IP FB + FF Tests

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***

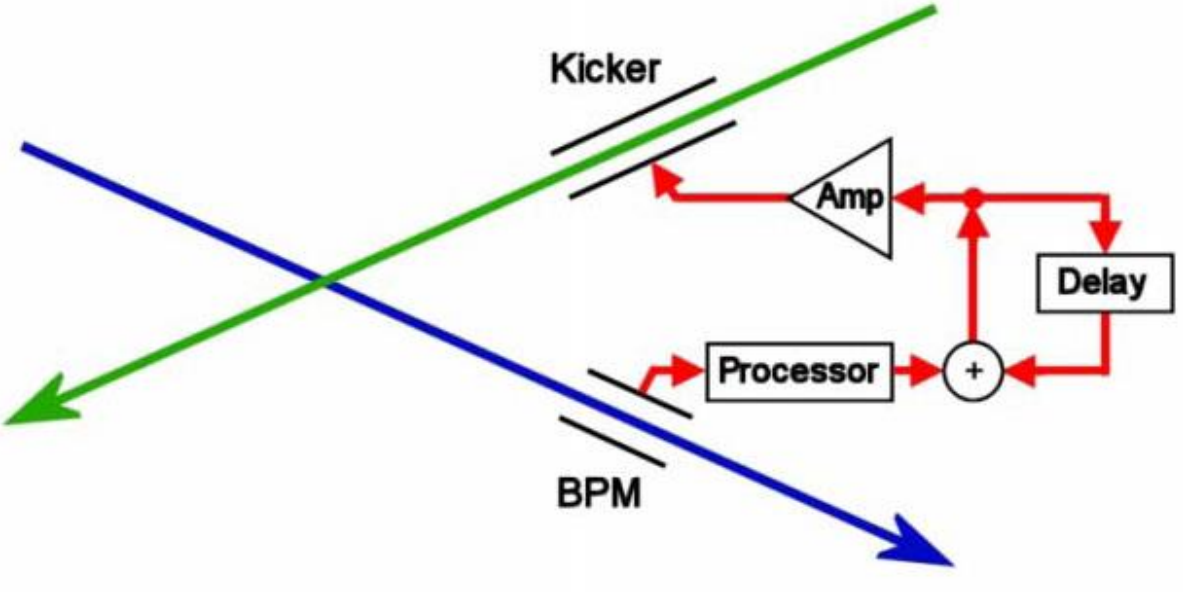
Javier Resta Lopez ***U. Valencia***

Outline

- Reminder of IP FB requirements
- FONT ILC + CLIC prototypes
- ATF2 IP FB concept
- Initial results

