

# ATF2 Goal 2: IP Feedback

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## Feedback On Nanosecond Timescales (FONT):

**Philip Burrows**

**Neven Blaskovic, Douglas Bett, Glenn Christian,  
Michael Davis, Young Im Kim, Colin Perry**

*John Adams Institute*

*Oxford University*

**Robert Apsimon, Ben Constance** *CERN*

**Javier Resta Lopez** *U. Valencia*

# Outline

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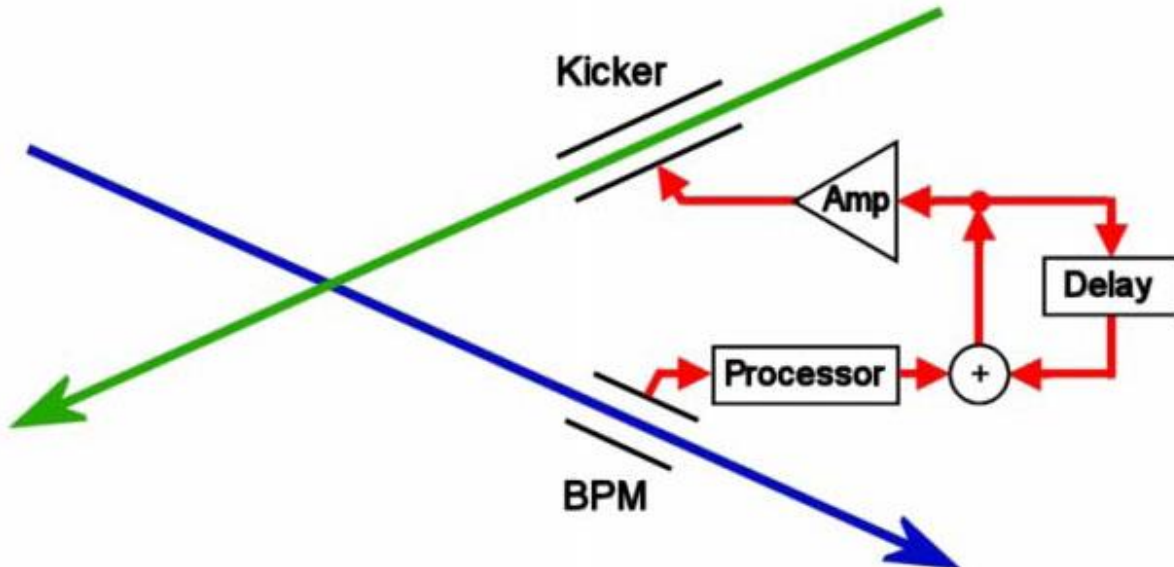
- **Reminder of ILC IP FB requirements**
- **FONT ILC prototype**
- **ATF2 IP FB concept**
- **Setting up for IP FB at ATF2**
- **Initial results**

# IP beam feedback concept

Last line of defence  
against relative  
beam misalignment

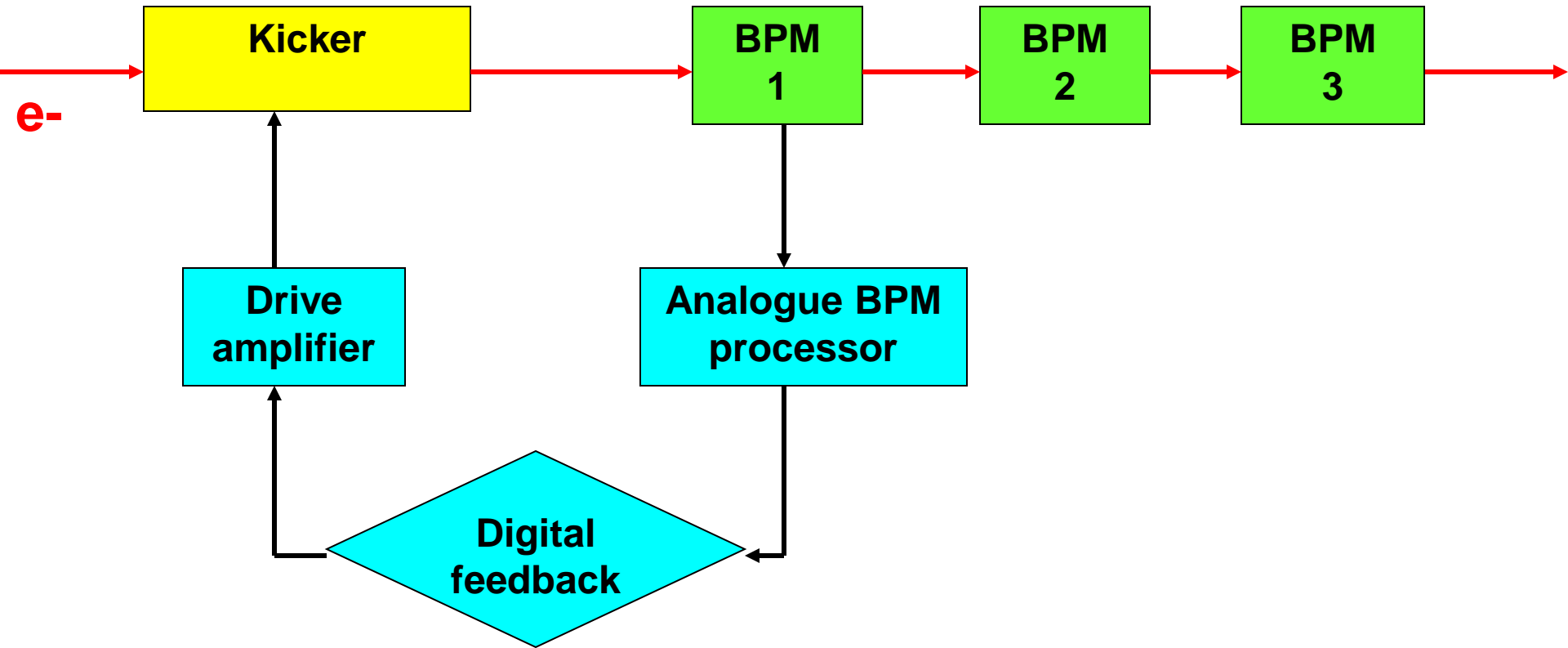
Measure vertical  
position of outgoing  
beam and hence  
beam-beam kick  
angle

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

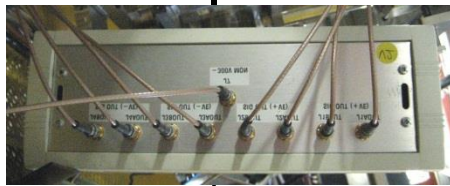
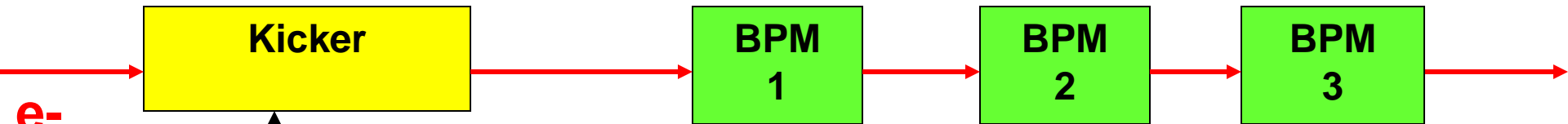


**FONT – Feedback On Nanosecond Timescales**

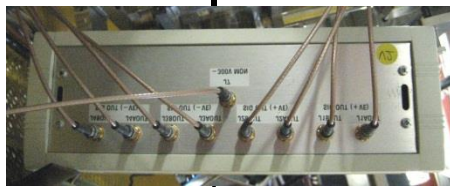
# ILC prototype: FONT4 at KEK/ATF



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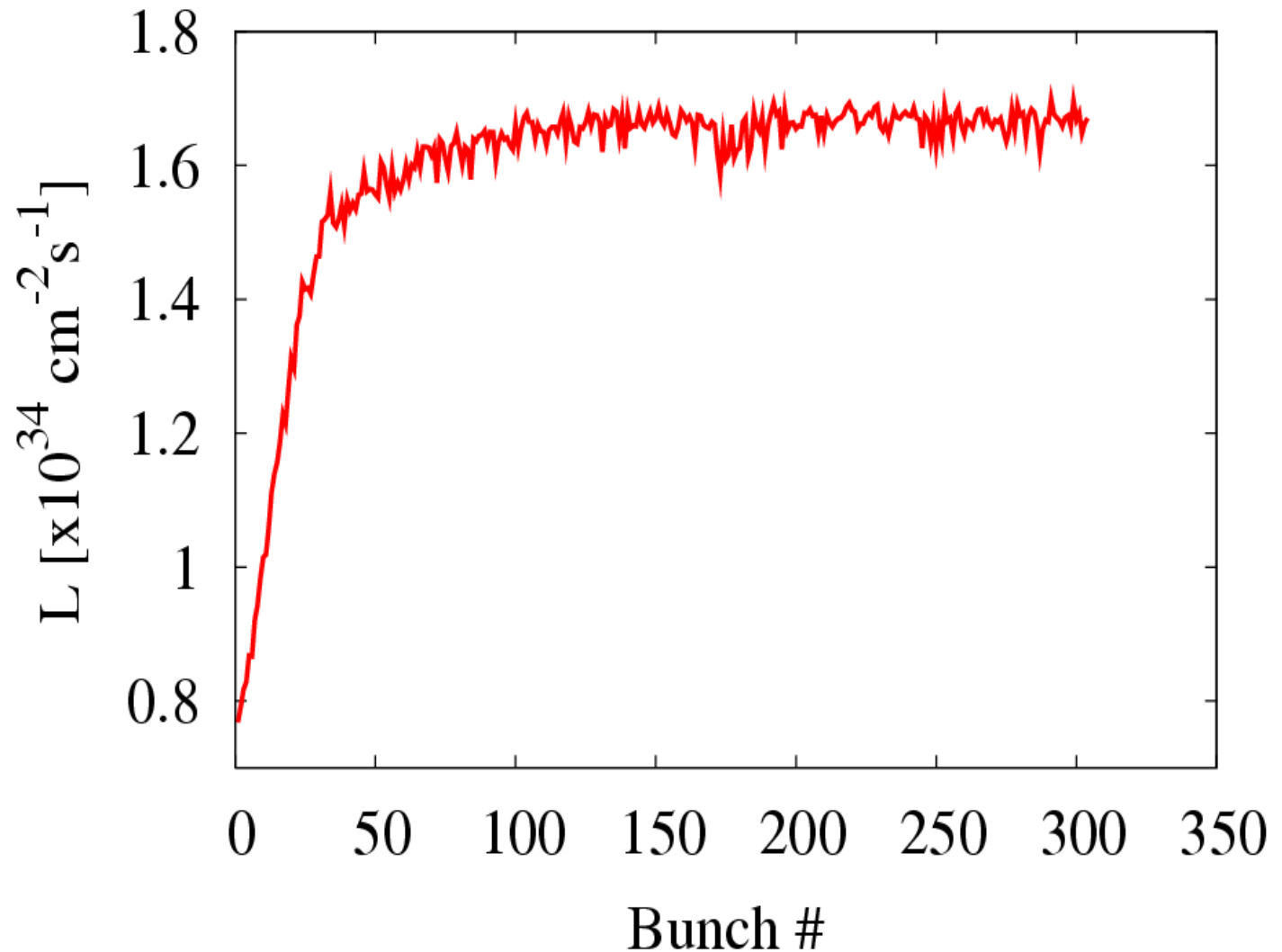


