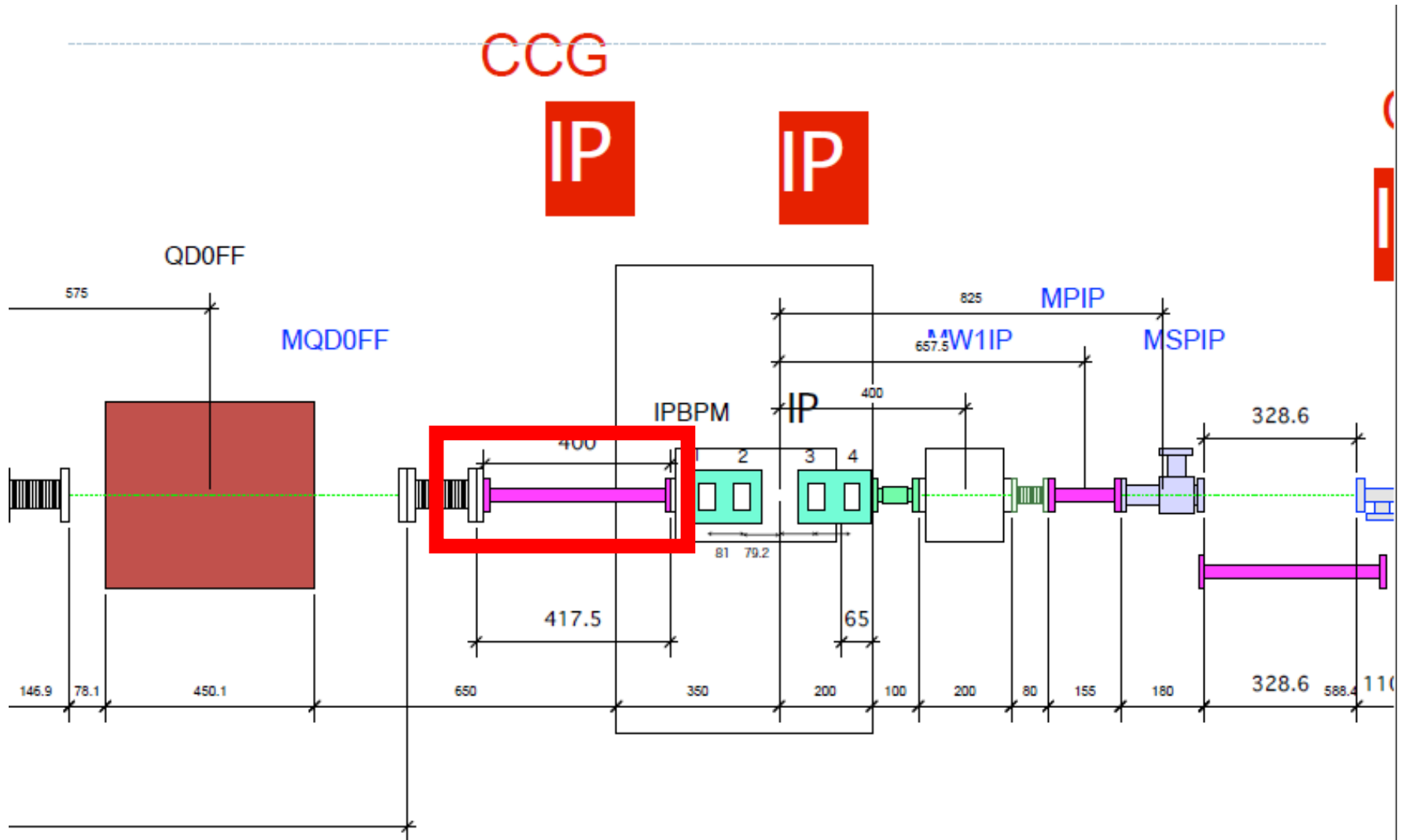# IPBPM configuration