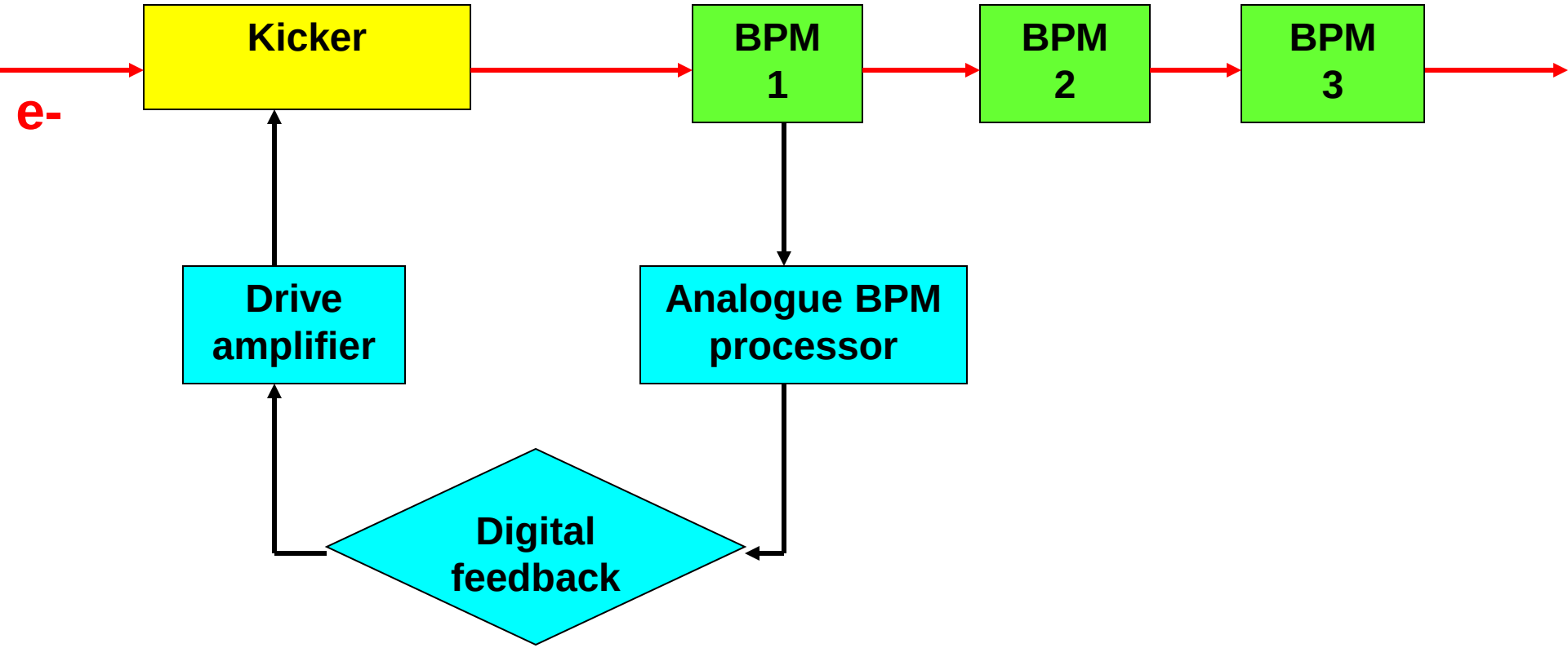
IP beam feedback concept

- 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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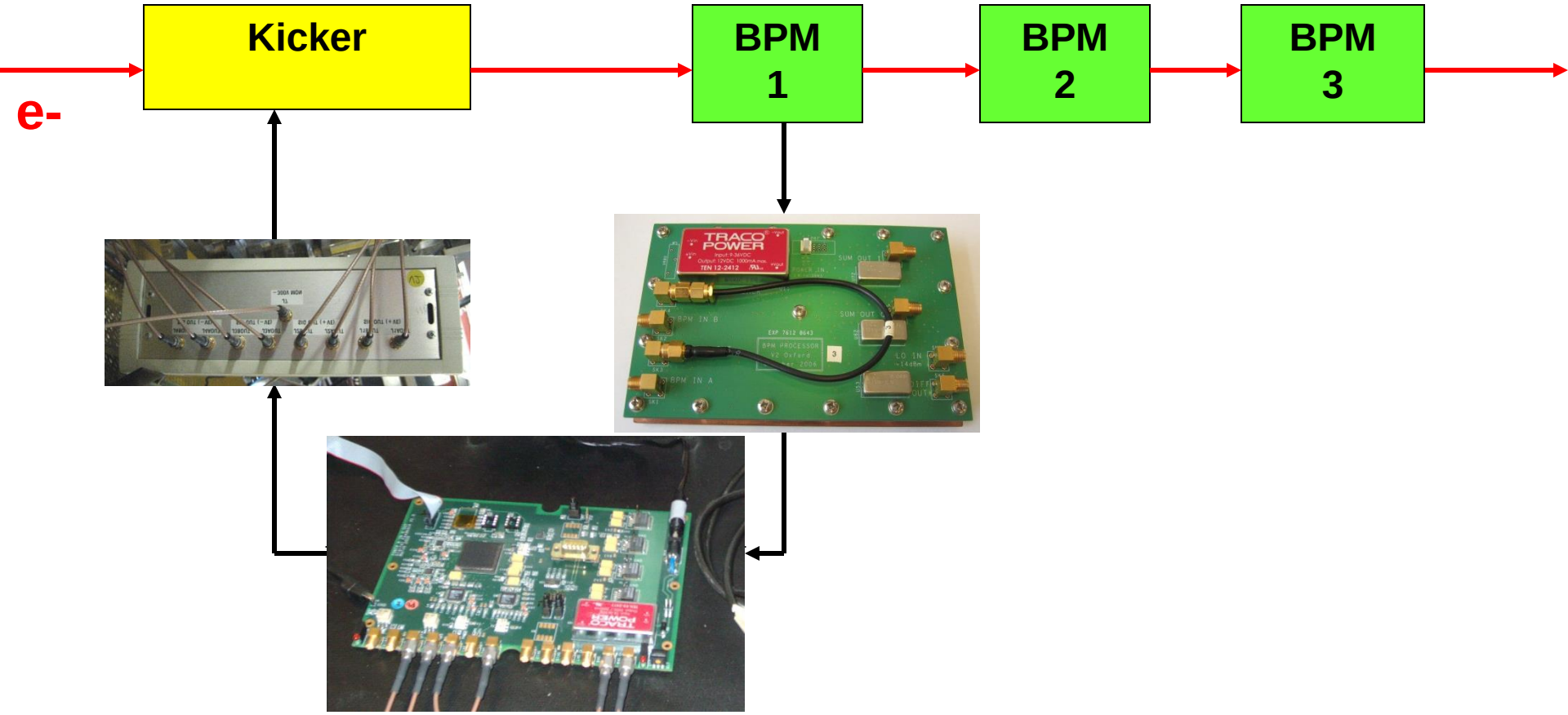

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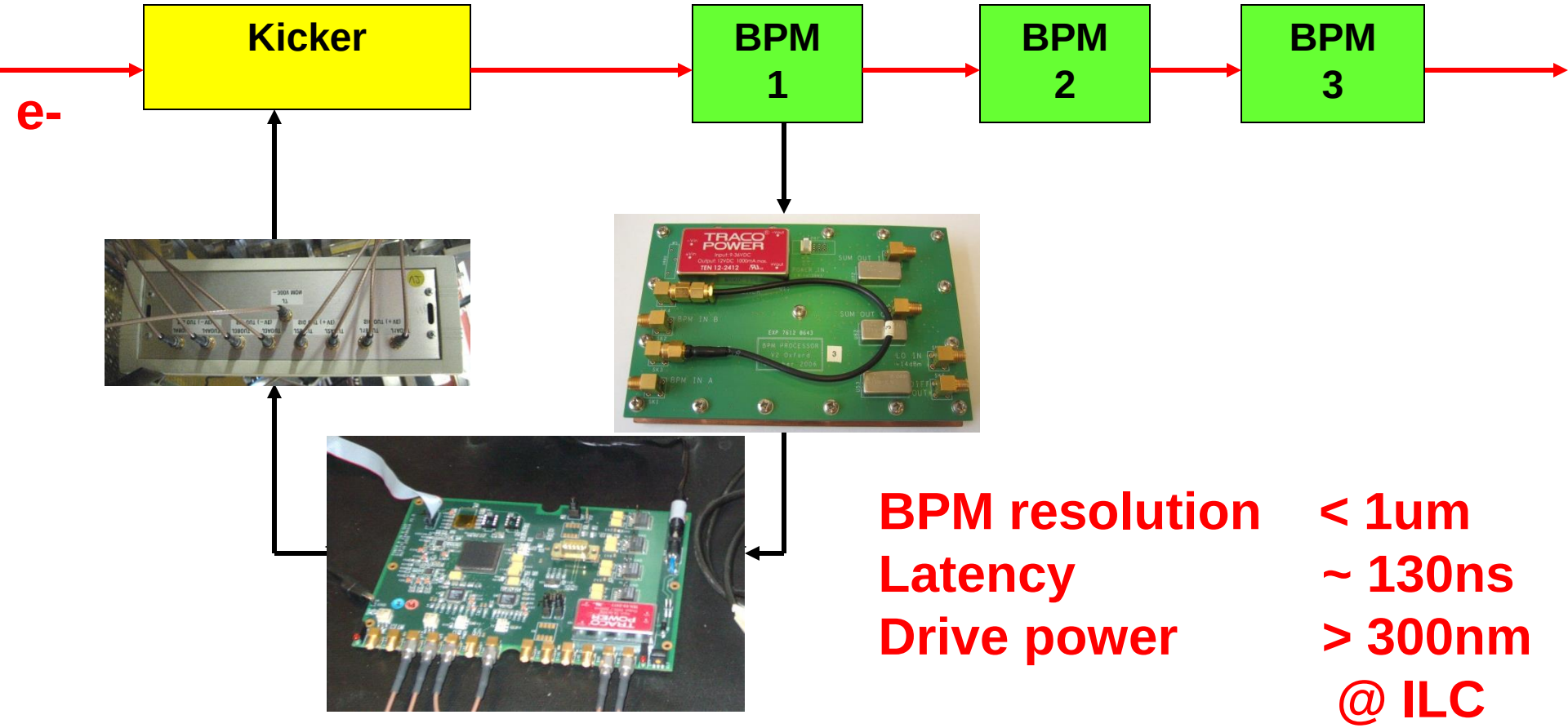
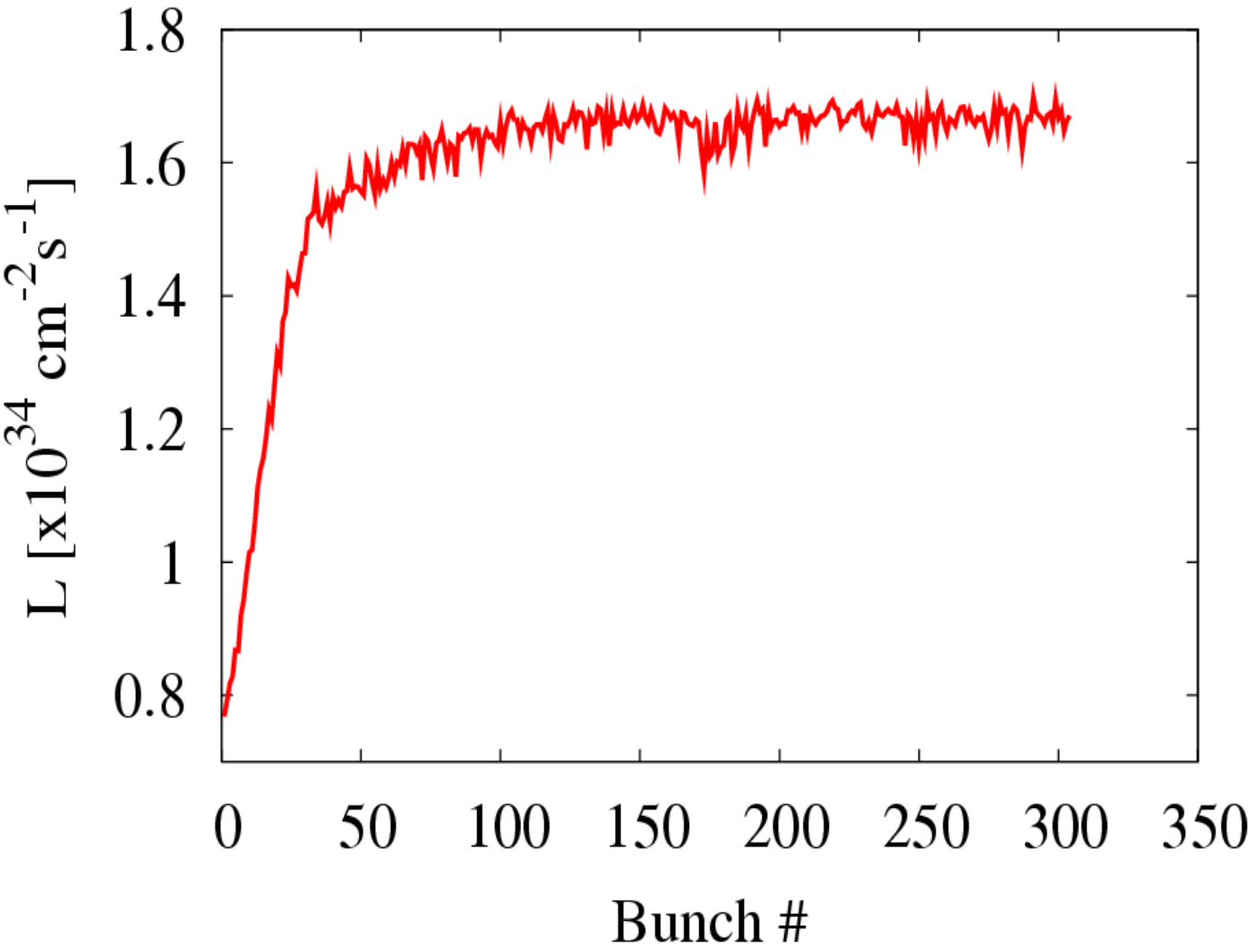