# ILC prototype: FONT4 at KEK/ATF

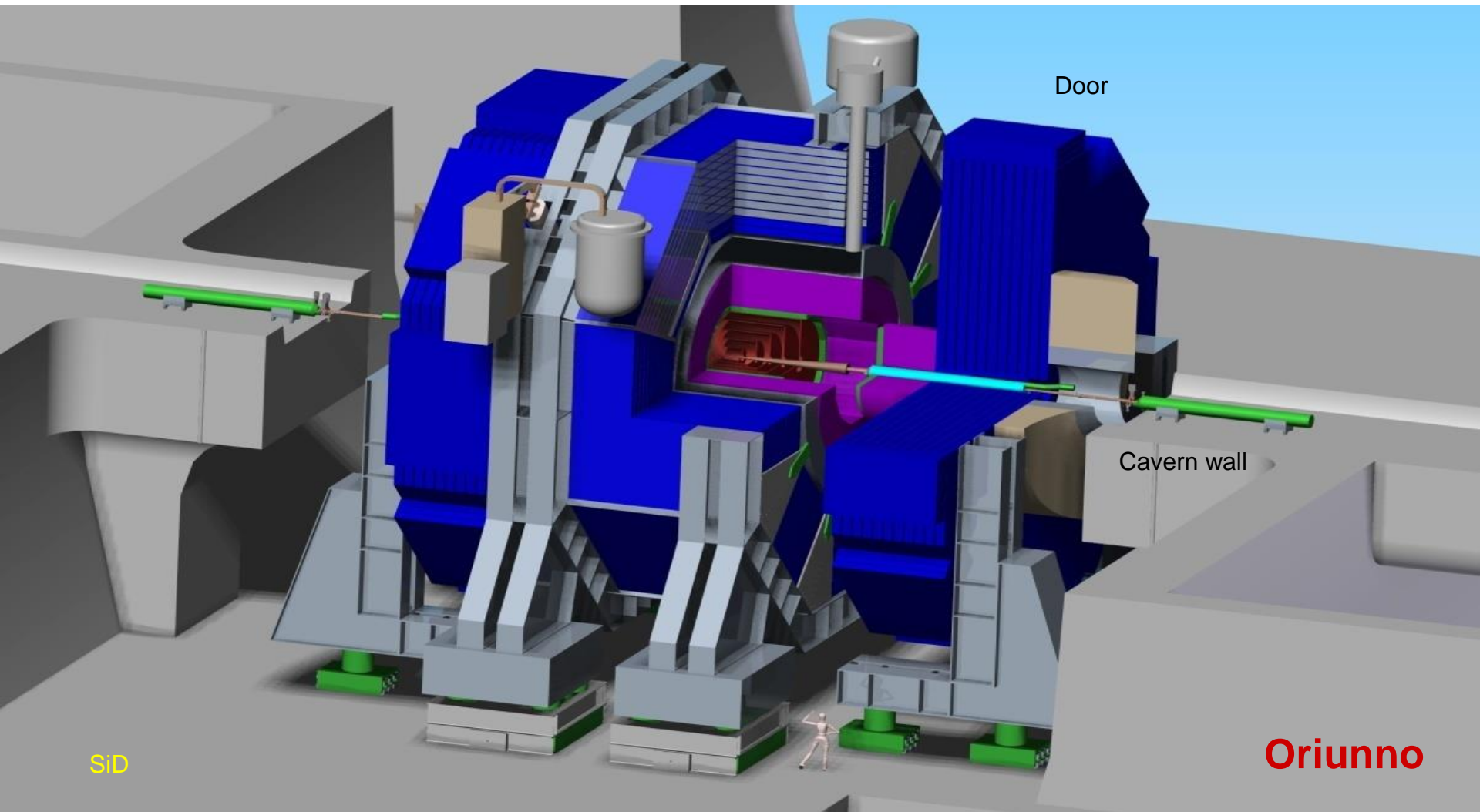


**BPM resolution** < 1 $\mu$ m  
**Latency** ~ 130ns  
**Drive power** > 300nm  
**@ ILC**

# ILC IP FB performance

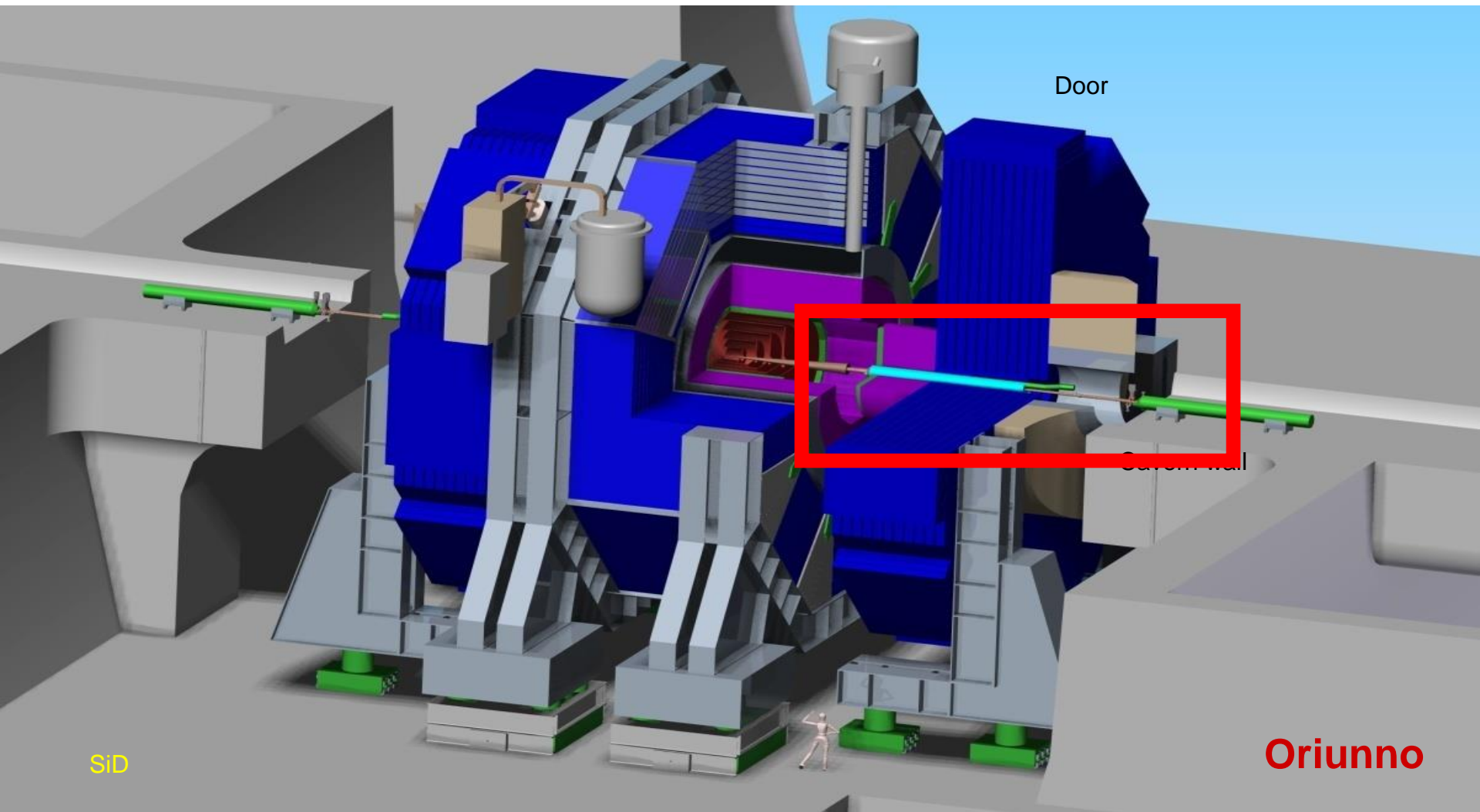


# ILC IR: SiD for illustration

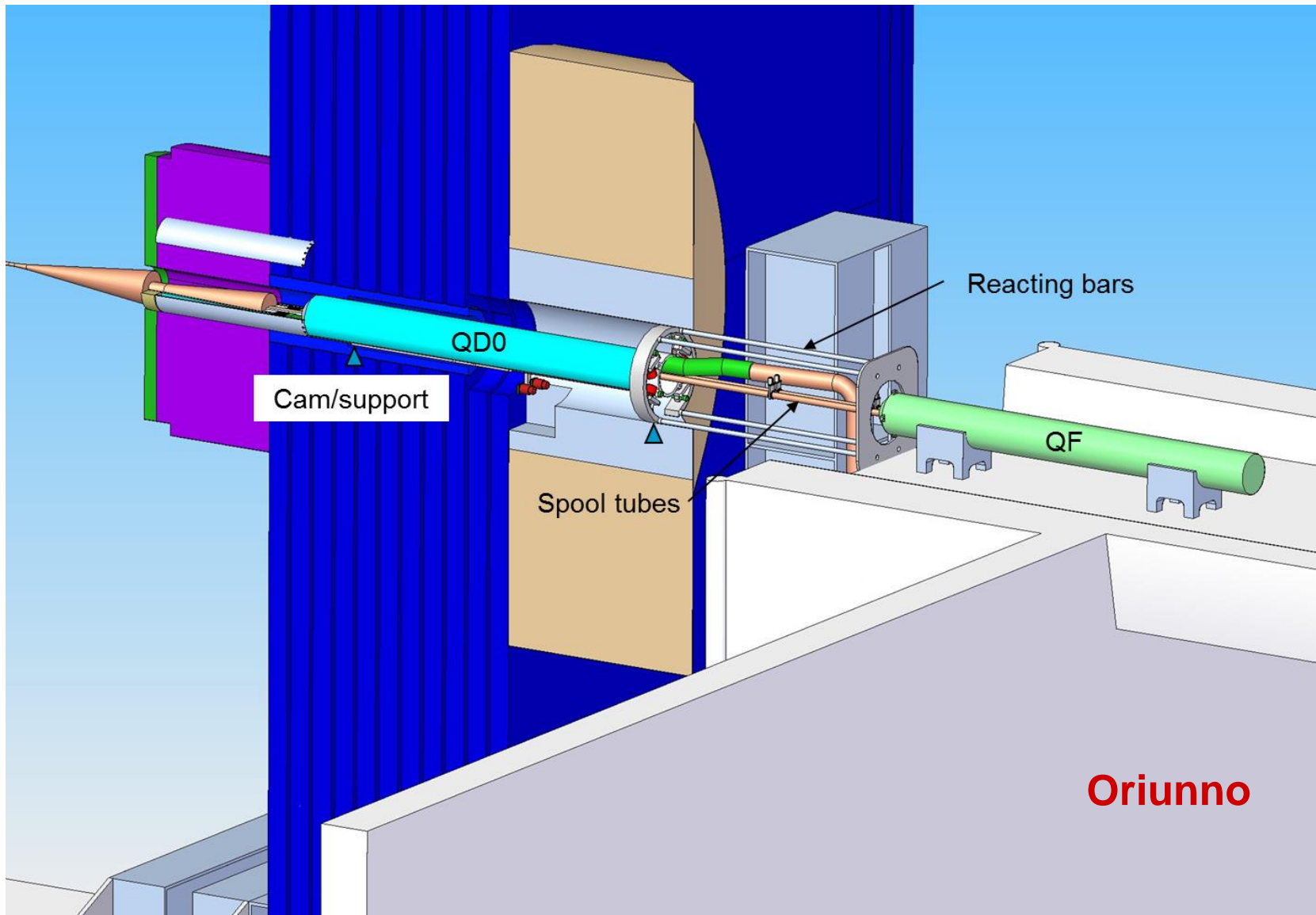




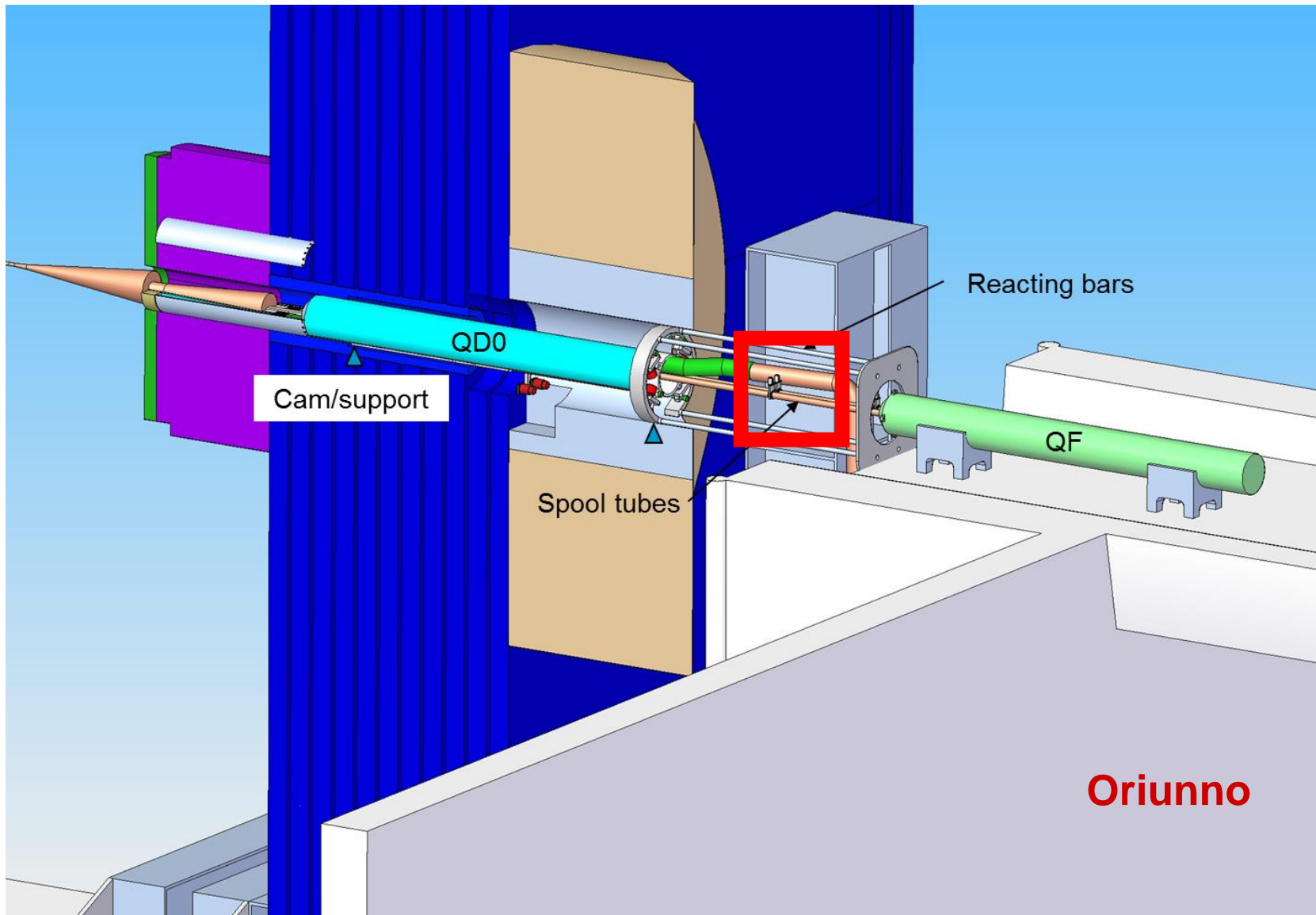
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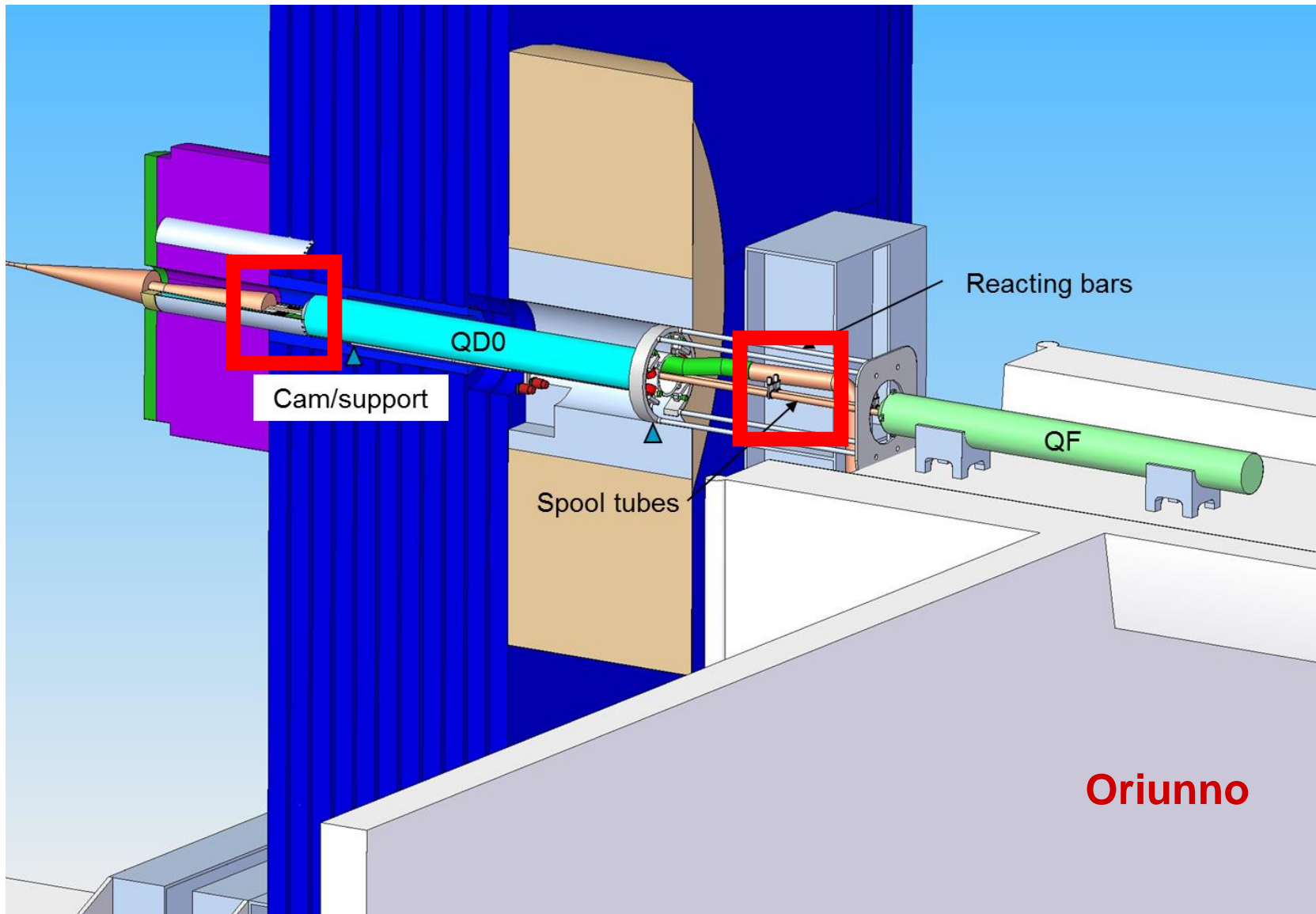
# Final Doublet Region (SiD)