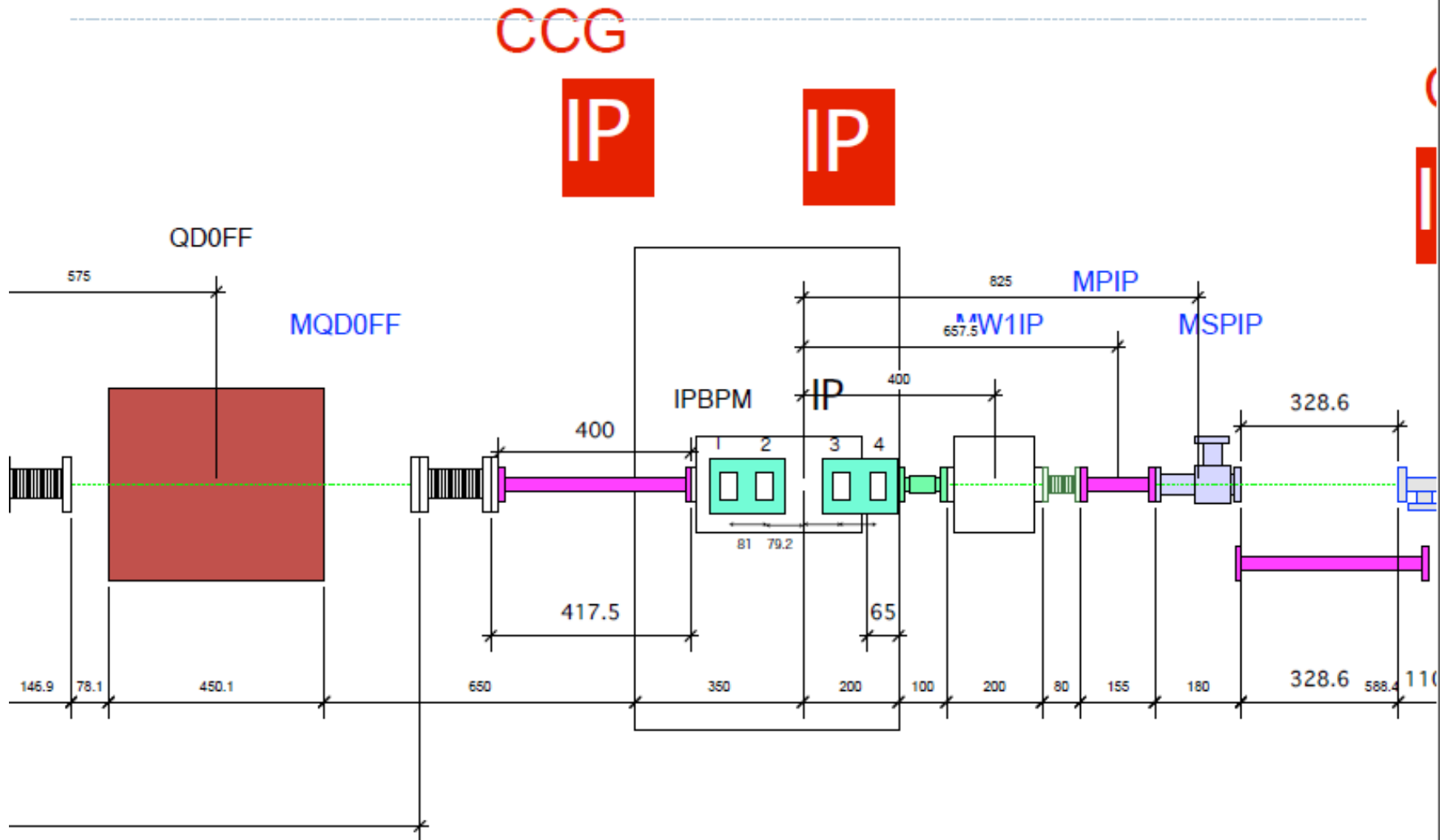
IPBPM configuration