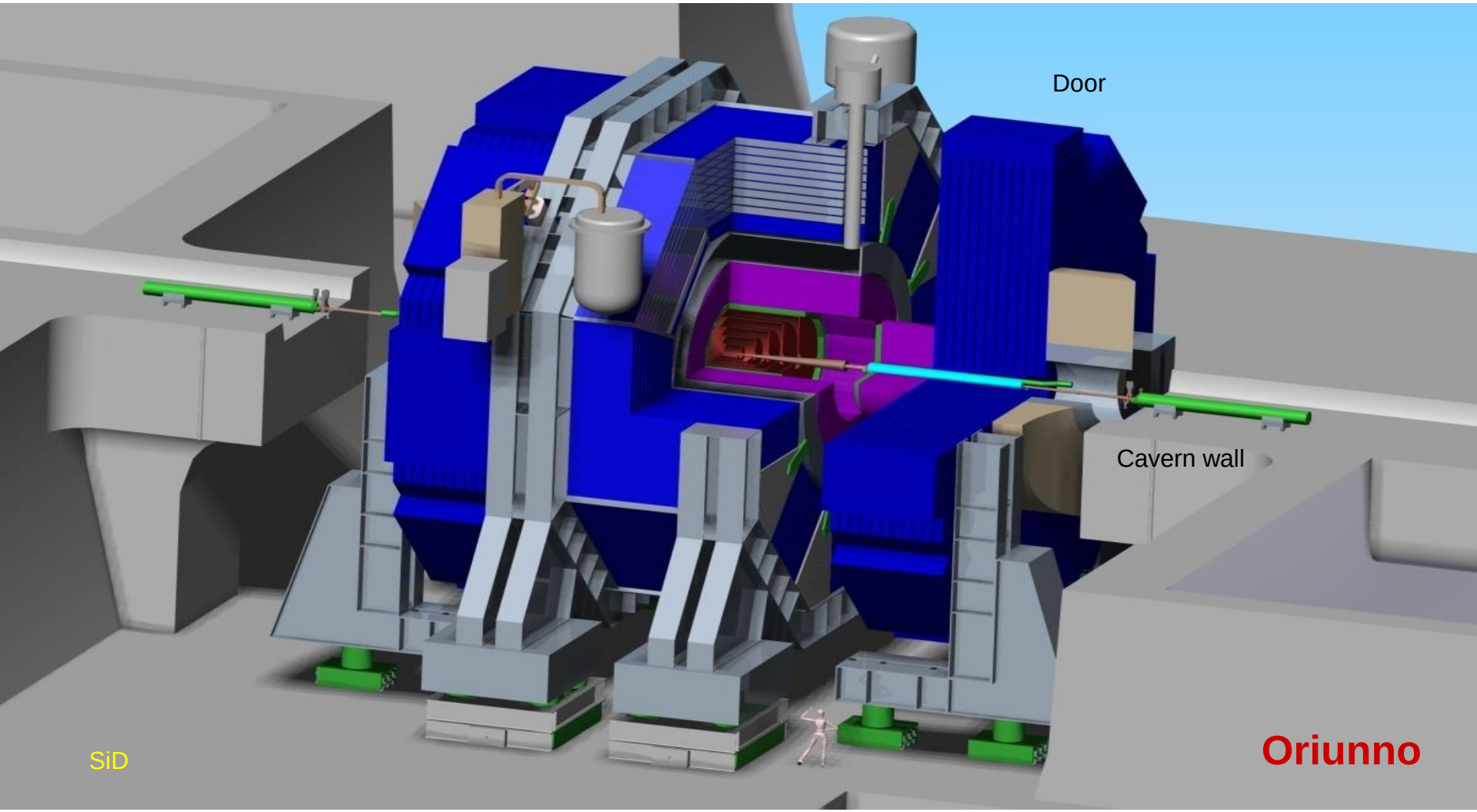
BPM resolution **< 1um**
Latency **~ 130ns**
Drive power **> 300nm @ ILC**