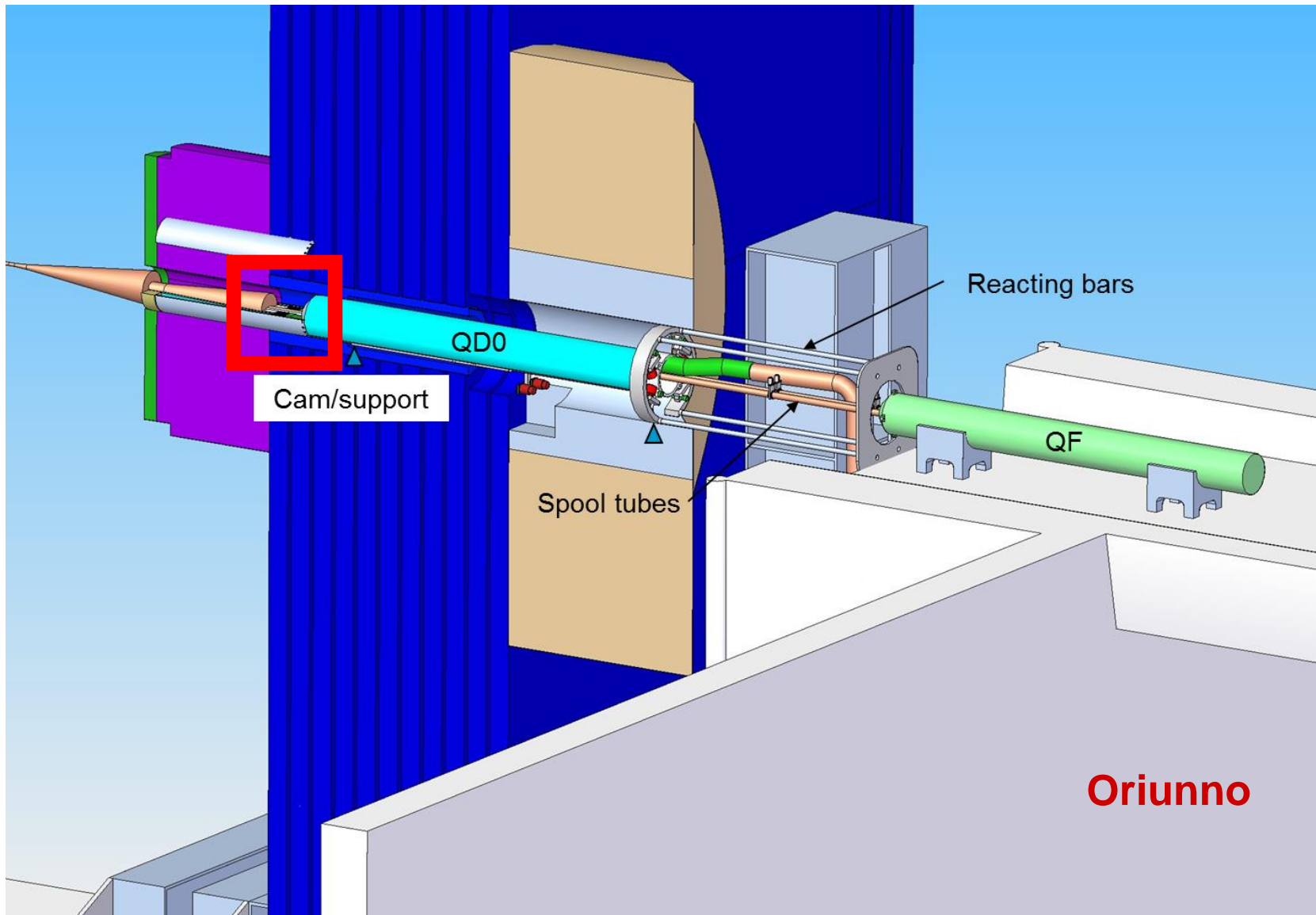
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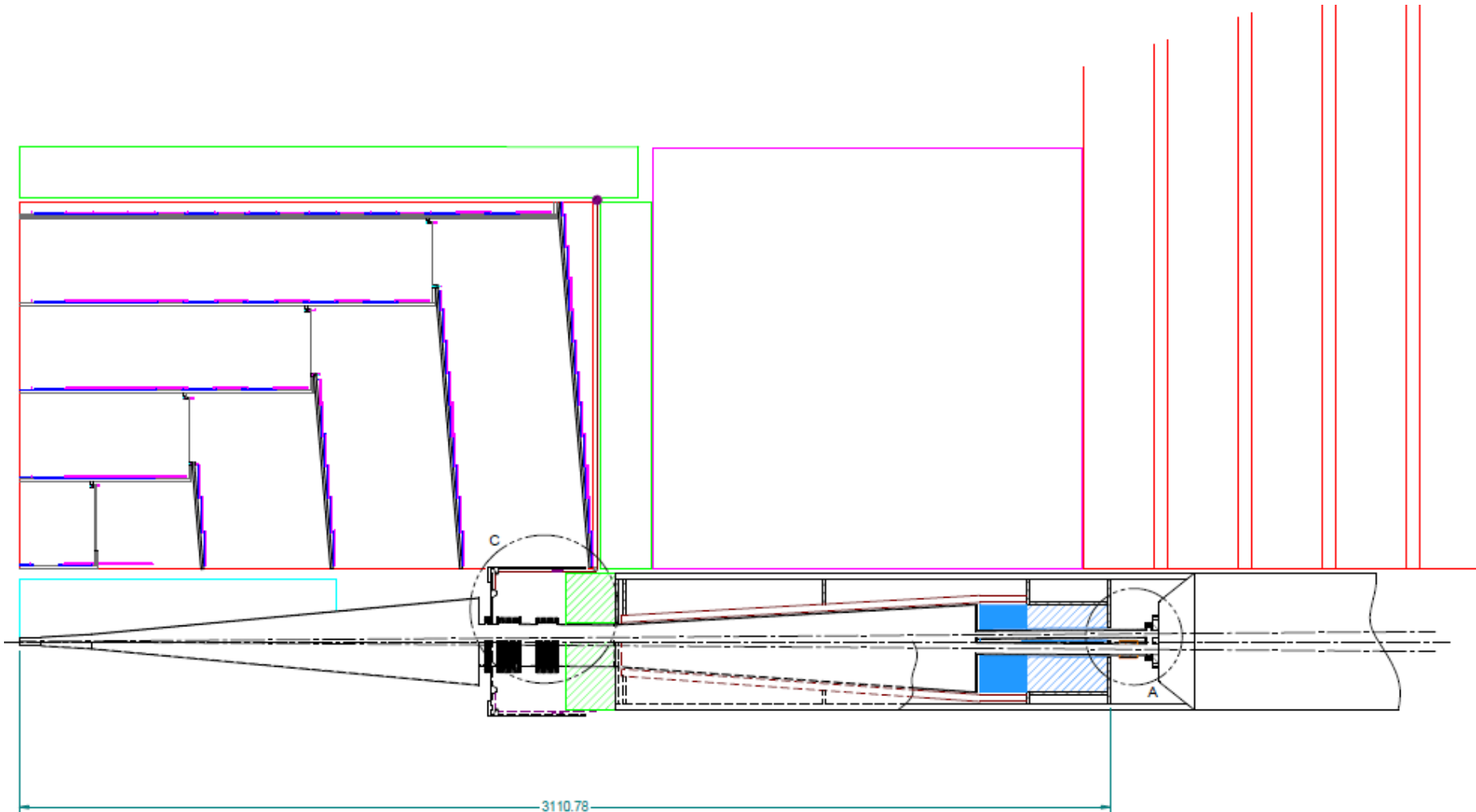
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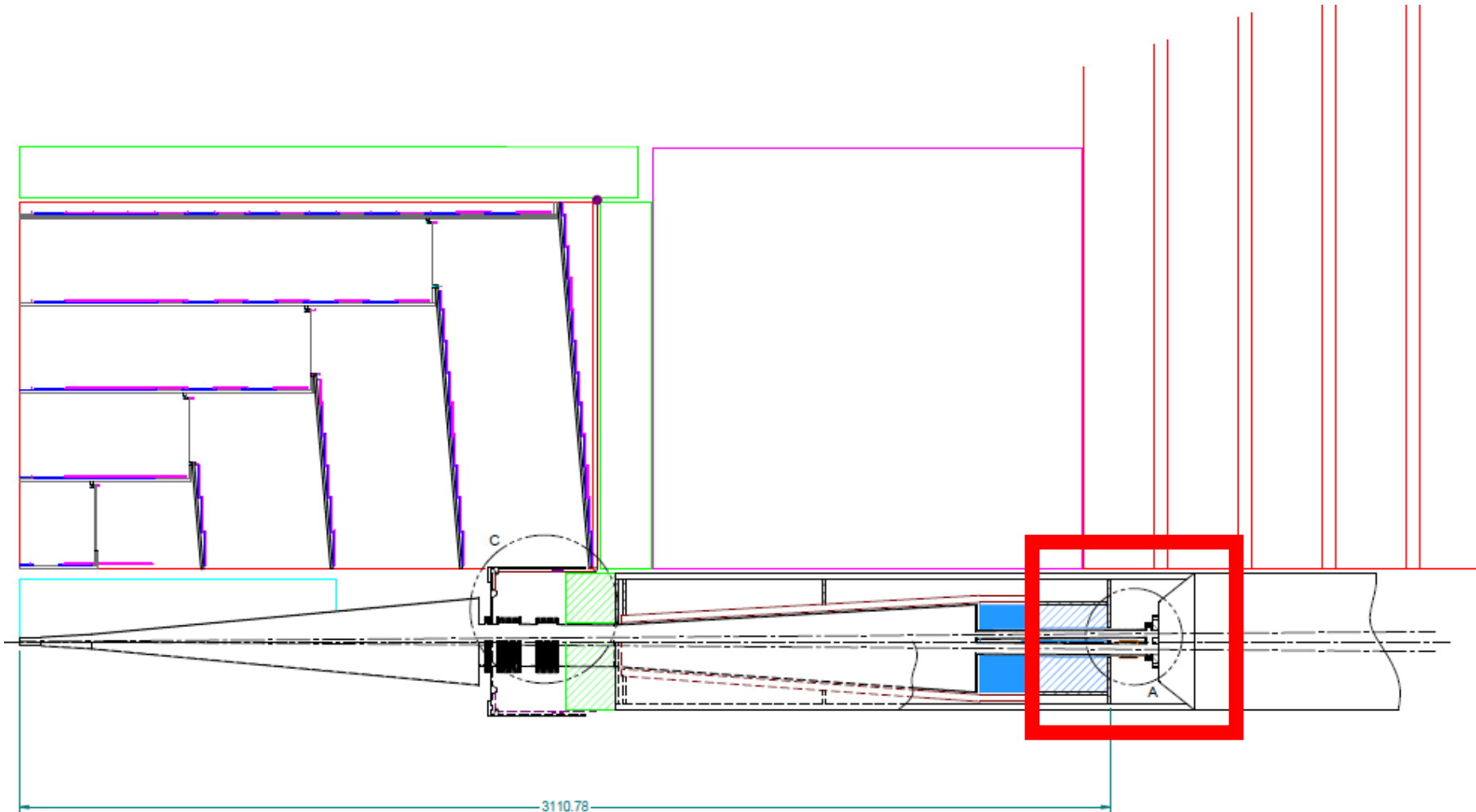
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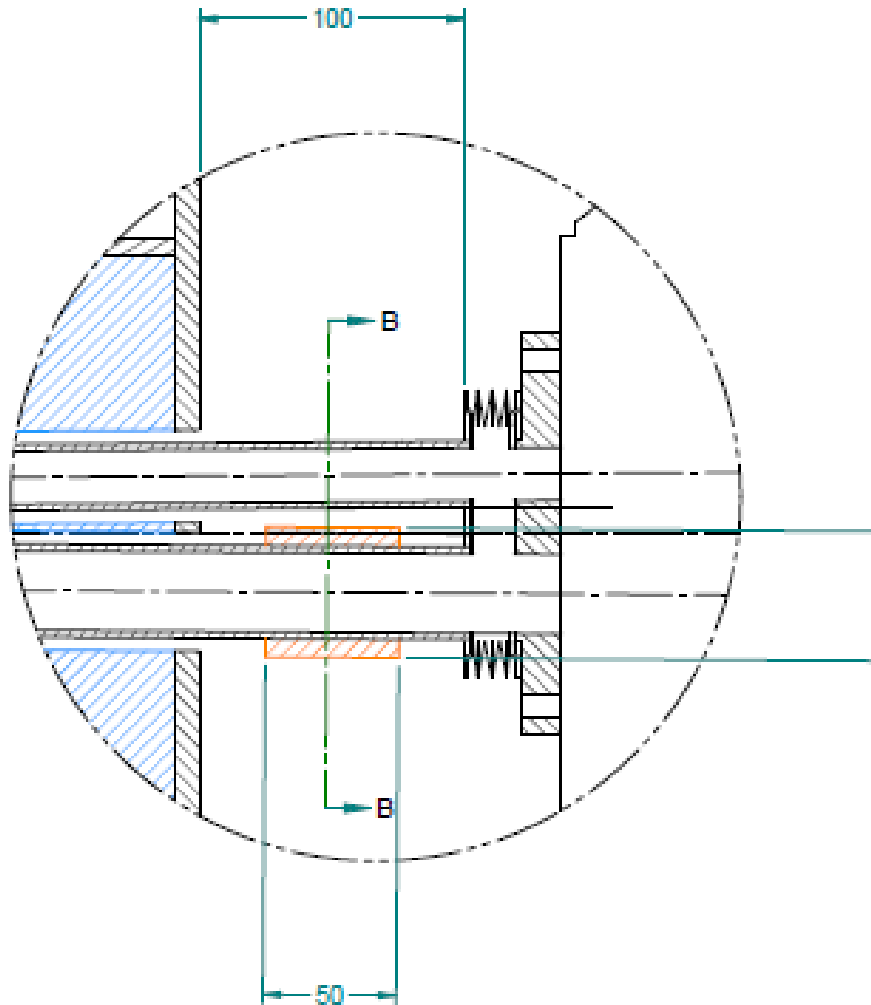
# IP Region (SiD)



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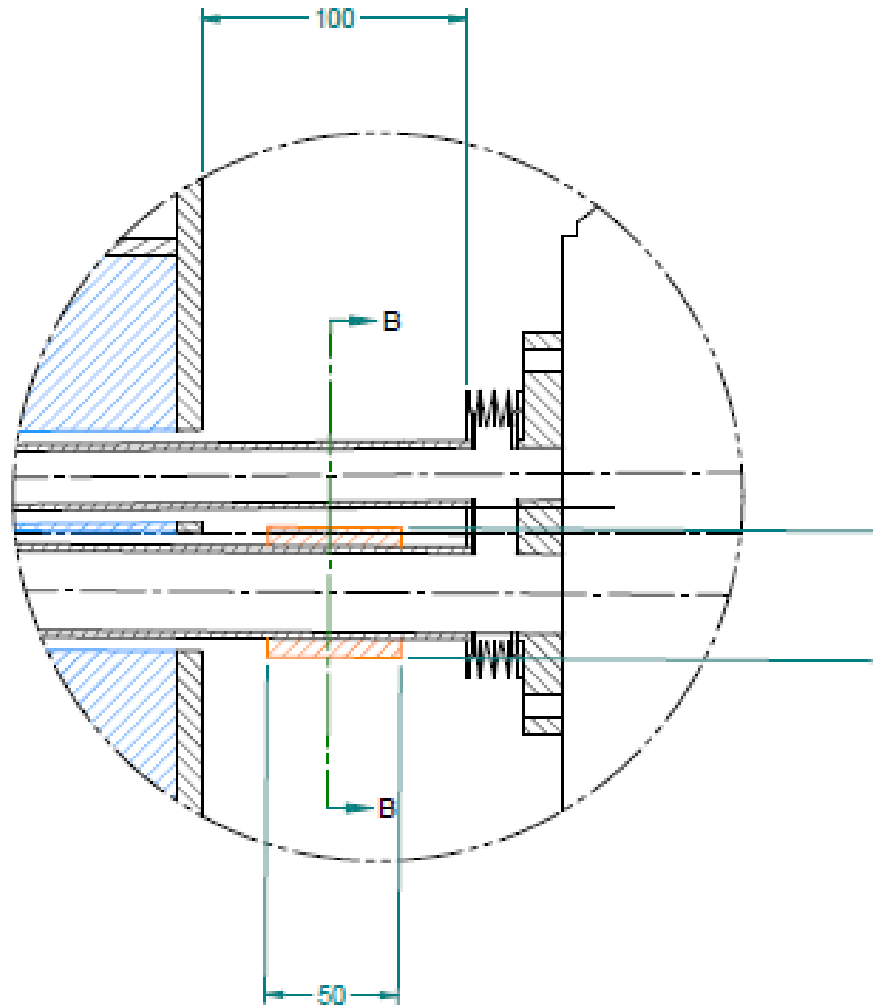
# Beamcal – QD0 Region (SiD)