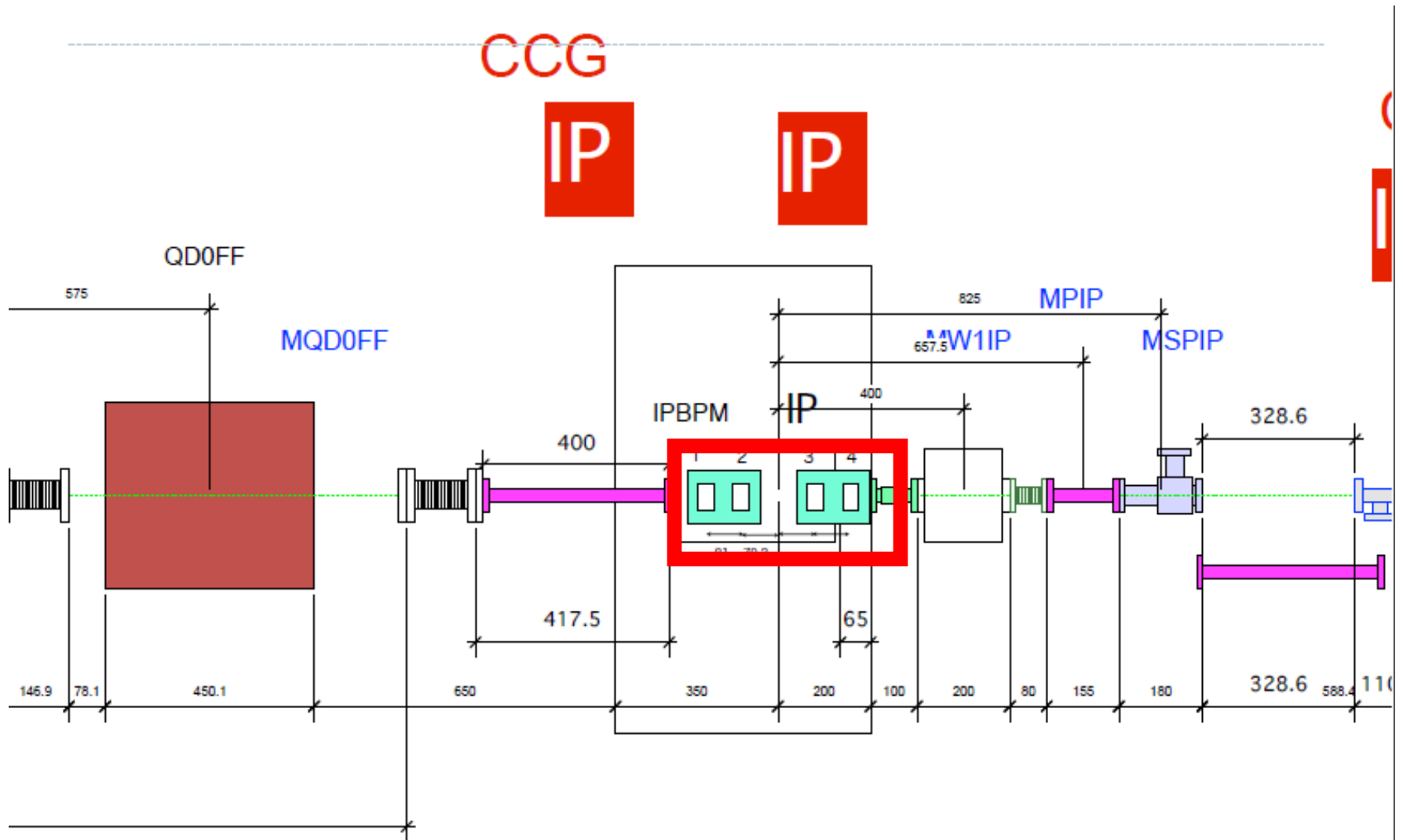
Kicker location