ILC IP FB performance

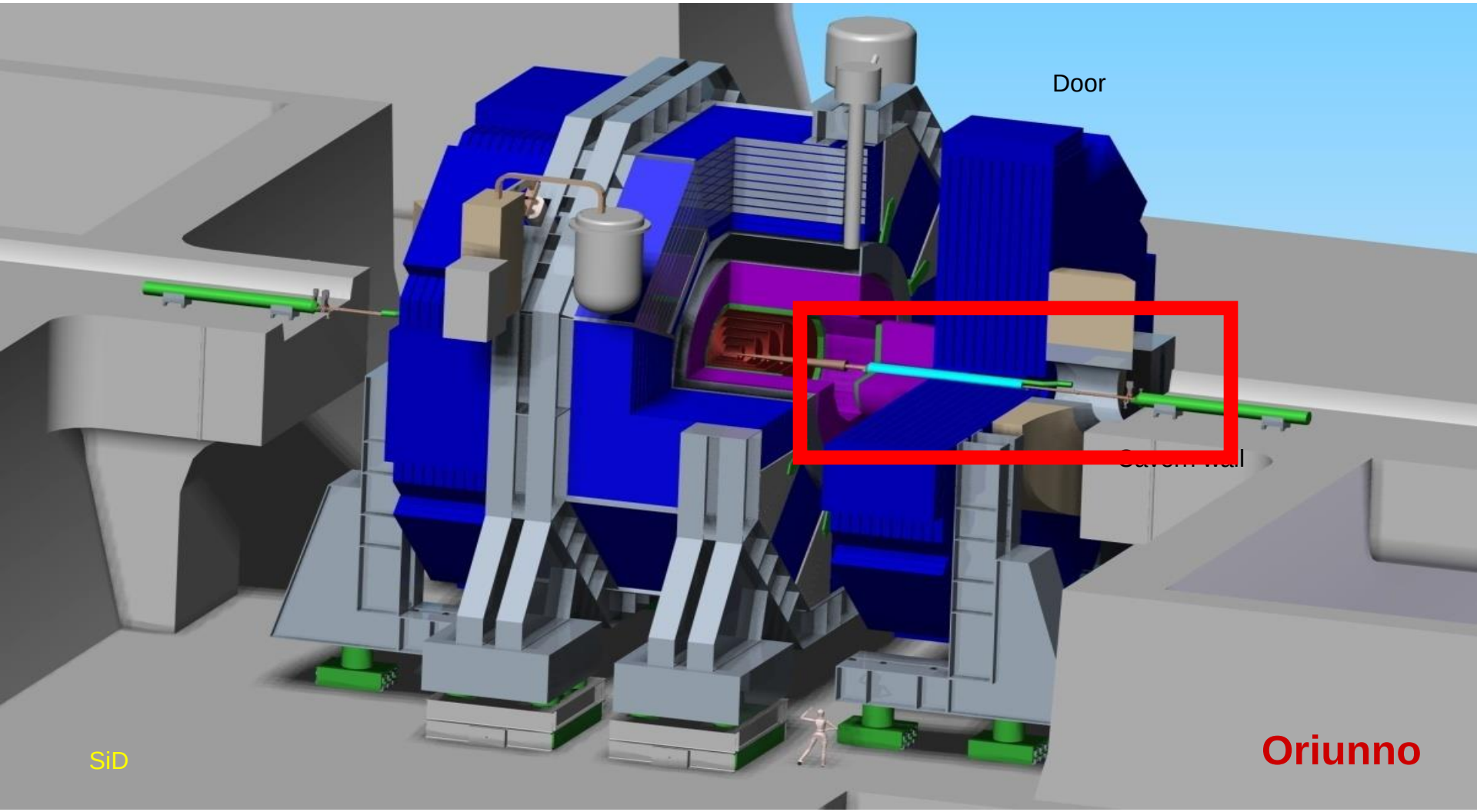


Resta Lopez

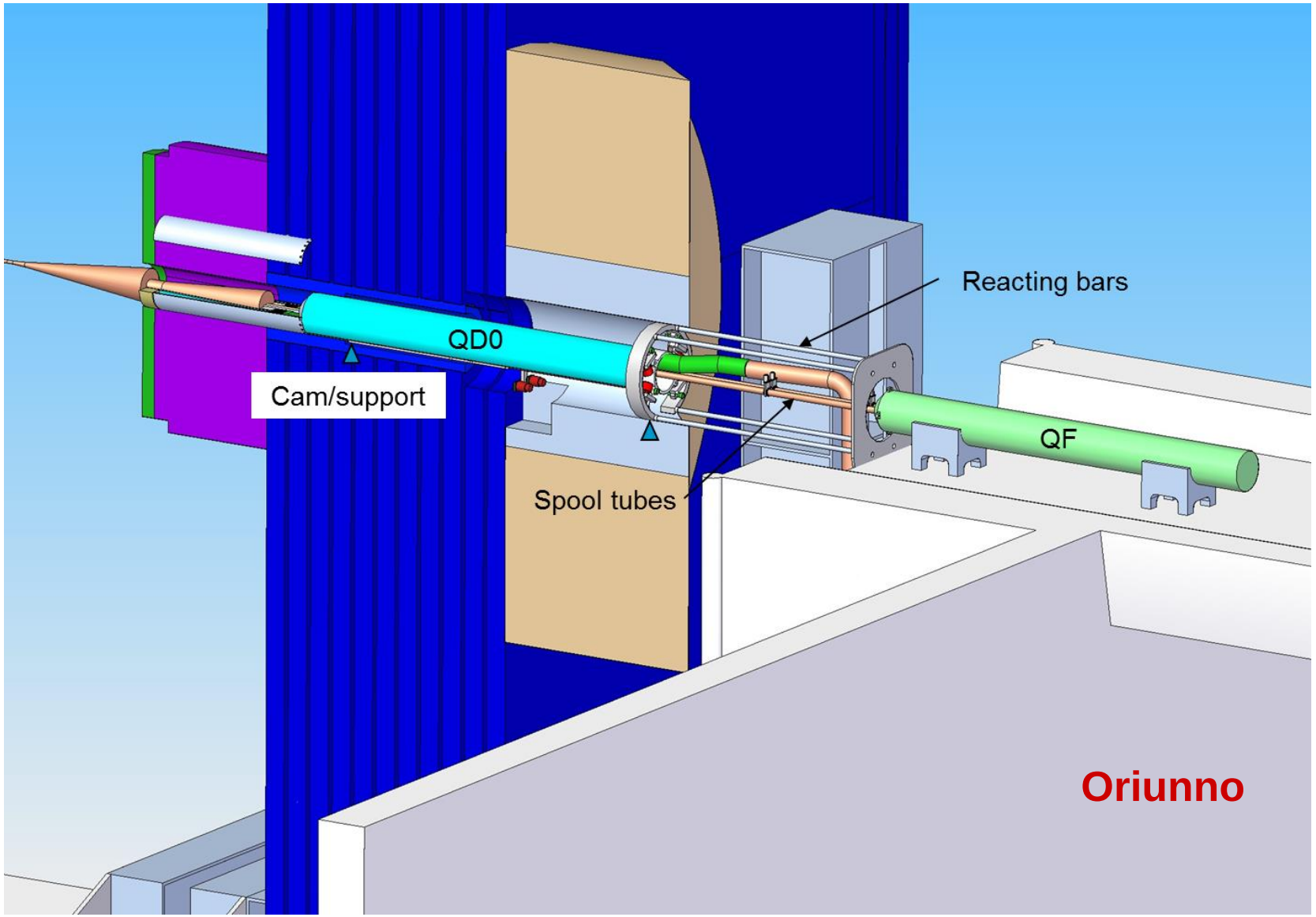
ILC IR: SiD for illustration



ILC IR: SiD for illustration



Final Doublet Region (SiD)