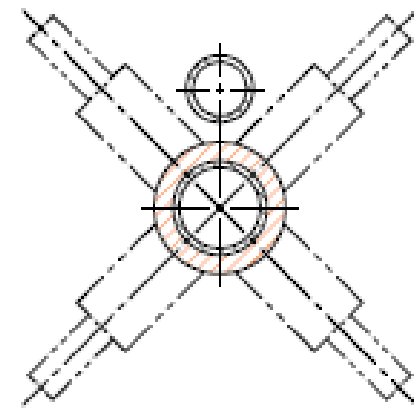
DETAIL A  
SCALE 4:1



# IP FB BPM Detail (SiD)



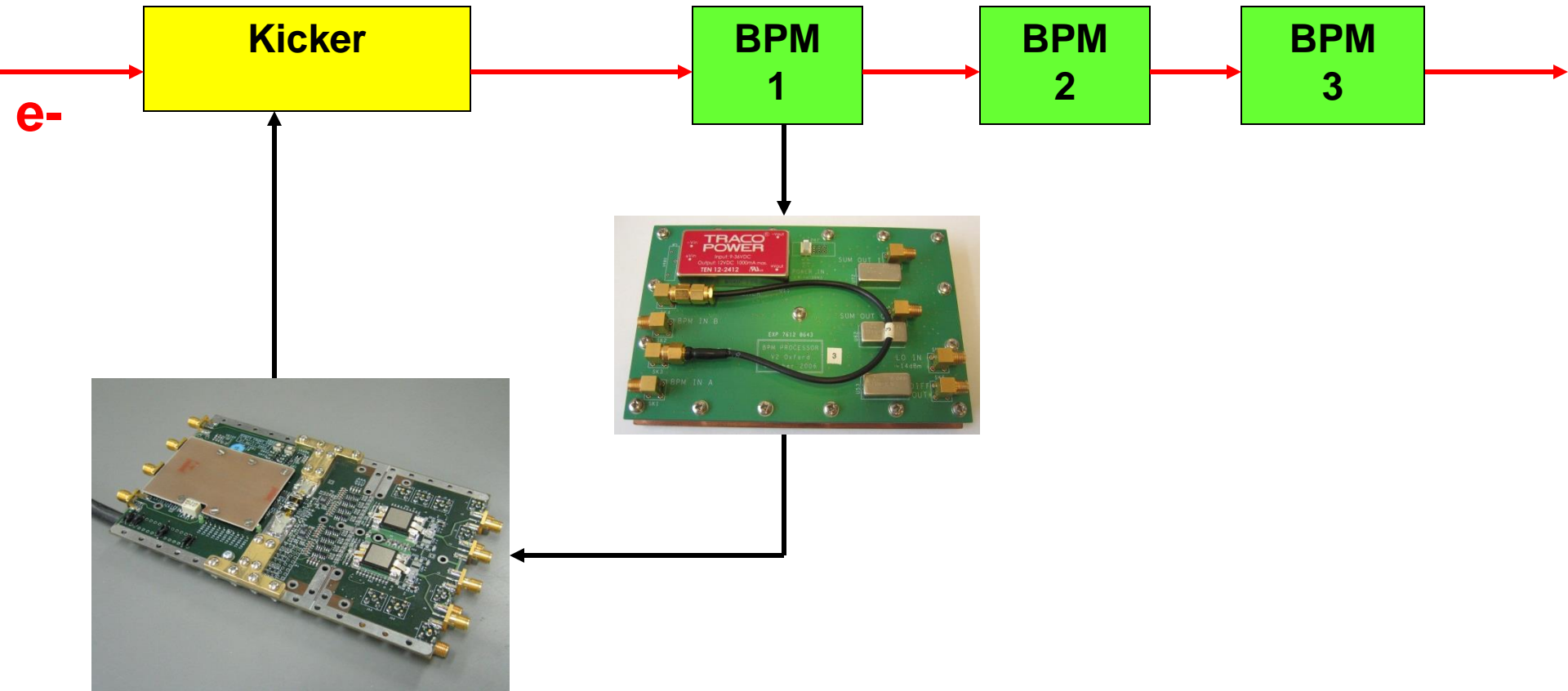
DETAIL A  
SCALE 4:1



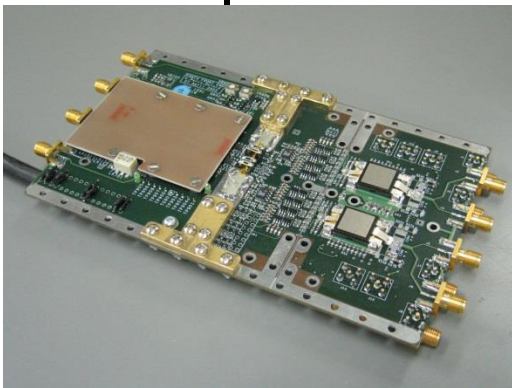
SECTION B-B  
SCALE 4:1

**Smith**

# CLIC prototype: FONT3 at KEK/ATF



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**Electronics latency ~ 13ns**  
**Drive power > 50nm**  
**@ CLIC**

# FONT5 location

ATF2 extraction line

ビーム取り出しライン  
— 世界最先端ビームモニタの開発 —  
Extraction line

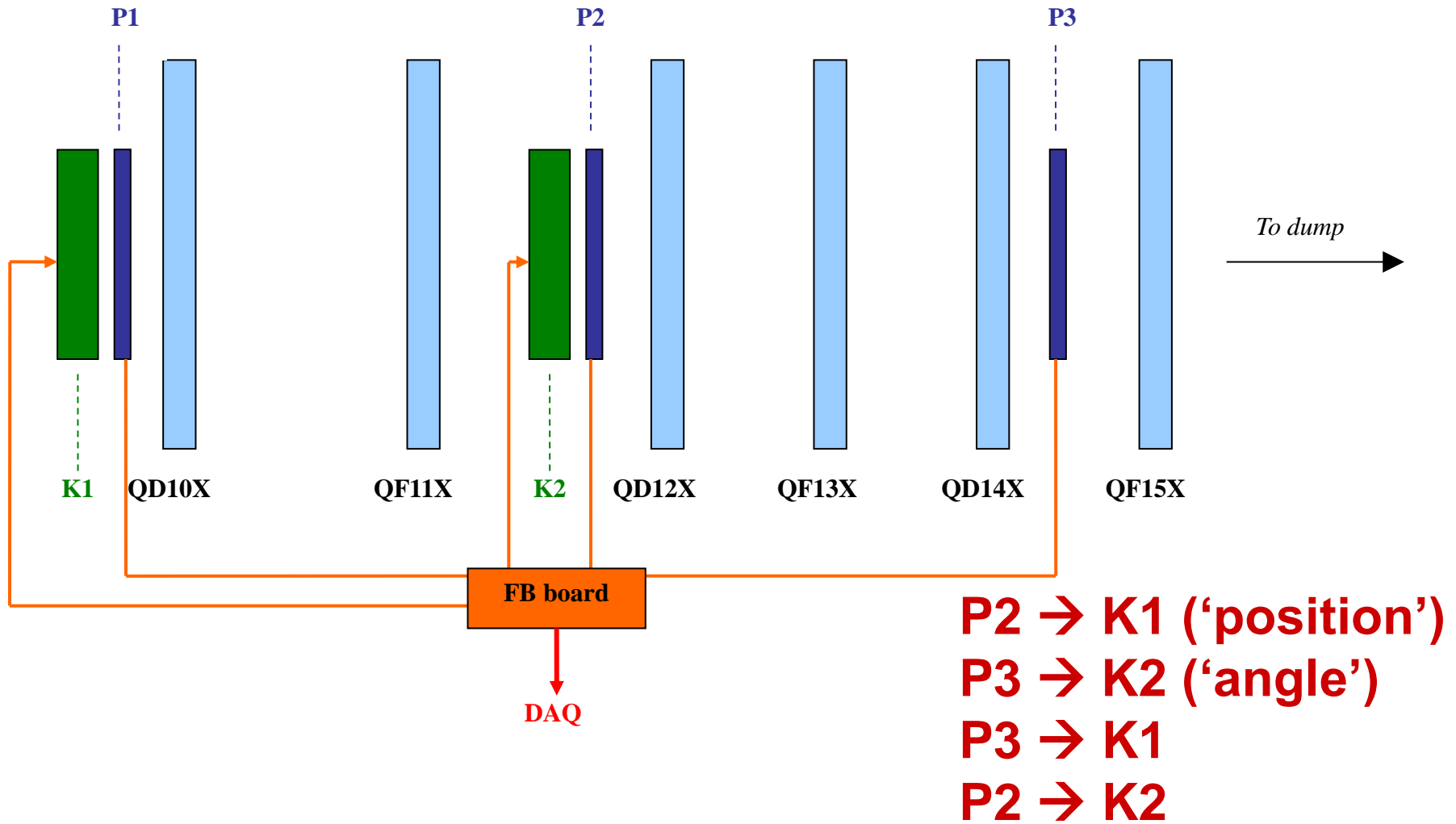
最終収束ビームライン  
— ナノメートルビームの開発 —  
Nano-meter beam R&D (ATF-FF)

ダンピングリング  
— 世界最高品質の電子ビームに変換する —  
Damping Ring

光陰極型高周波電子銃  
— 電子ビームを生成する —  
Photocathode RF Gun

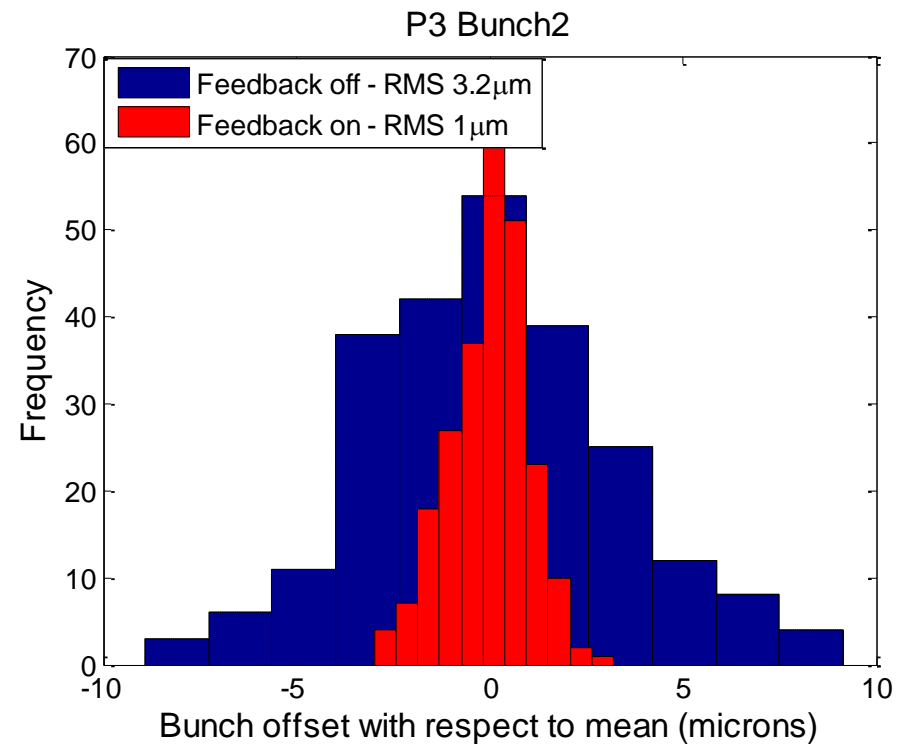
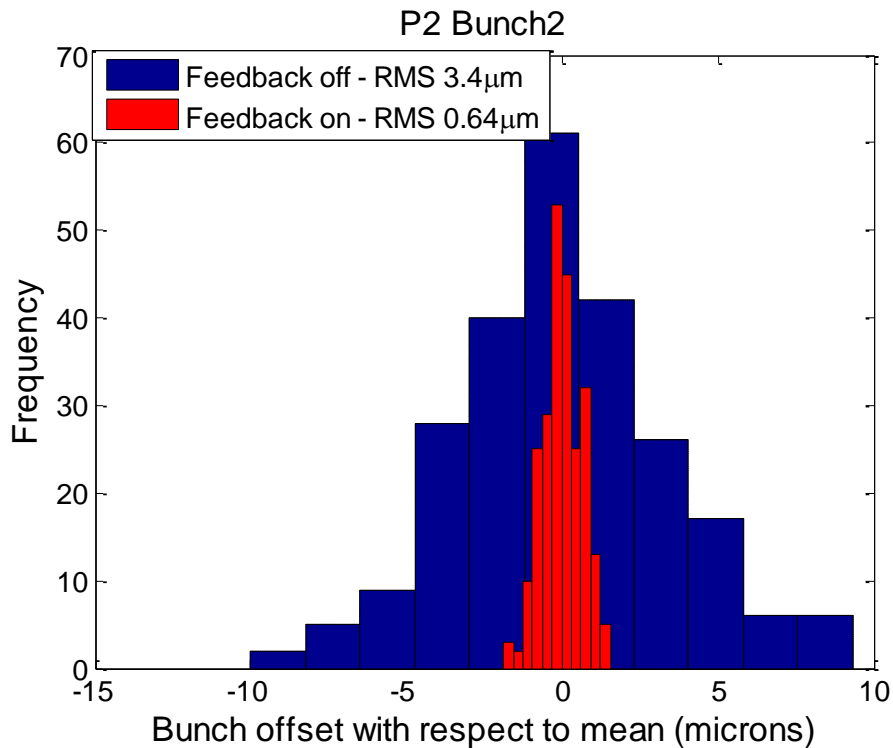
電子線形加速器 (1.3GeV)  
— 電子ビームを加速する —  
S-band electron LINAC

# FONT5 setup

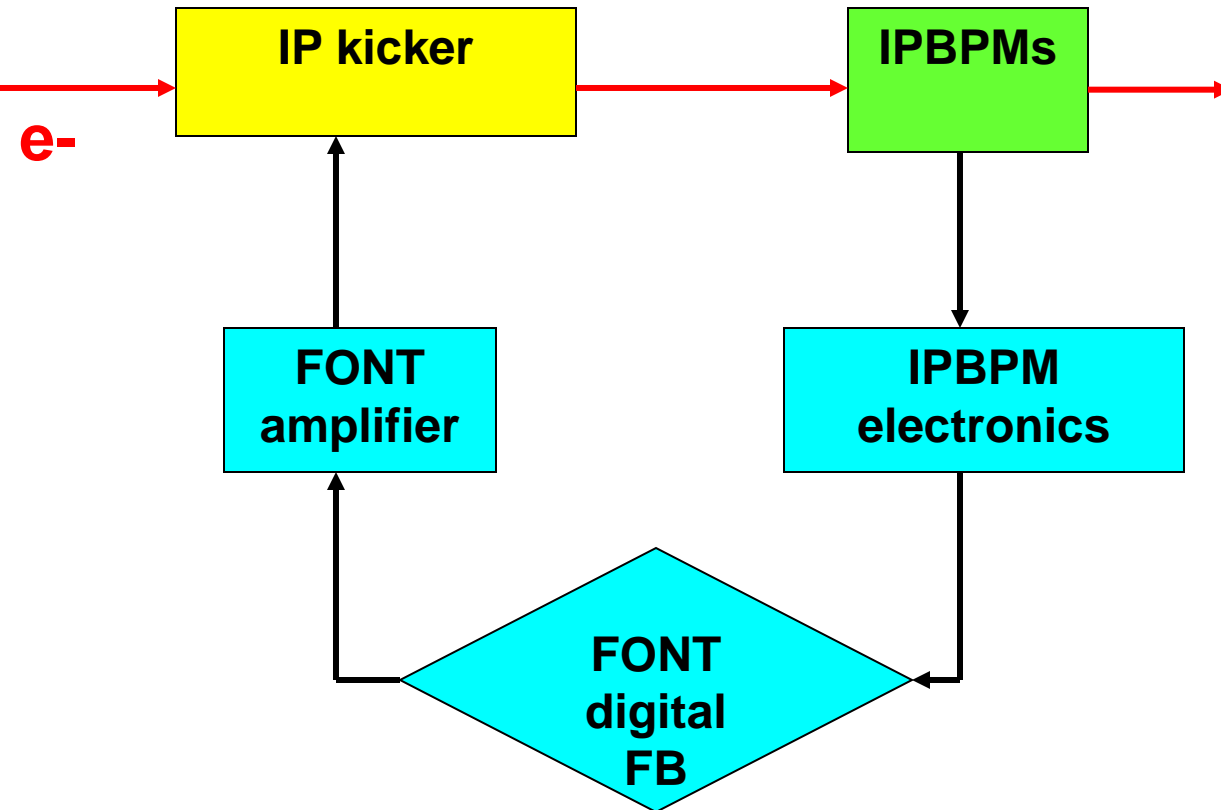


# Feedback Performance

(example FB Run 6 13/12)