Some working assumptions (1)

- **Kicker centre ~ 0.5m upstream of IPBPM**

- **Kicker aperture 40mm (?)**

- **Kicker length ~ 15 cm (?)**

- **Matched 50 Ohm terminations**

    → Half of current FONT5 sensitivity:

    0.5 urad / Amp

(can easily scale from above assumptions)

Some working assumptions (2)

Dynamic correction range:

- **Beam size 37 nm**

- **Beam y jitter ~ beam size (?)**

- **2 sigma correction**

  → 70 nm @ IP = 140 nrad kick

  → drive current = 0.15/0.5 ~ 0.3 A (per strip)

Some working assumptions (3)

Amplifier:

- **Peak power = 0.3 **2 x 50 = 5 W per strip**

    → **eg. Minicircuits: 10W, 5 → 500 MHz**

- **Low latency (5 ns)**

- **Output can be pulsed for long bunch train**

- **No margin for kick**

Caveat

If the IP beam size, and hence the beam jitter, were significantly larger, the amplifier power requirements would be more serious, and the latency correspondingly longer …

Present FONT amplifier provides 30 urad kick and takes 35ns to do so!

IPBPM electronics
(Aeyoung Heo)

1. Improved conversion gain
2. Low Noise Figure
3. Narrow Bandwidth
4. Latency: less than 20ns
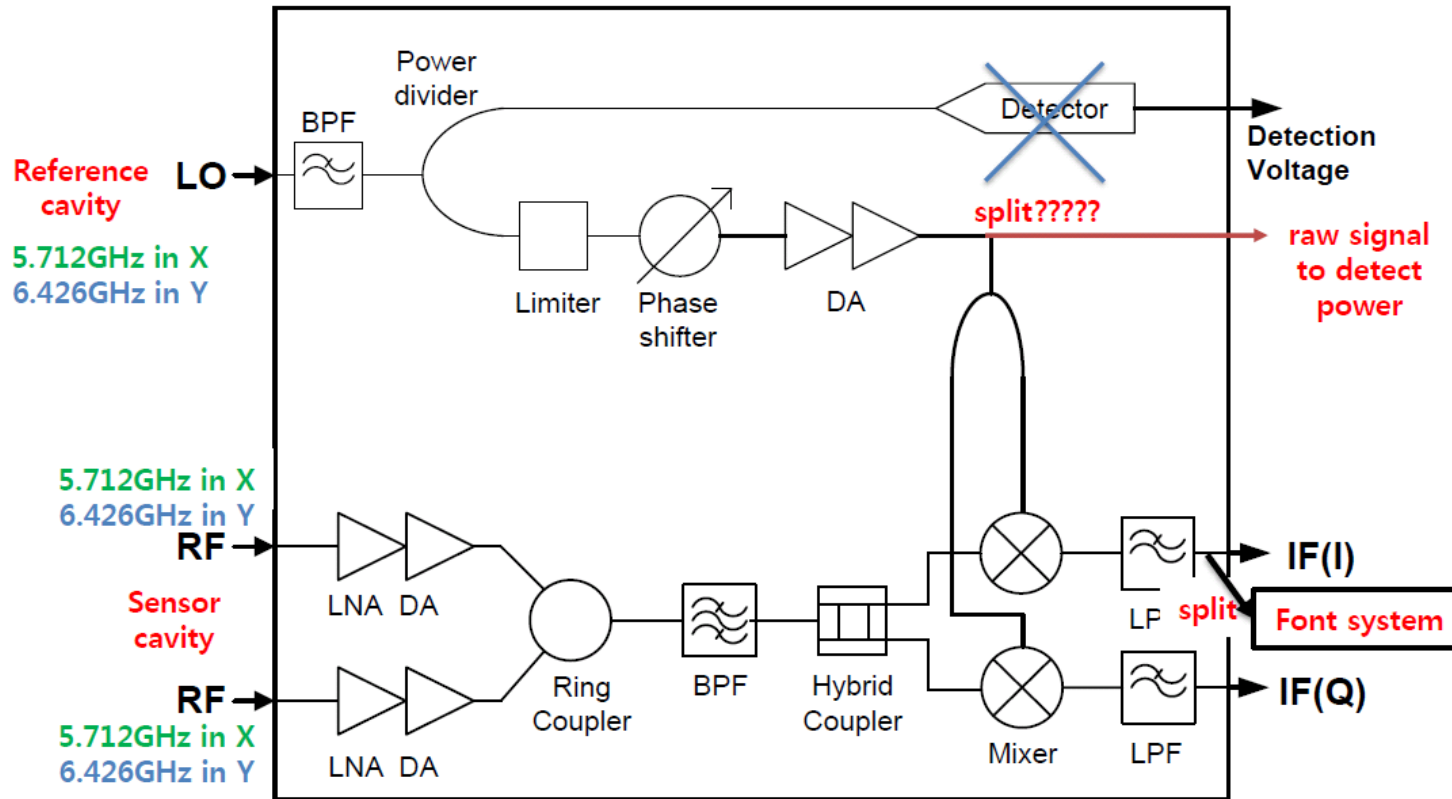
Digitisation of IPBM signal