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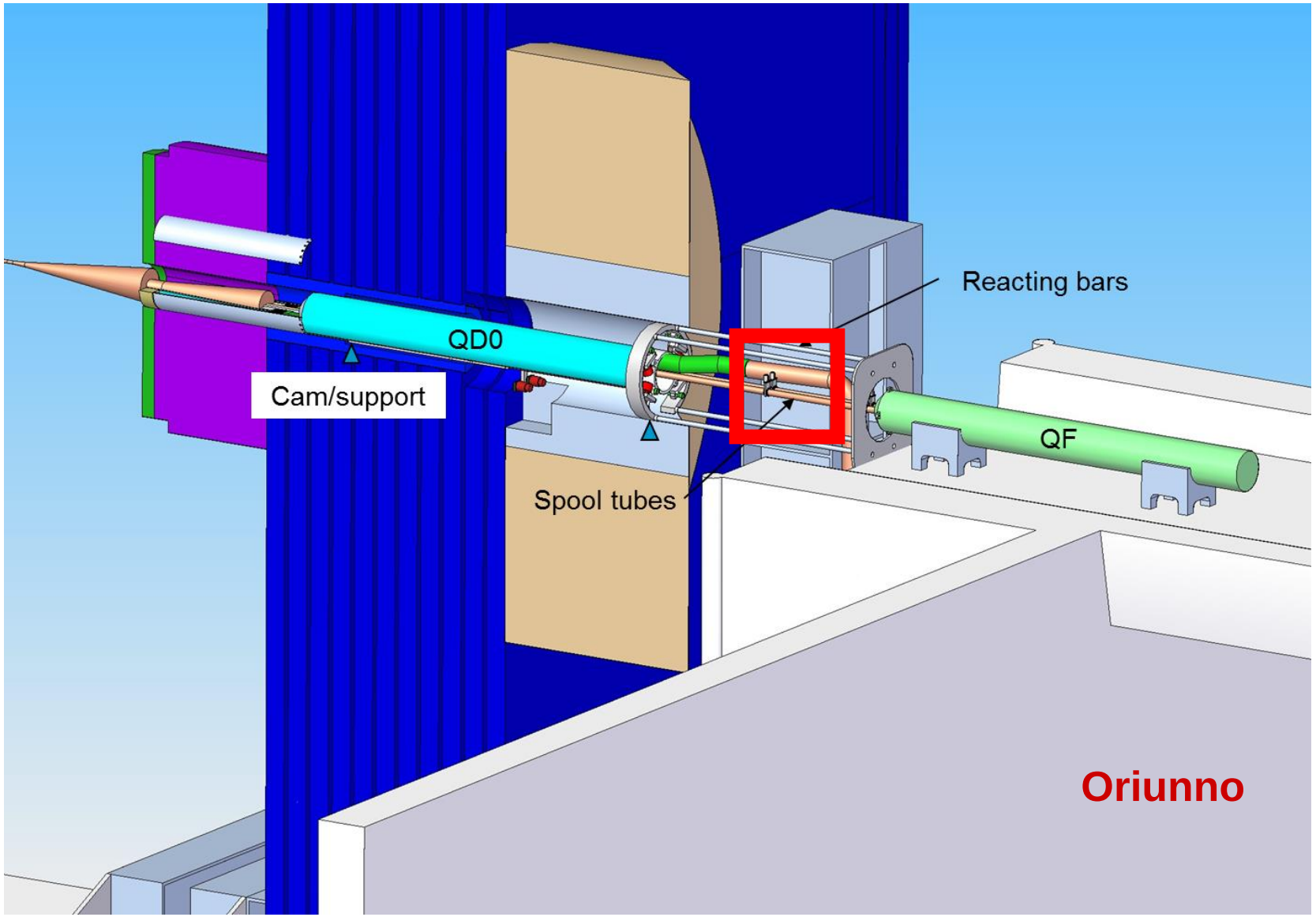

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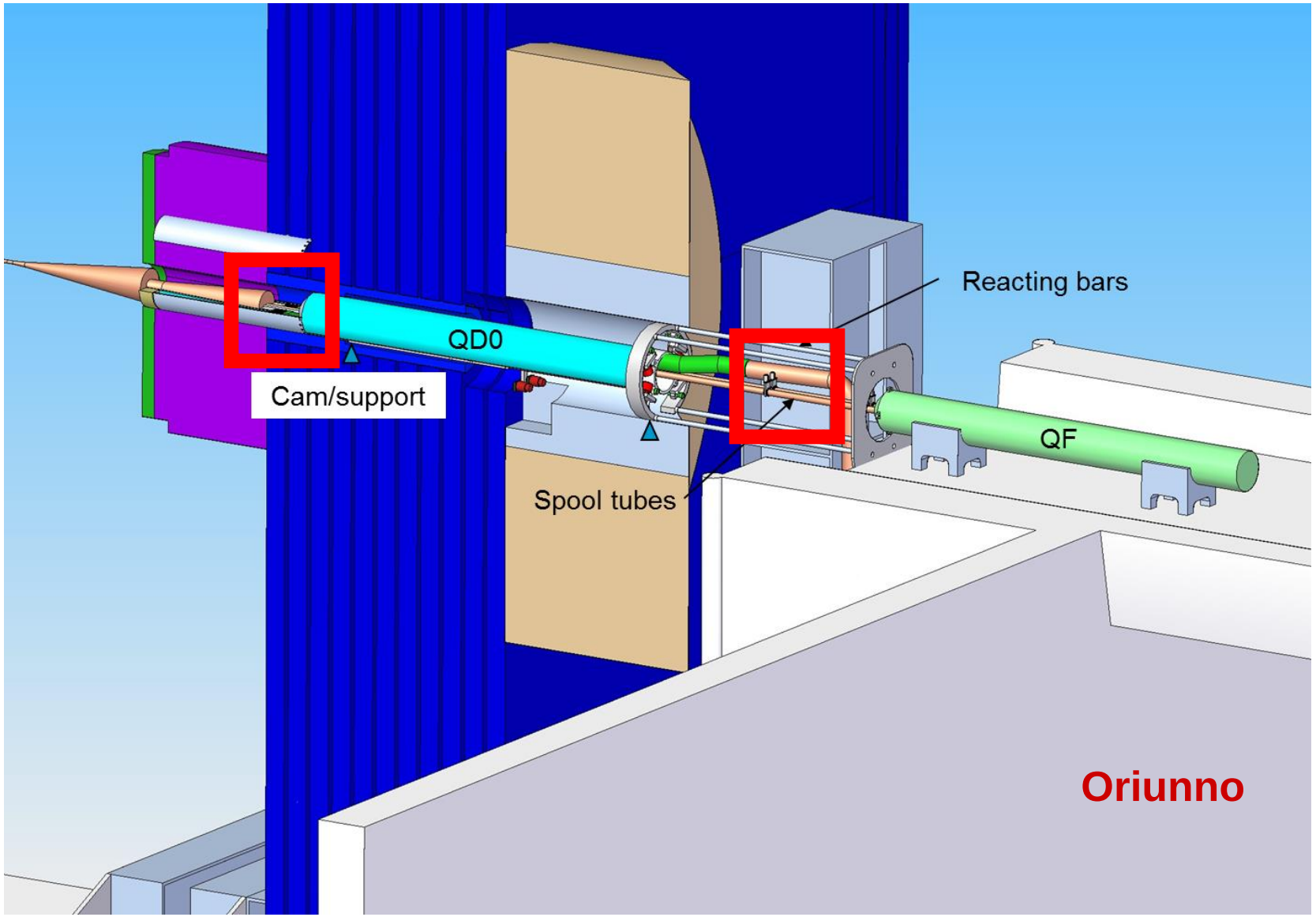