# ATF2 IP FB loop scheme



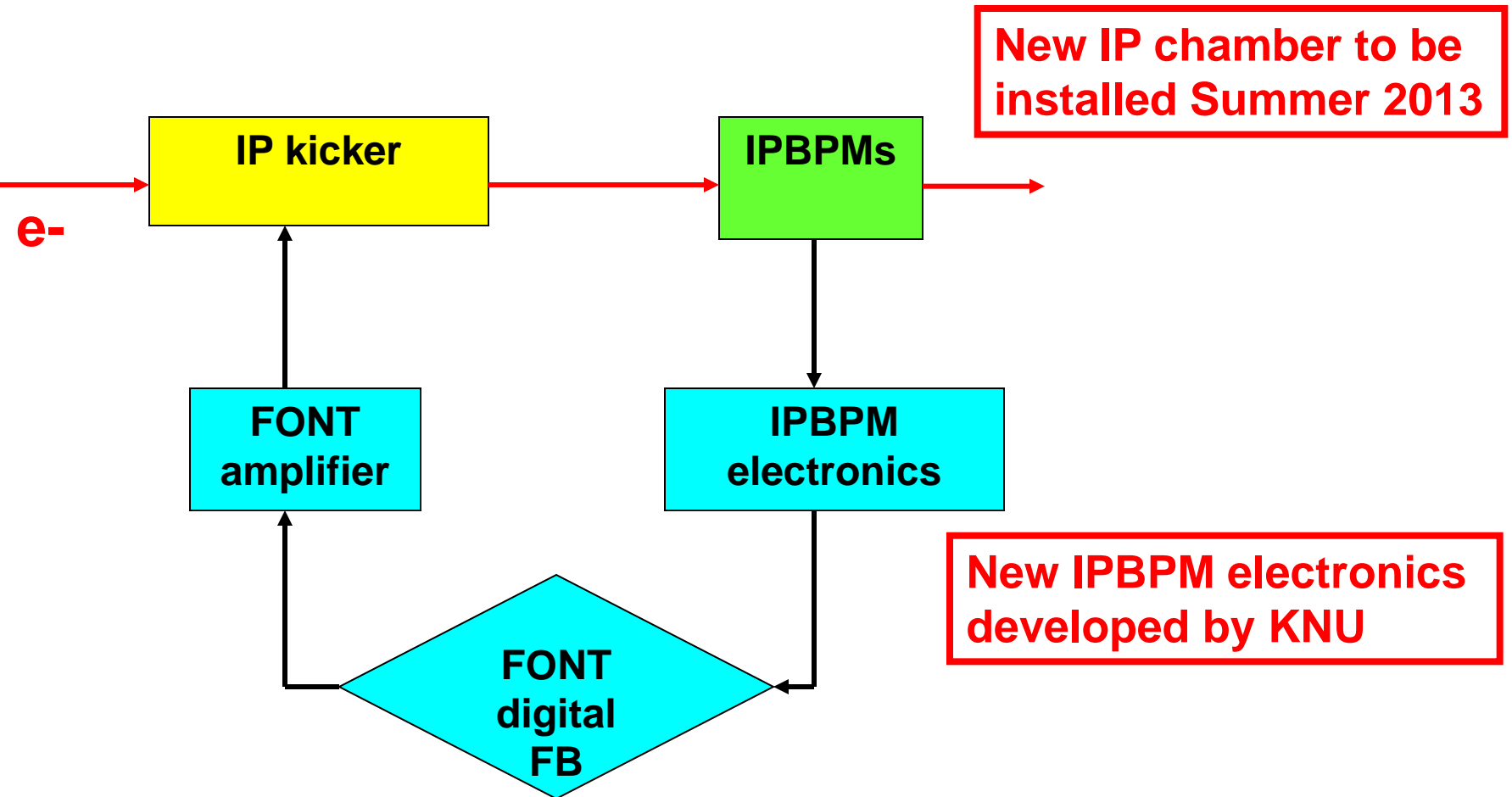
# General Issues for IPFB at ATF2

---

- **Much harder than IPFB at ILC!**
- **Only 1 beam → must measure beam position directly**
- **nm-level stabilisation requires nm-level position meas.**
  - **Cavity BPMs (rather than striplines)**
- **Cavities intrinsically slow, signal processing complicated**
- **Cavities required to resolve 2 bunches within  $\ll 300\text{ns}$** 
  - **Low-Q cavities and low-latency signal processing**
  - **KNU group, new IP chamber (LAL)**



# ATF2 IP FB loop scheme

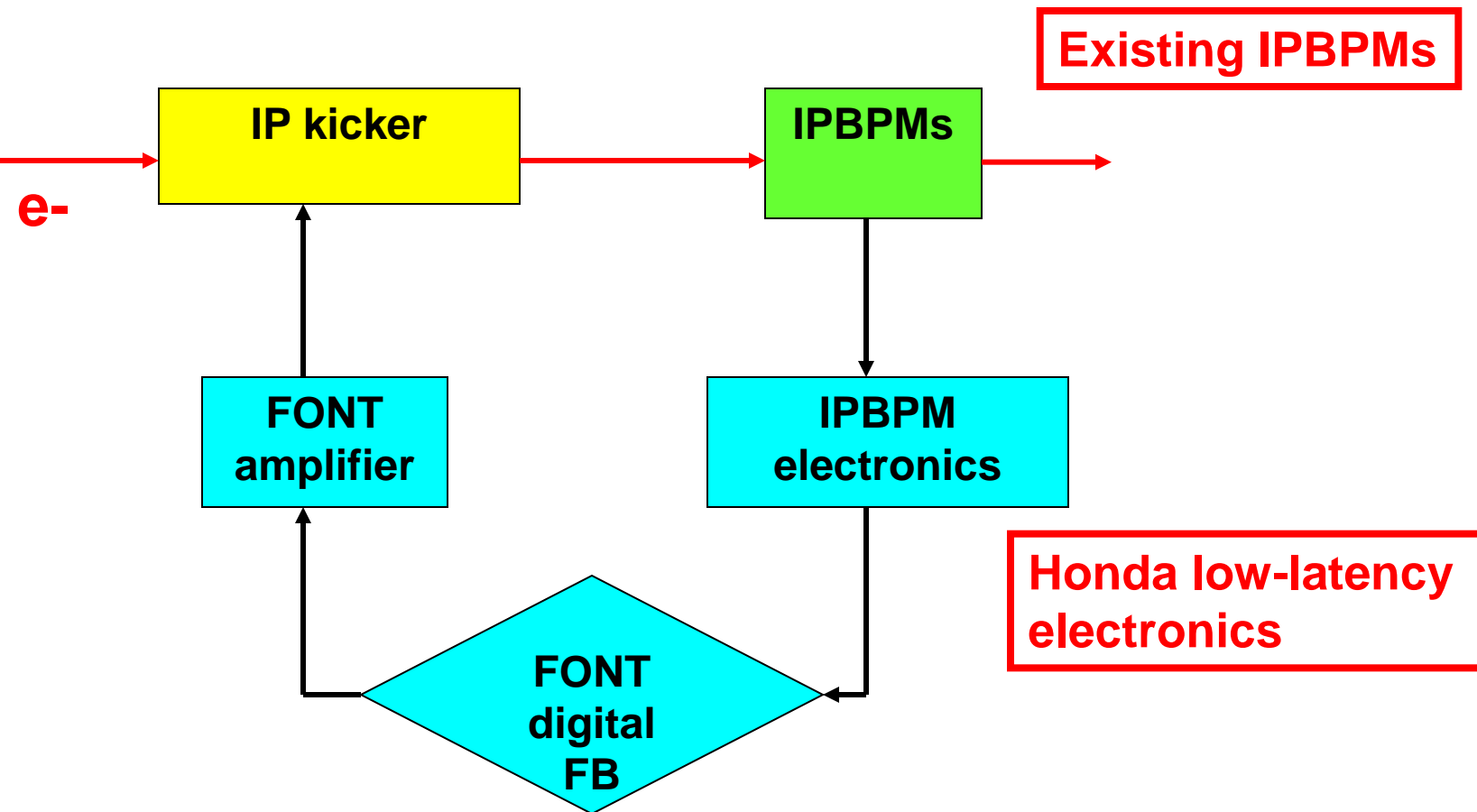


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- **We decided to make preparations with existing hardware ...**

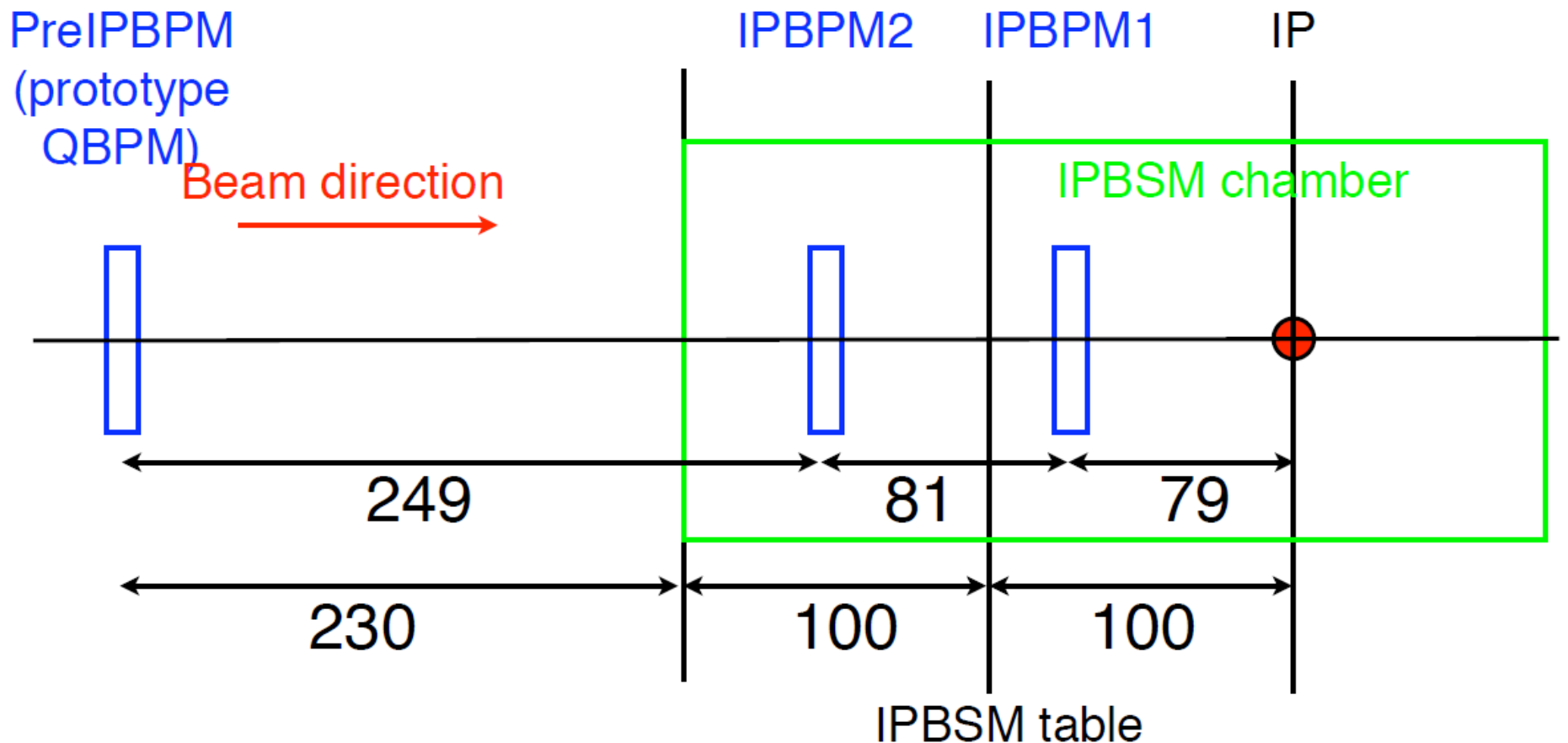
# ATF2 IP FB loop scheme



# Existing IP-BPM geometry

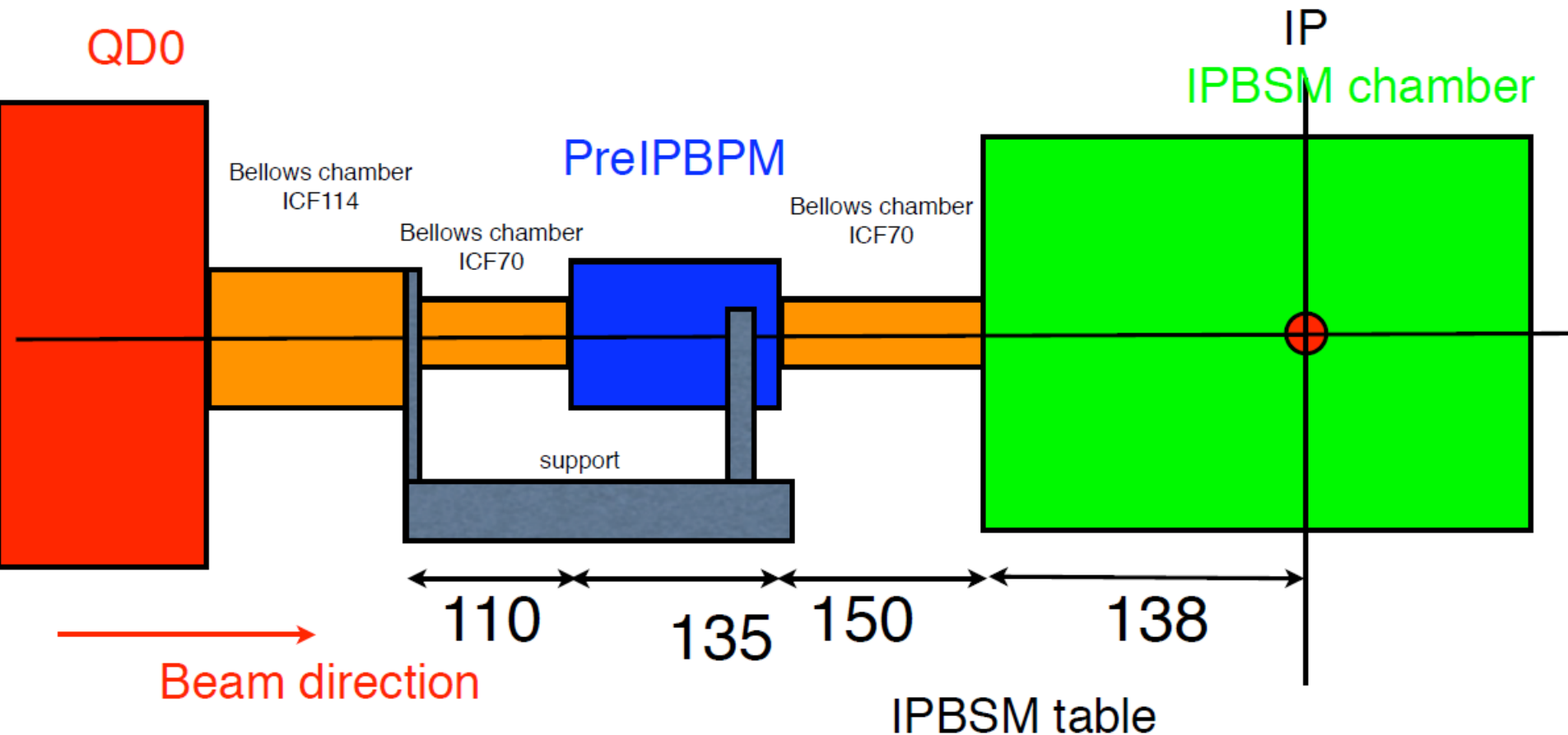
2011.6.29 Y.Honda

- Relative location of IP and two IPBPMs in BSM chamber and PreIPBPM.
- Accuracy of the number should be a few mm.

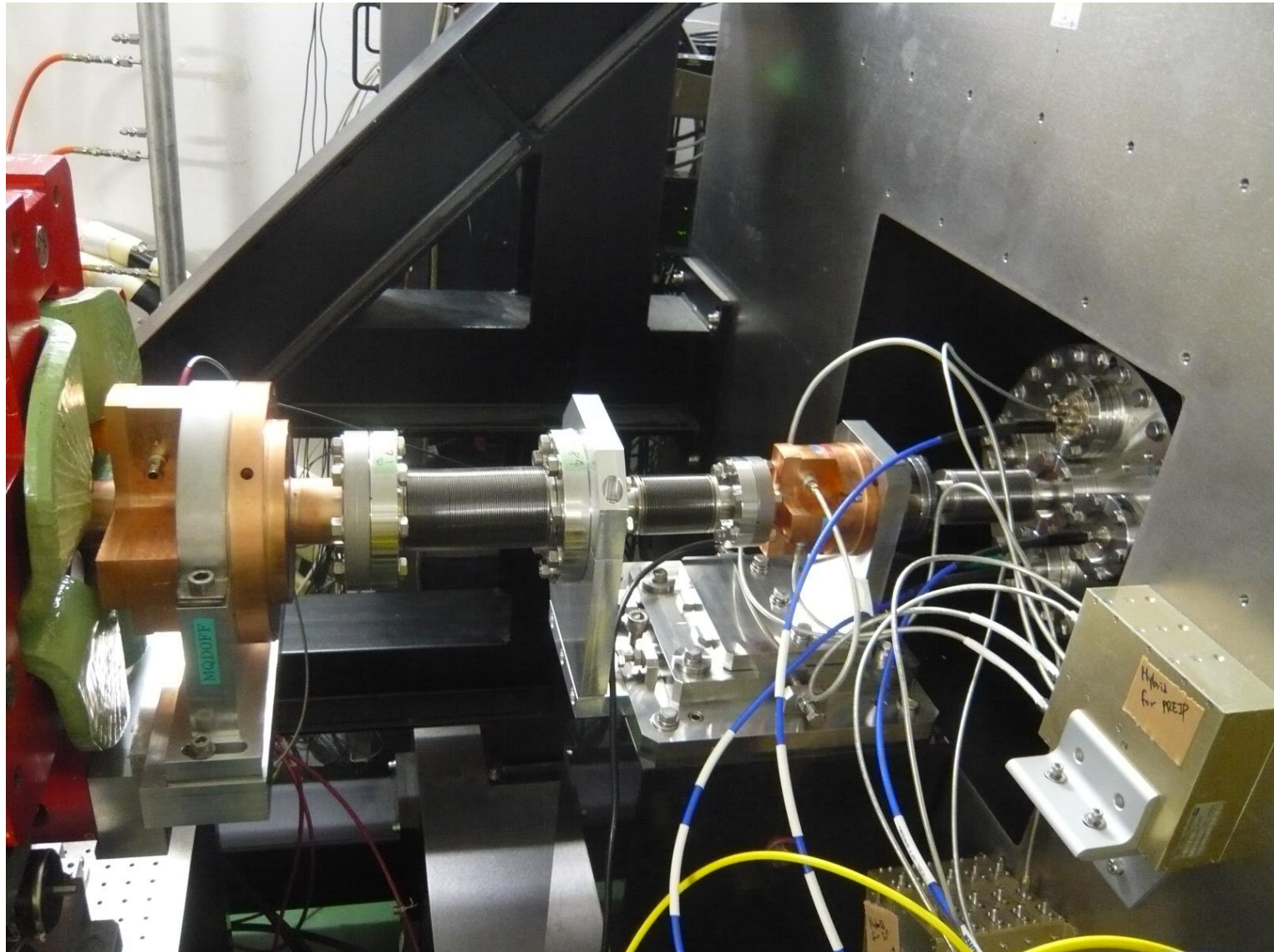


# Chamber geometry

- PreIPBPM is connected with ICF70 bellows at both ends for position adjustment.
- QDO is with ICF114 bellows for its position adjustment. (Since it needs to balance vacuum force for both ends, this should be ICF114 size.)
- ICF70-114 bellows joint is supported from PreIPBPM table.