- **Digitise I and Q signals**

- **Derive amplitude and phase**

    → charge-independent position signal

- **FONT5 ADCs (TI ADS5474) clocked at 357 MHz**

- **Very high bandwidth sample point**

- **Sample time adjustment sensitivity c. 100ps**

FONT Digitisation

I

Q

$$I(n) = \frac{A_{BPM}}{A_{REF}} \cos(\phi_{BPM} - \phi_{REF})$$

$$Q(n) = \frac{A_{BPM}}{A_{REF}} \sin(\phi_{BPM} - \phi_{REF})$$
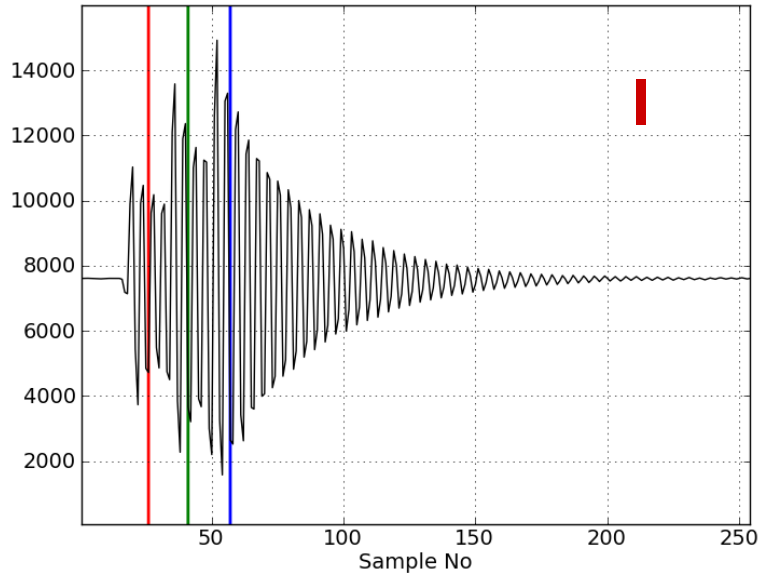
Joshi

Digitisation of IPBM signal

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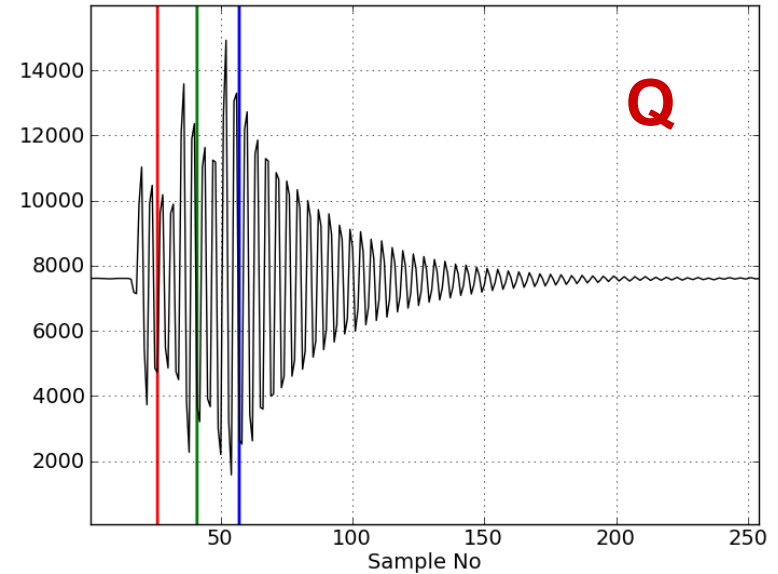
- **Sample time adjustment sensitivity c. 100ps**

- **Up- and downstream IPBPM signals needed**

Latency estimate

- **Amplifier (as described)**   **5ns**

- **Kicker fill (15cm)**   **0.5ns**

- **Beam flight time amplifier → IPBPM**   **2ns**

- **Cables (3 x 1.5m?)**   **23ns**

- **IPBPM electronics**   **40ns?**

- **Digital processing**   **60ns**

Total   **131ns**

IPBPM signal requirements

- **Prefer 'baseband' signal**

  could deal with up to 100 MHz

- **Ideally I, Q signal levels ~ 100 mV**

  could deal with almost any power

  levels (by amplification)

- **Met with Kim-san at KEK Dec 2010**

Summary

- Conceptual design for IP FB system

- System parameters look feasible

- Critical parameters:

   dynamic correction range, bunch spacing

- Digitisation of IPBPM I and Q signals is easiest approach

- Technical details need to be finalised:

   locations of BPM + kicker, kicker aperture,

   cable runs …

Postscript 1

- **Intra-train beam feedback requires extremely high degree of spatial correlation between the bunches**

- **With the current ATF2 setup (existing kicker system and 3 bunches) we occasionally see good correlations, usually after a lot of tuning**

  → see my talk of yesterday

- **May be better off extracting just 2 bunches?**

Postscript 2

- **The hard part of the IPFB is achieving nanometer position resolution with the KNU BPM electronics …**