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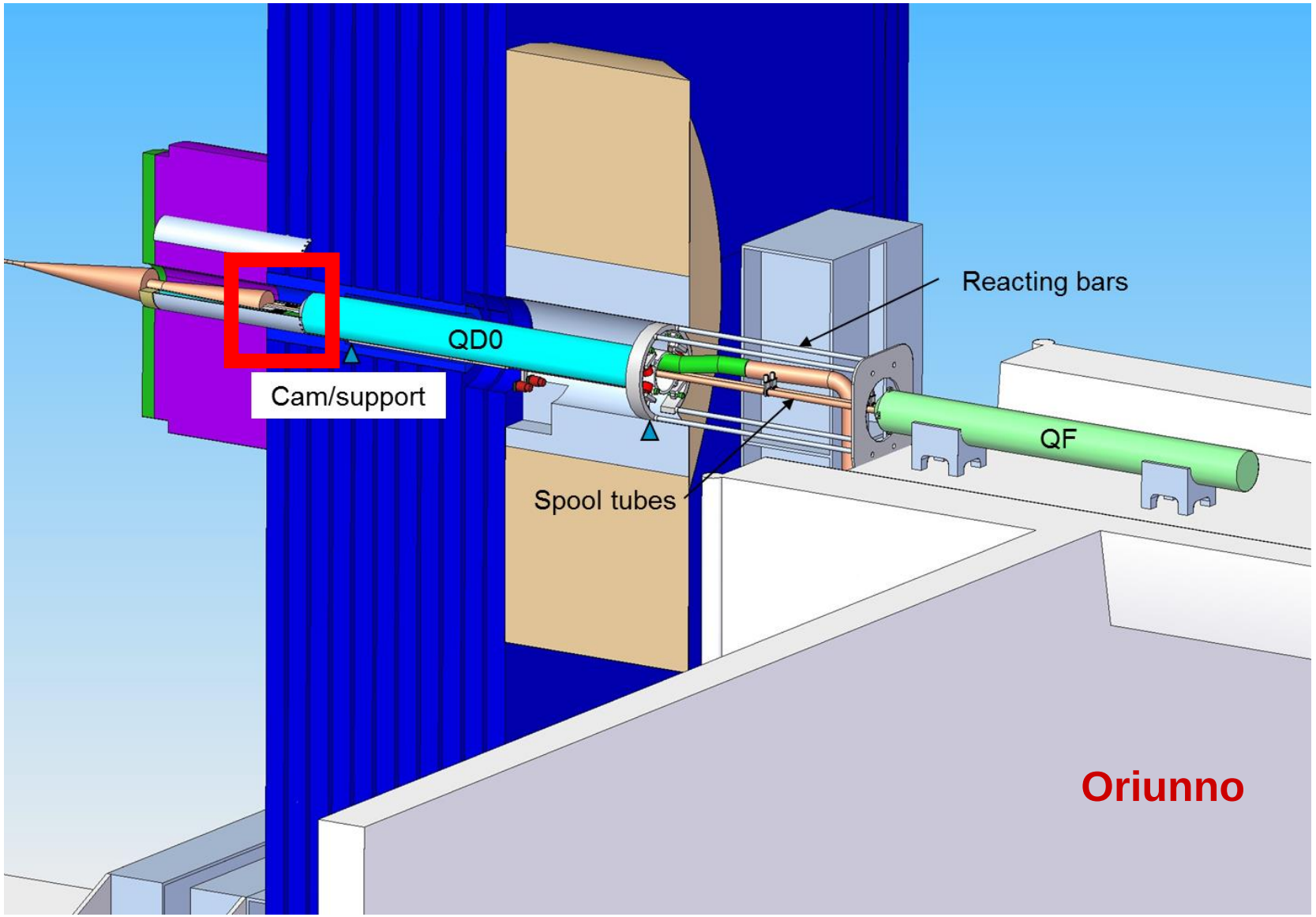
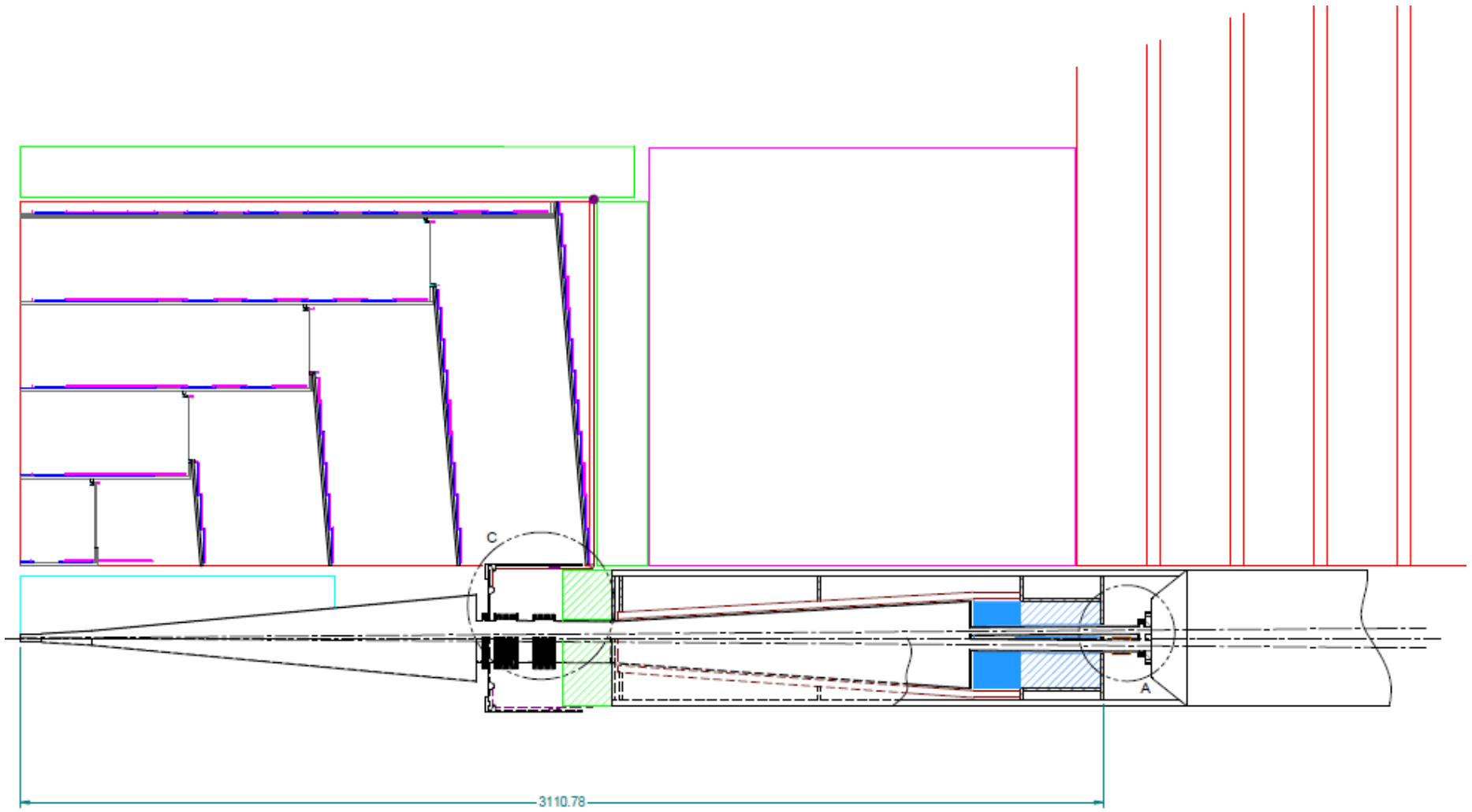
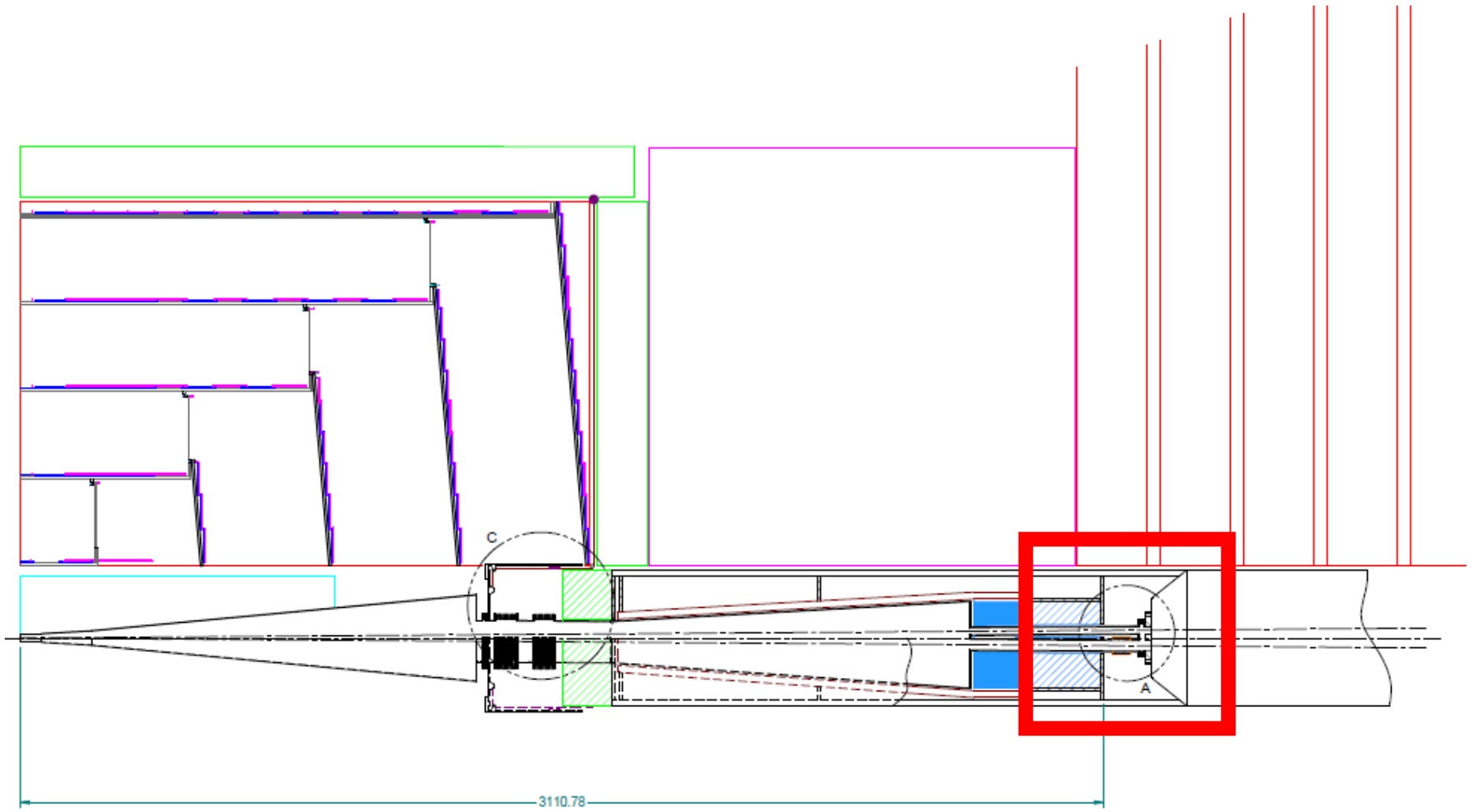