# Layout (before May 2012)

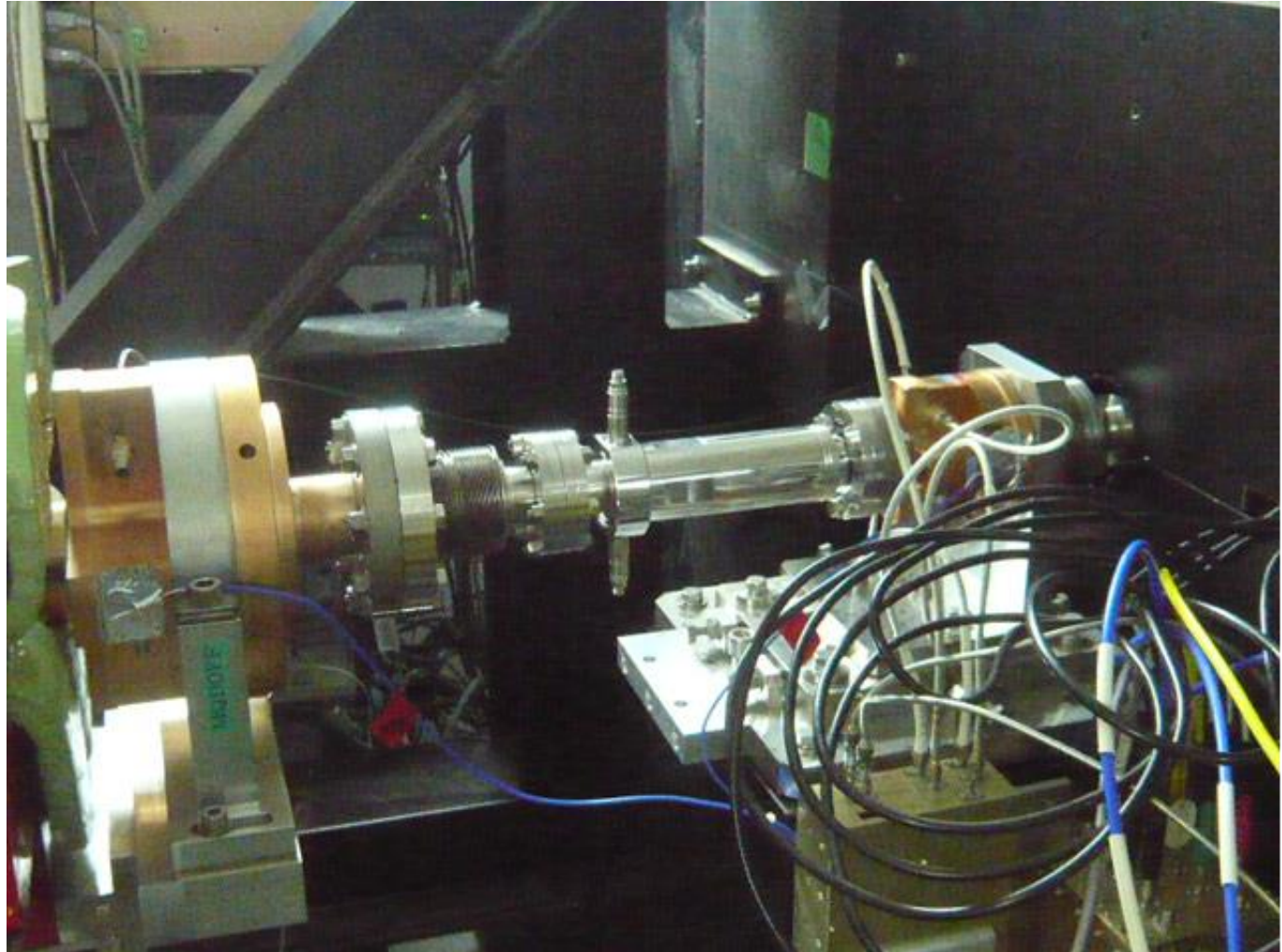


# New IP kicker

**Designed  
by Oxford**

**Fabrication  
arranged  
by KEK**

**Installed  
May 2012**



# Preparations with existing setup

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- **Test new IP kicker with FONT amplifier:**
  - ensure functionality**
  - measure dynamic range of kick**
- **Instrument existing IPBPMs w. Honda electronics, for 2-bunch readout:**
  - digitise signals with FONT5 board**
  - cross check with EPICS in 1-bunch mode**
  - understand cavity BPM signals w. 2 bunches**
  - exercise system in preparation for IPFB**



# FONT drive amplifier

FONT5 amplifier, built by TMD Technologies

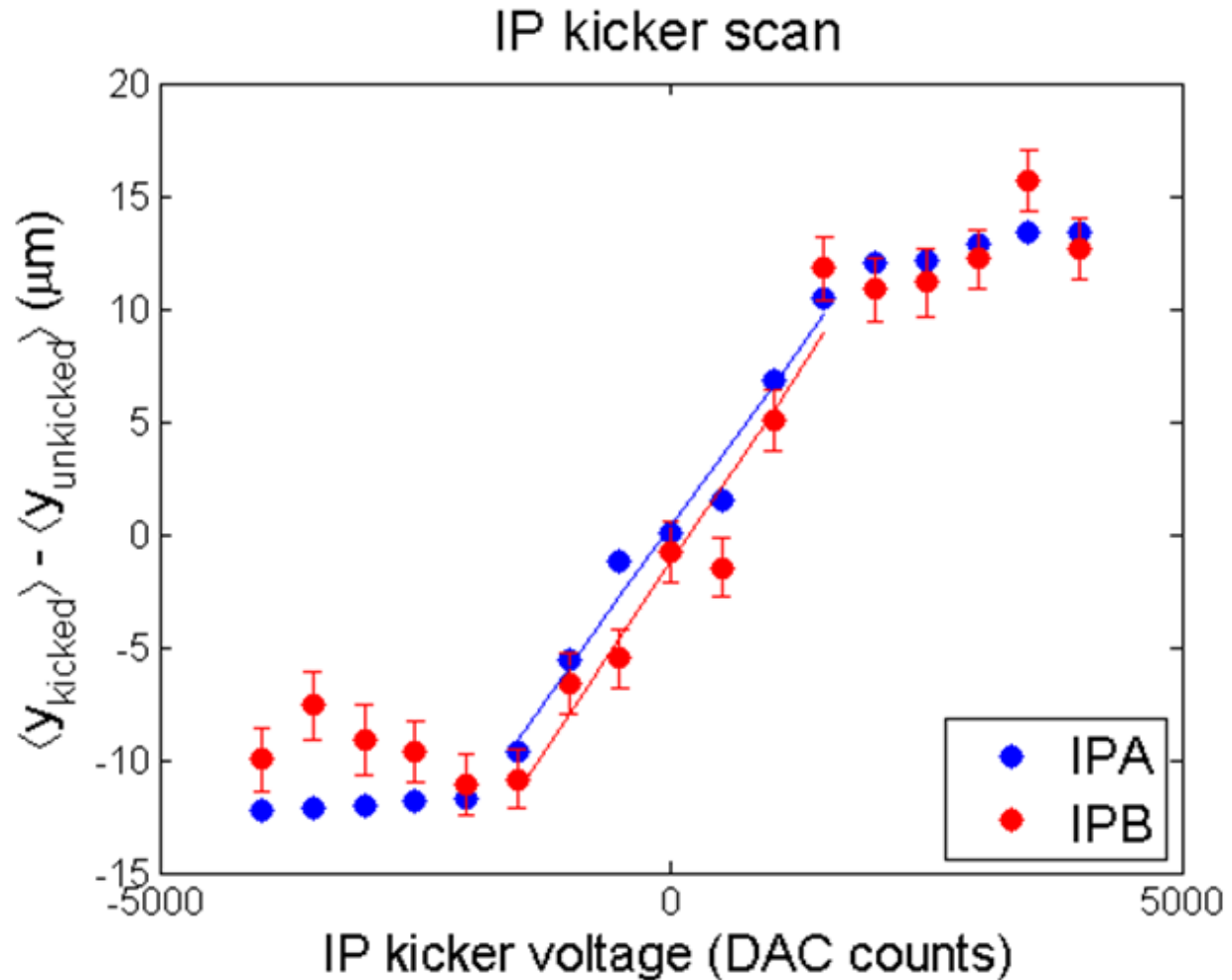
## Specifications:

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



# IP kicker drive scan

EPICS  
readout  
of IPBPMs



# IP kicker conclusions

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- **Kicker is working well**
  - **FONT amplifier is able to drive kicker**
  - **Dynamic kick range almost  $\pm 15$   $\mu\text{m}$  at IPBPMs**
  - **Linear kick range  $> \pm 10$   $\mu\text{m}$**
- $\rightarrow$  plenty of drive for beam stabilisation @ IP**

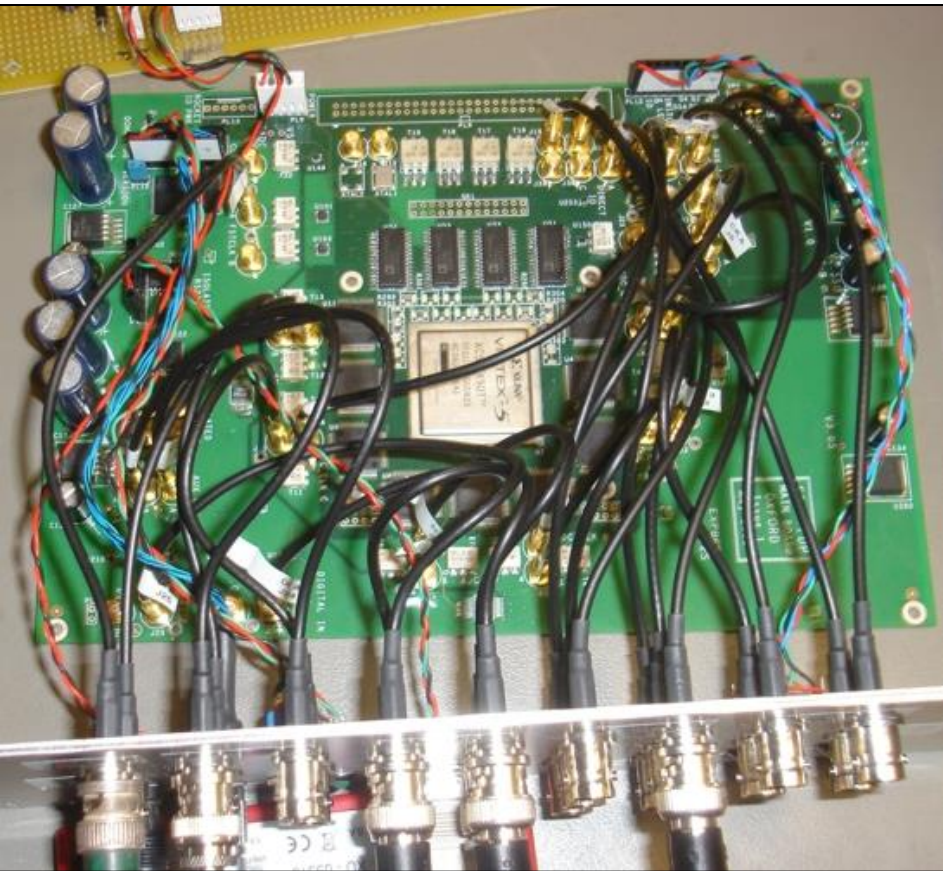
# IPBPM tests (single bunch)

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- **IPBPM A+B signals split:**
  - 1) **SLAC electronics → ATF EPICS controls**
  - 2) **Honda-san electronics → FONT5 board**