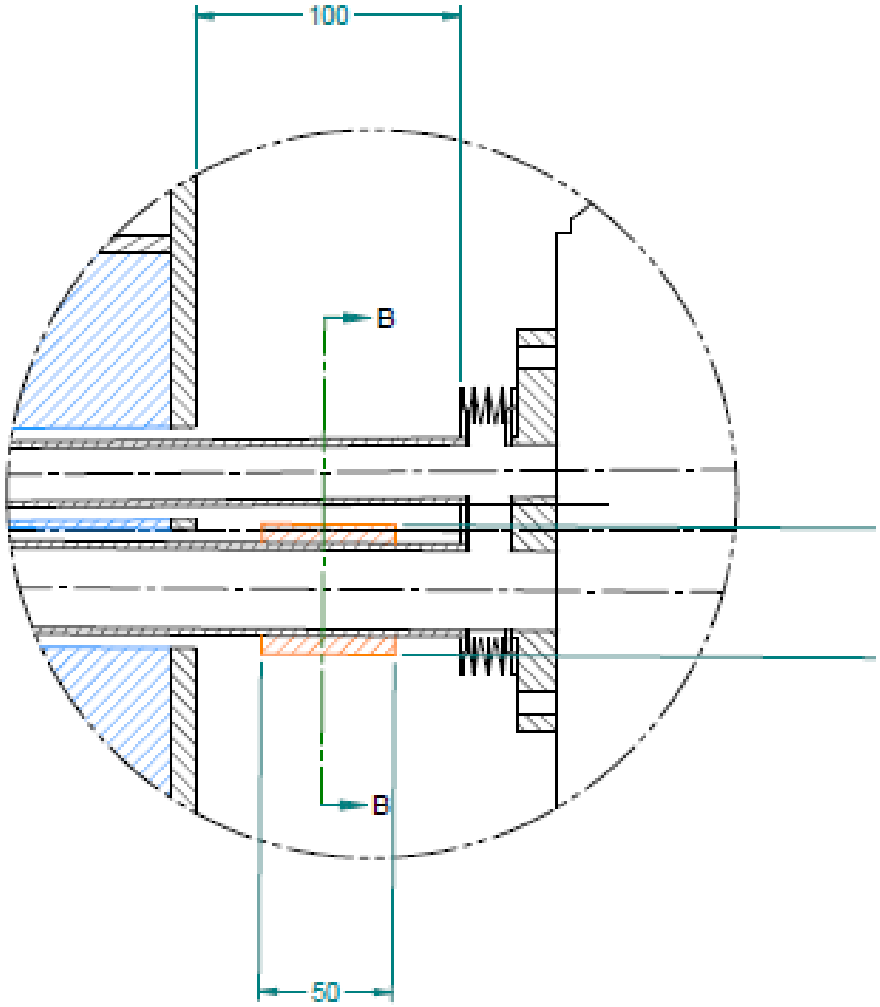
IP Region (SiD)