**allowed cross-check of standard electronics and FONT digitised readout**

# FONT5 digital FB board



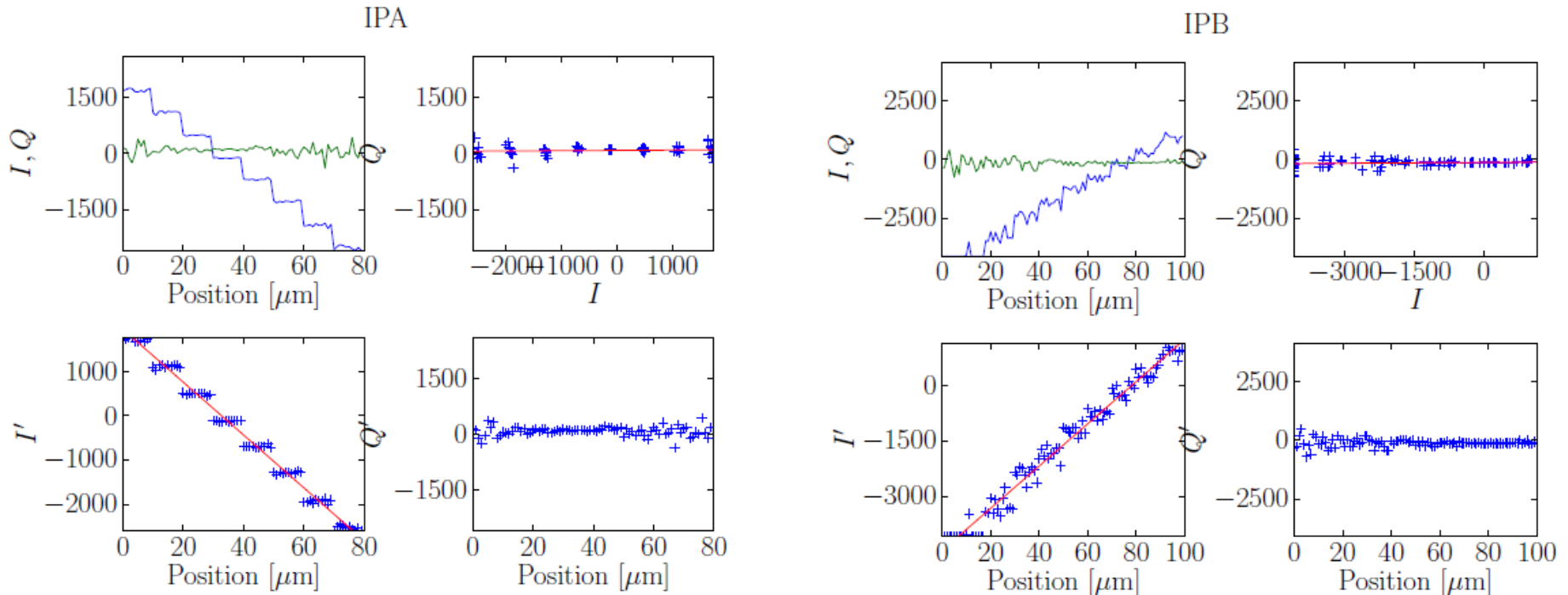
**Xilinx Virtex5 FPGA**

**9 ADC input channels  
(TI ADS5474)**

**4 DAC output channels  
(AD9744)**

**Clocked at 357 MHz  
phase-locked to beam**

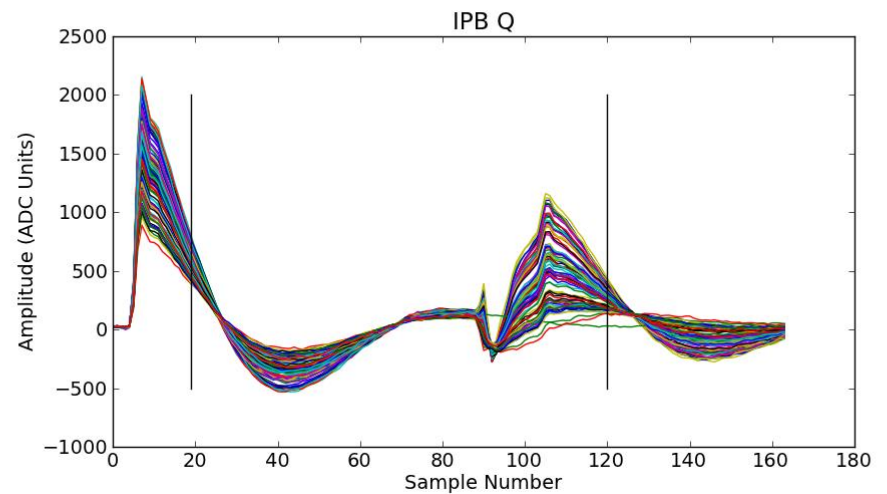
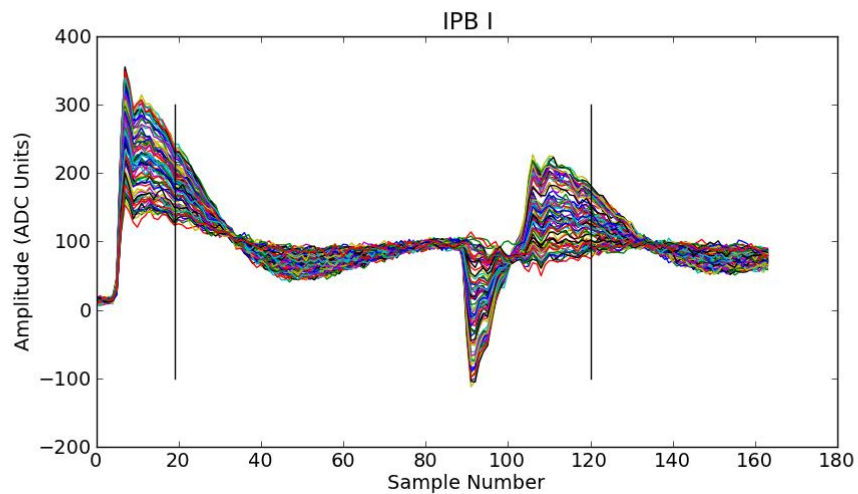
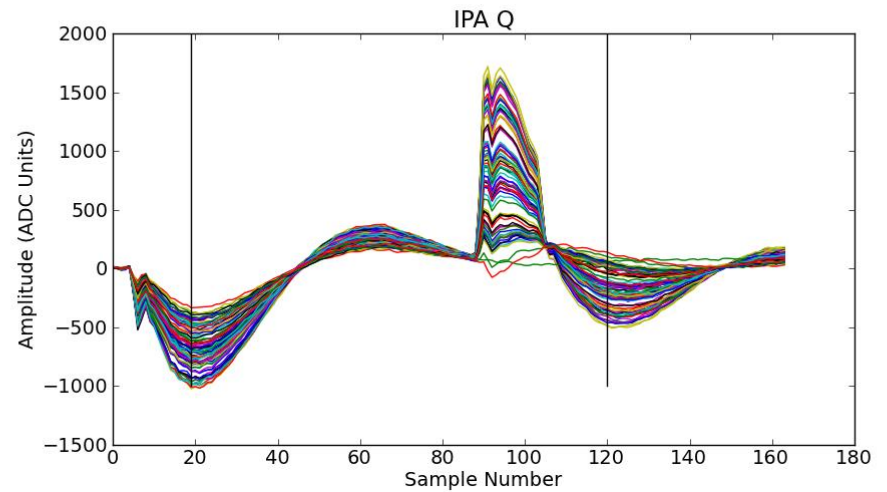
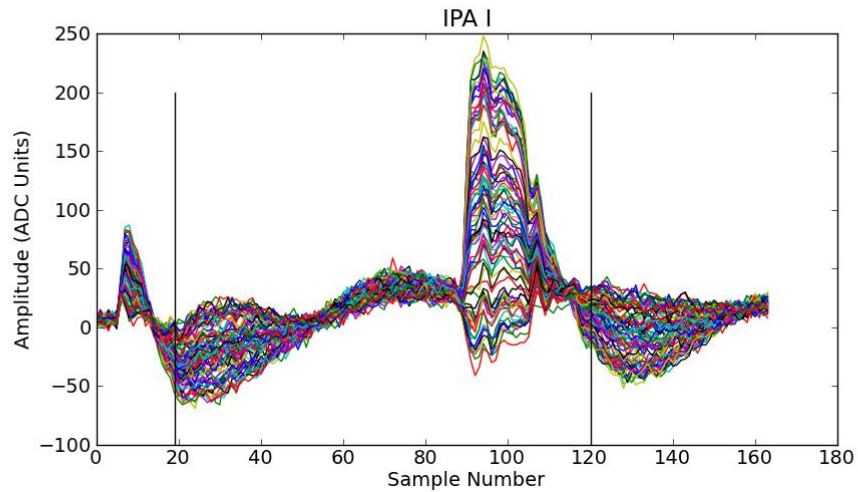
# FONT digitisation of IPBPMs



**Digitisation and calibration successful,  
with single-bunch beam**

# Digitised waveforms: 2 bunches

Raw Waveforms with Sample Number Selections for 20db Calibration

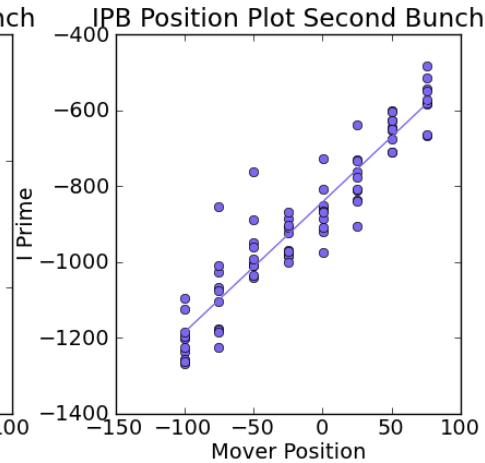
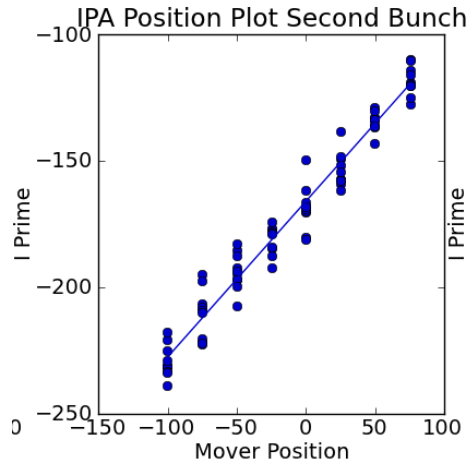


# Calibrations: 2 bunches

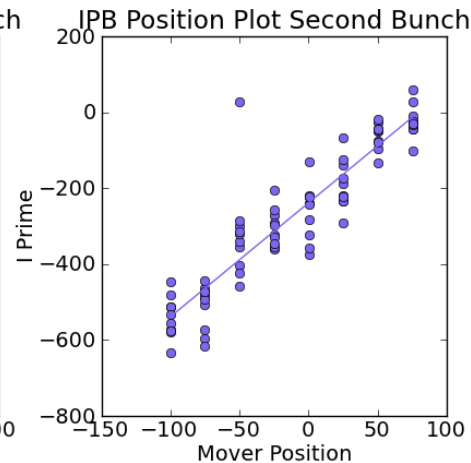
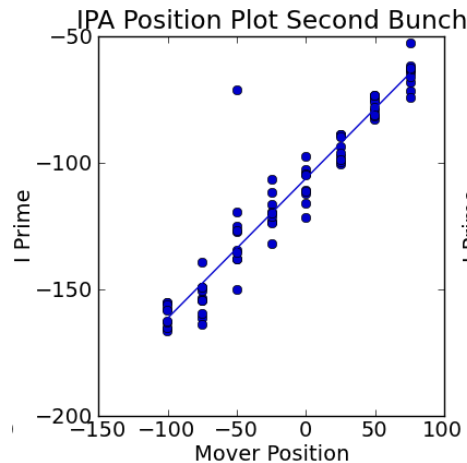
Bunch 1

IPBPM A

IPBPM B



Bunch 2





# IPBPM digitisation conclusions

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- **Able to set beam waist at IPBPM A or B**
- **Digitised Honda electronics output: I + Q**
- **Calibrated IPBPMs**
- **Recorded data successfully in 2-bunch mode**
  - FONT system is ready for IPFB tests**  
**towards ATF goal 2**

# Test programme

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Preparations for beam stability in IP region with

2-bunch beam:

1. Readout of IPBPMs with **2-bunch** beam
2. **Upstream FONT FB**: record beam in IPBPMs
3. **Feed-forward** from upstream FONT BPMs → IP  
kicker: record beam in IPBPMs
4. **IP FB** using IPBPM signal and IP kicker

# Test programme

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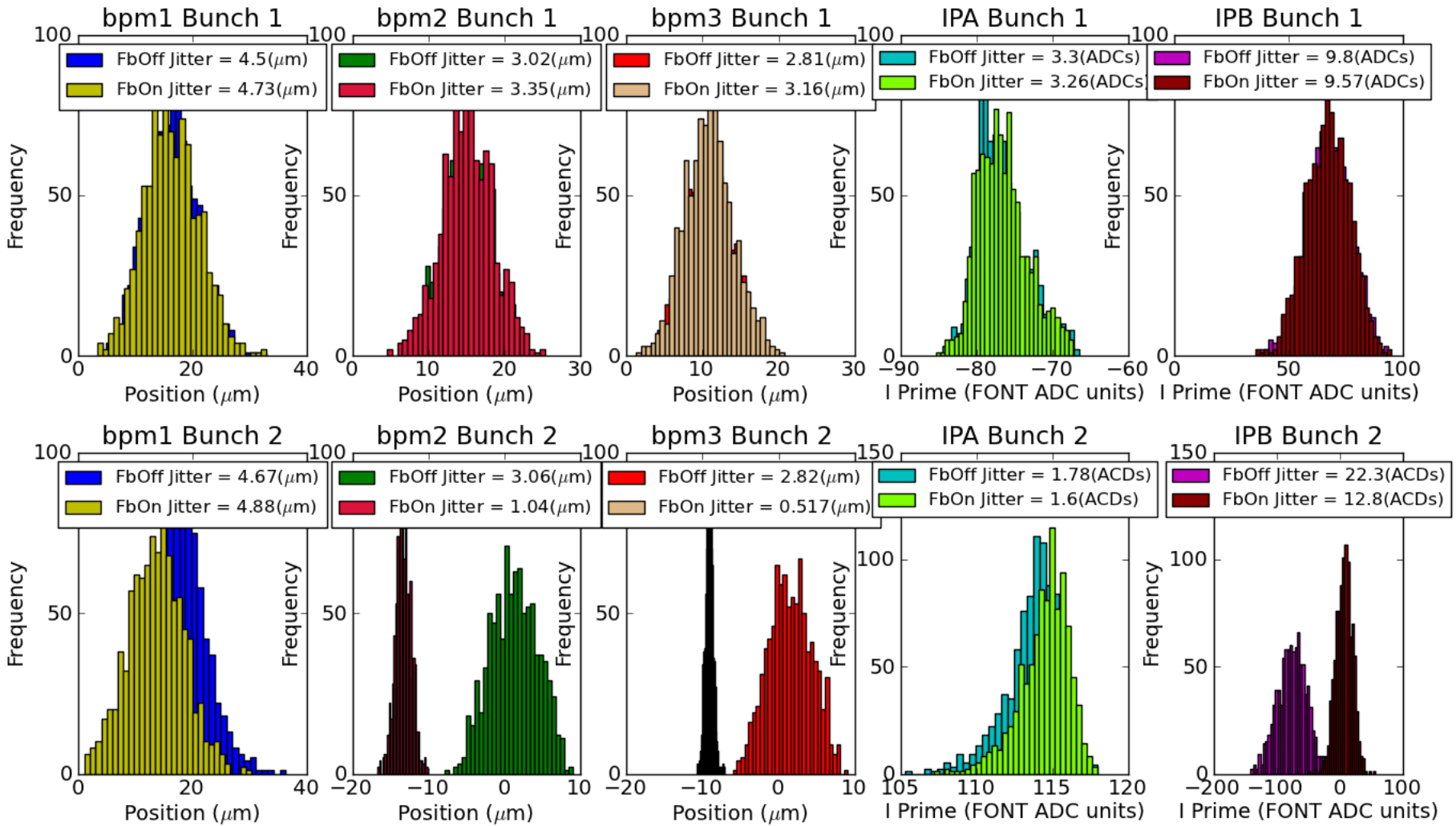
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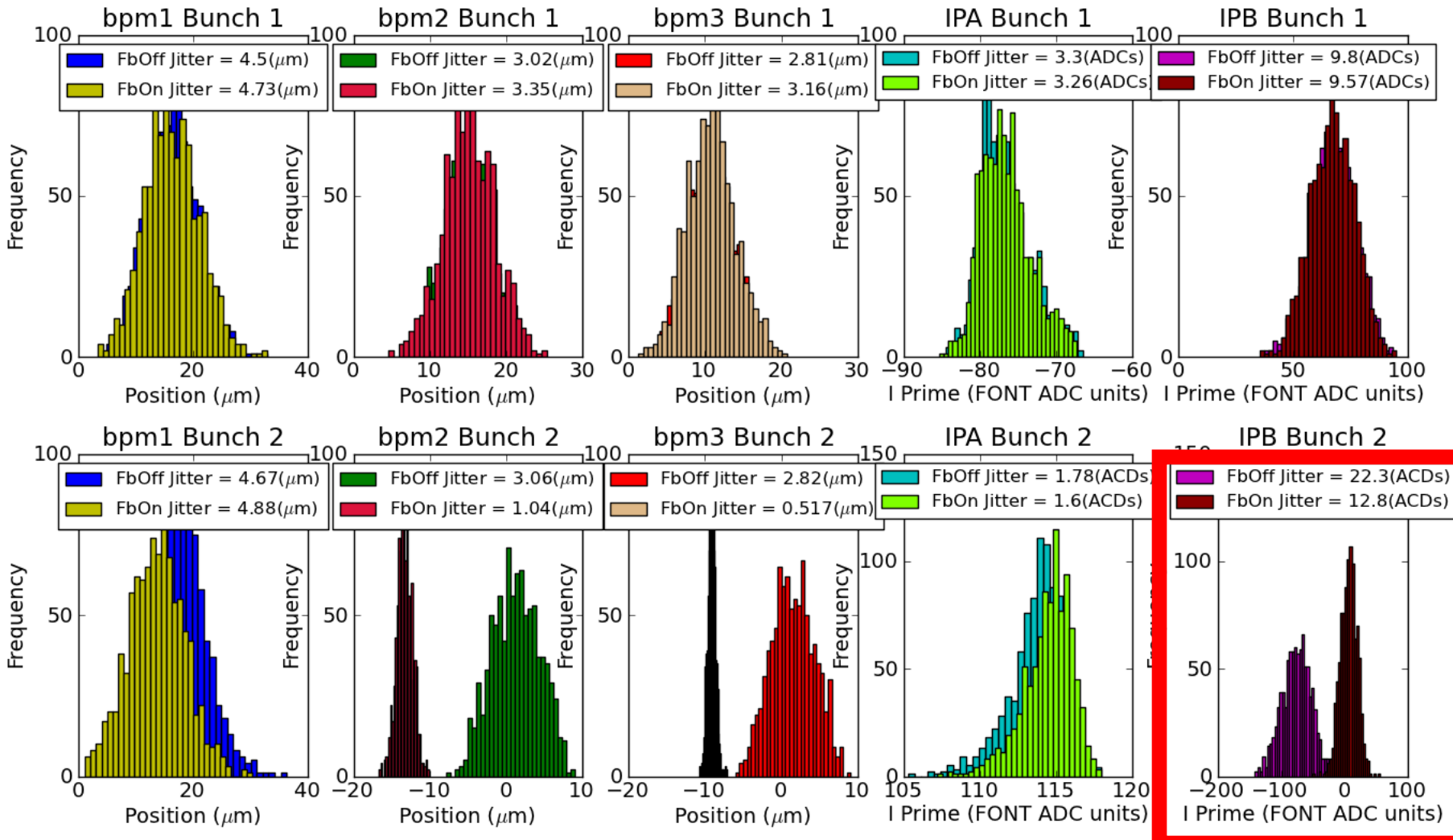
# Effect of upstream FB at IPBPM B

Jitter Histograms (fbRun10) Waste at IP



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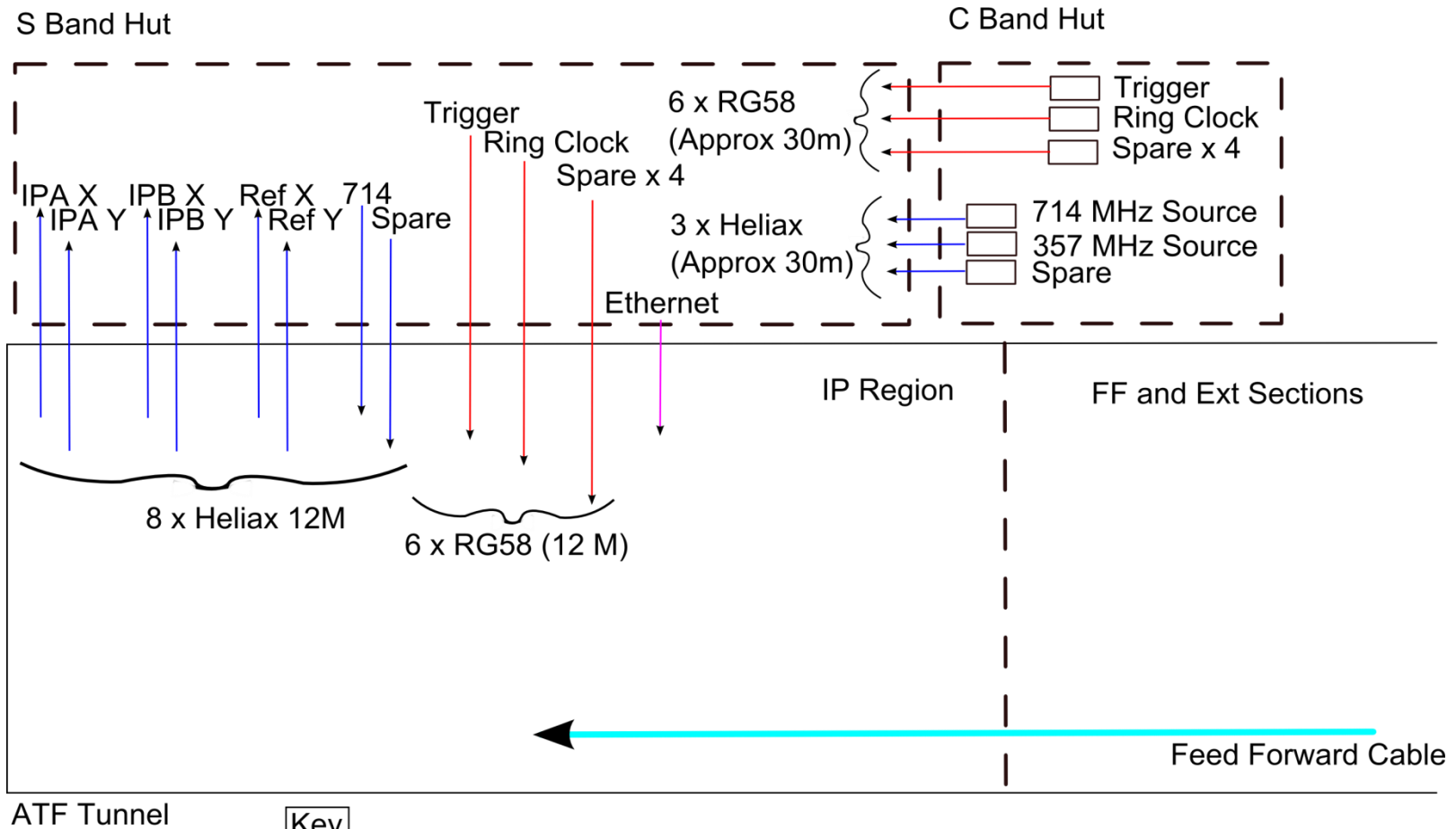
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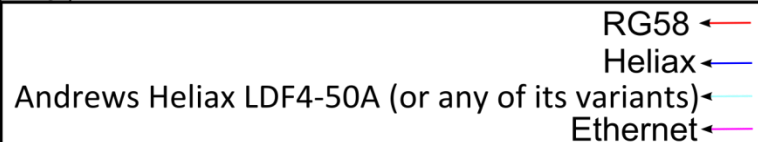
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# Setup (September 2012)

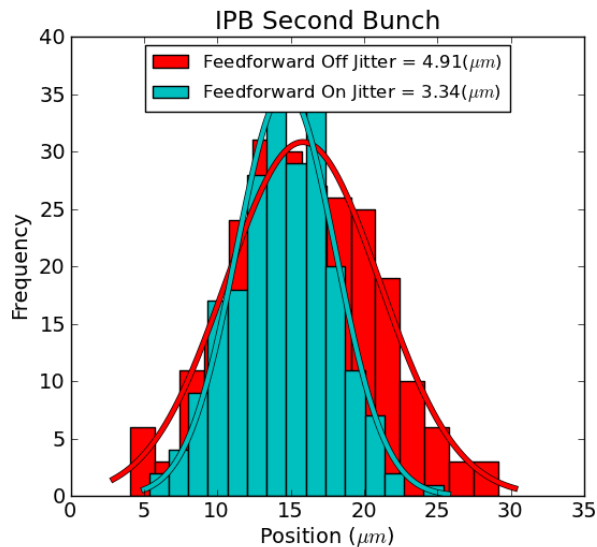
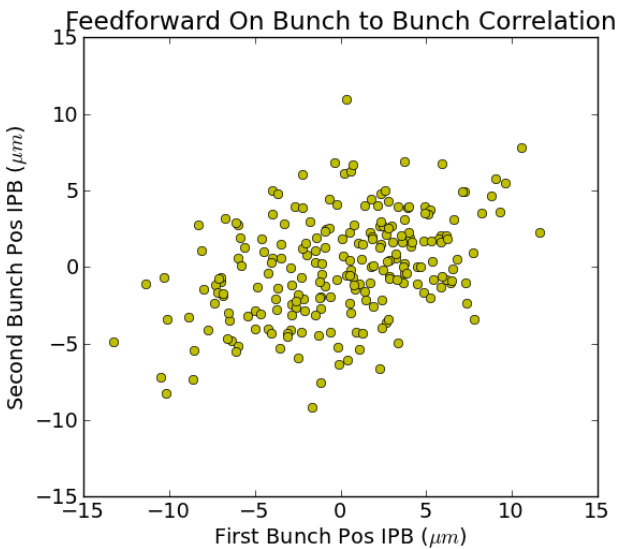
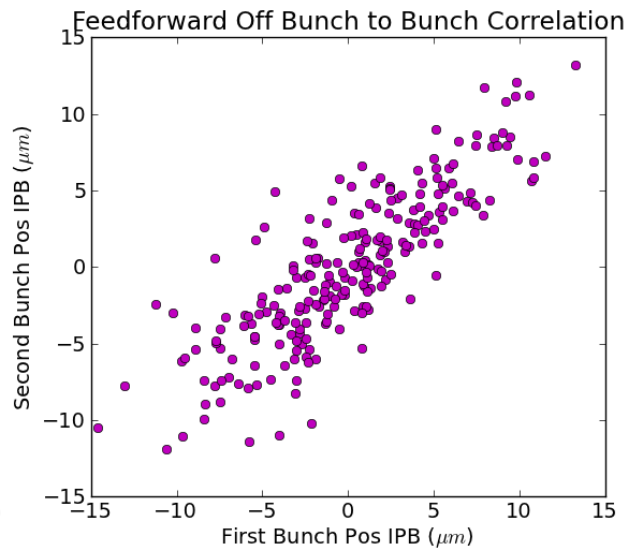
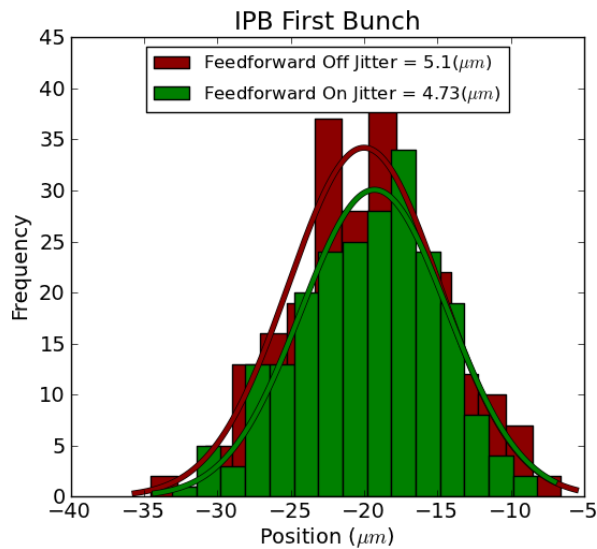


ATF Tunnel

Key



# Feed-forward from upstream

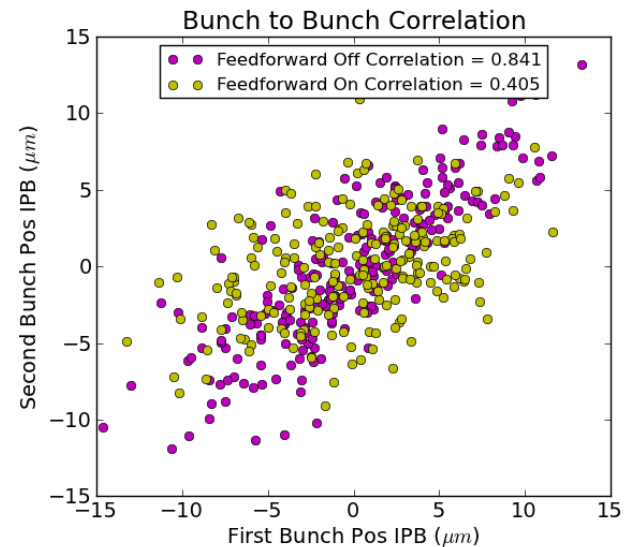


**jitters**  
P2 =  $3.73(\mu\text{m})$   
P3 =  $3.7(\mu\text{m})$   
IPB =  $5.1(\mu\text{m})$

**B To B Corrs**  
P2 = 0.938  
P3 = 0.903  
IPB = 0.841

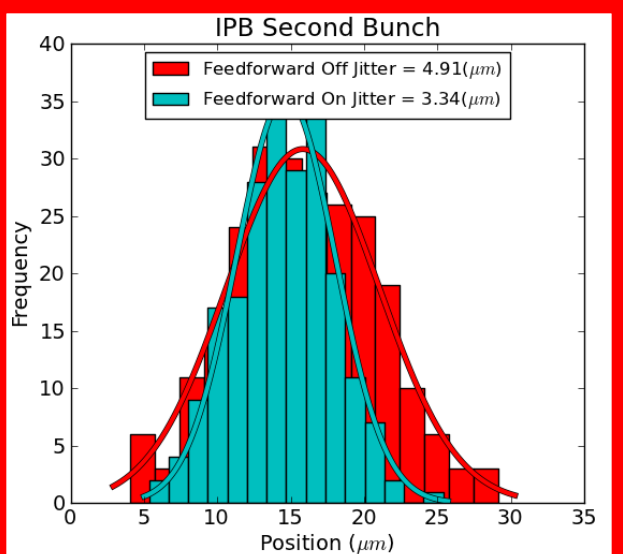
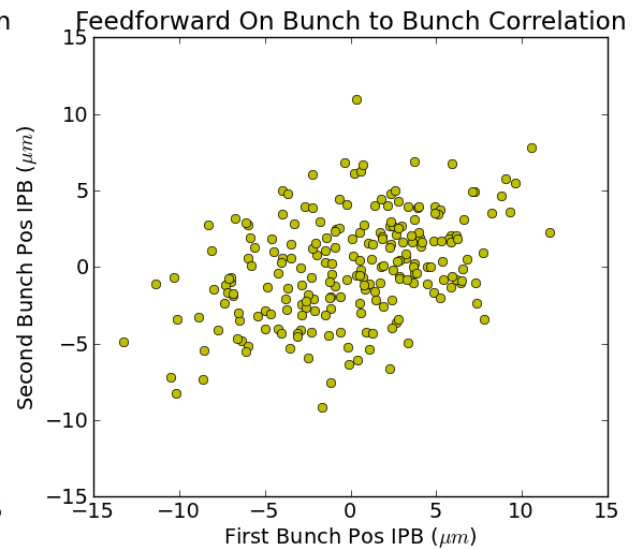
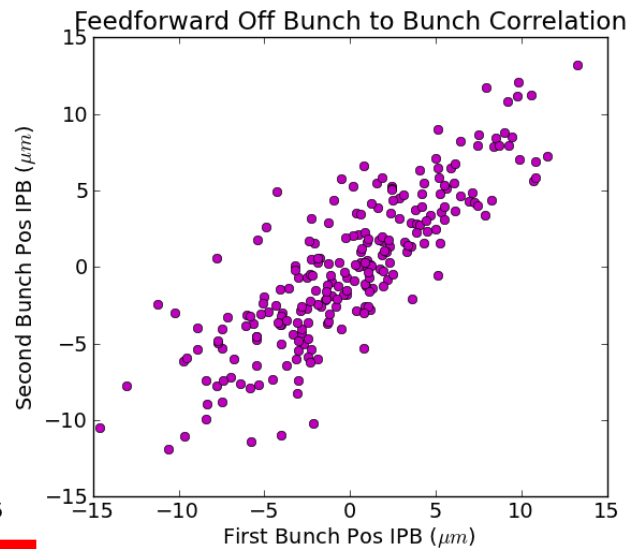
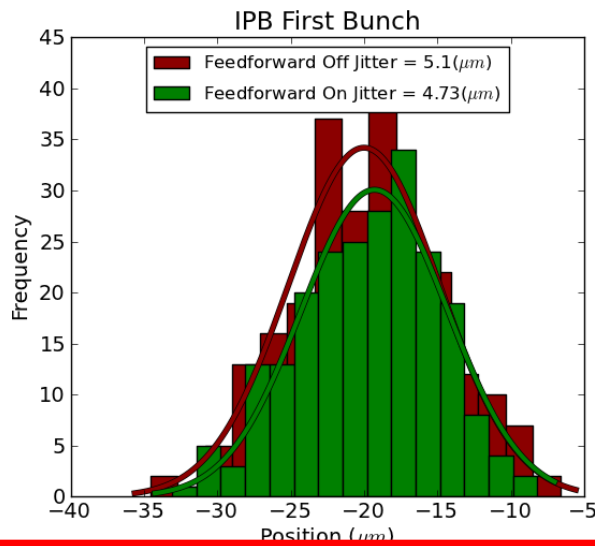
**Upstream Downstream Corrs**  
P2 IPB = -0.757  
P3 IPB = -0.71

**Upstream Downstream B To B Corrs**  
P2 Bunch 1 to IPB Bunch 2 = -0.692  
P3 Bunch 1 to IPB Bunch 2 = -0.628





# Feed-forward from upstream

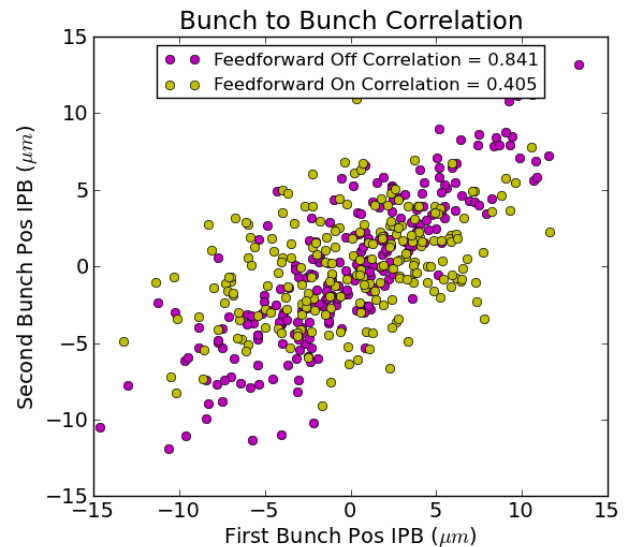


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If beamtime in April (+ June) repeat, and try to close FB loop  
with current IPBPMs and Honda electronics