IP Region (SiD)

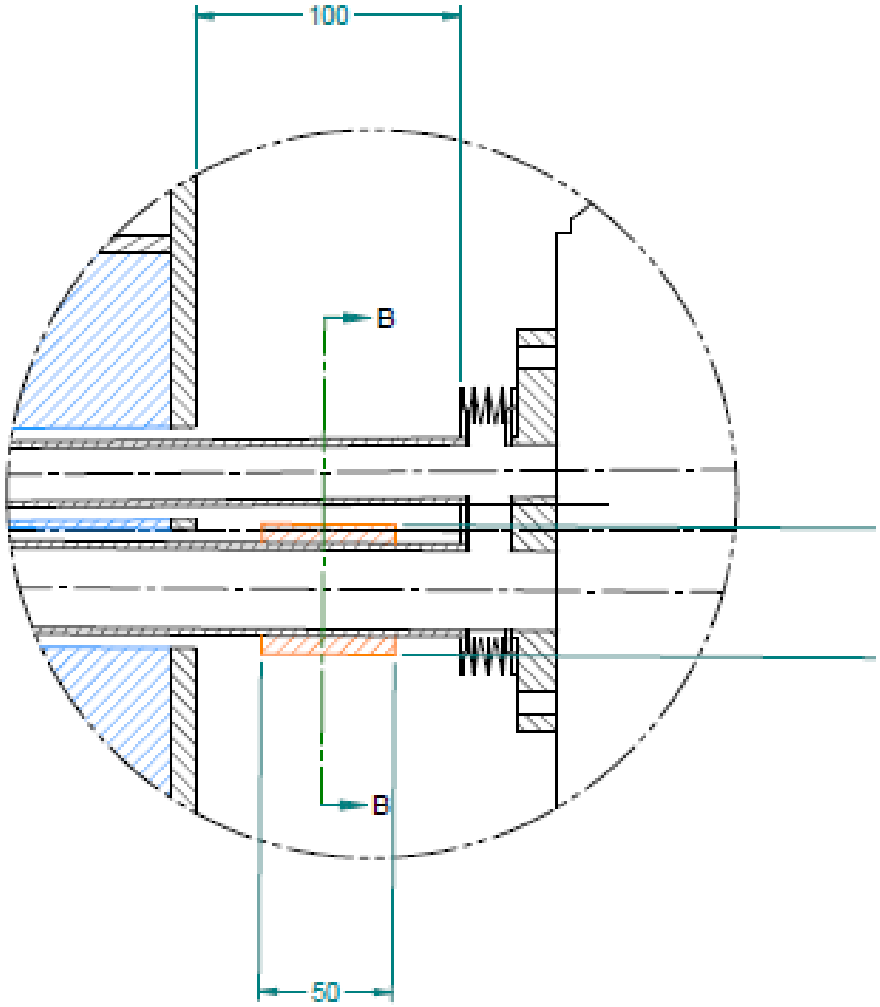


Beamcal – QD0 Region (SiD)



DETAIL A
SCALE 4:1

IP FB BPM Detail (SiD)



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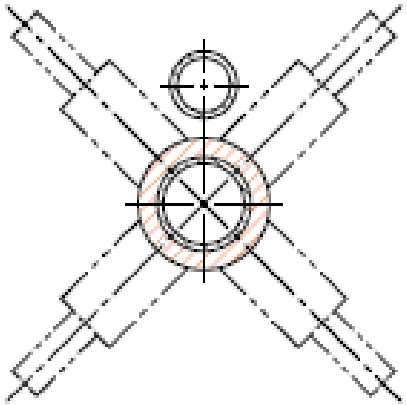
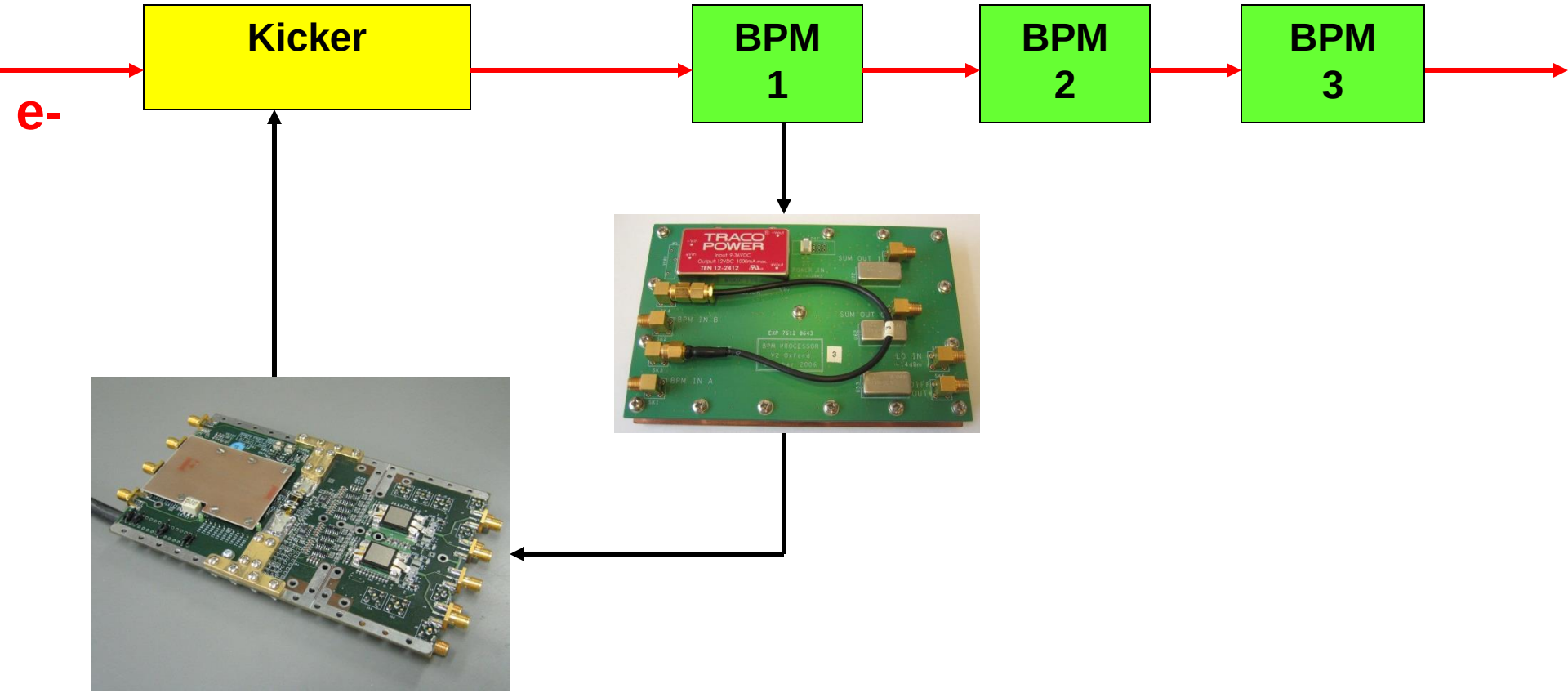


SECTION B-B
SCALE 4:1

Smith

CLIC prototype: FONT3 at KEK/ATF



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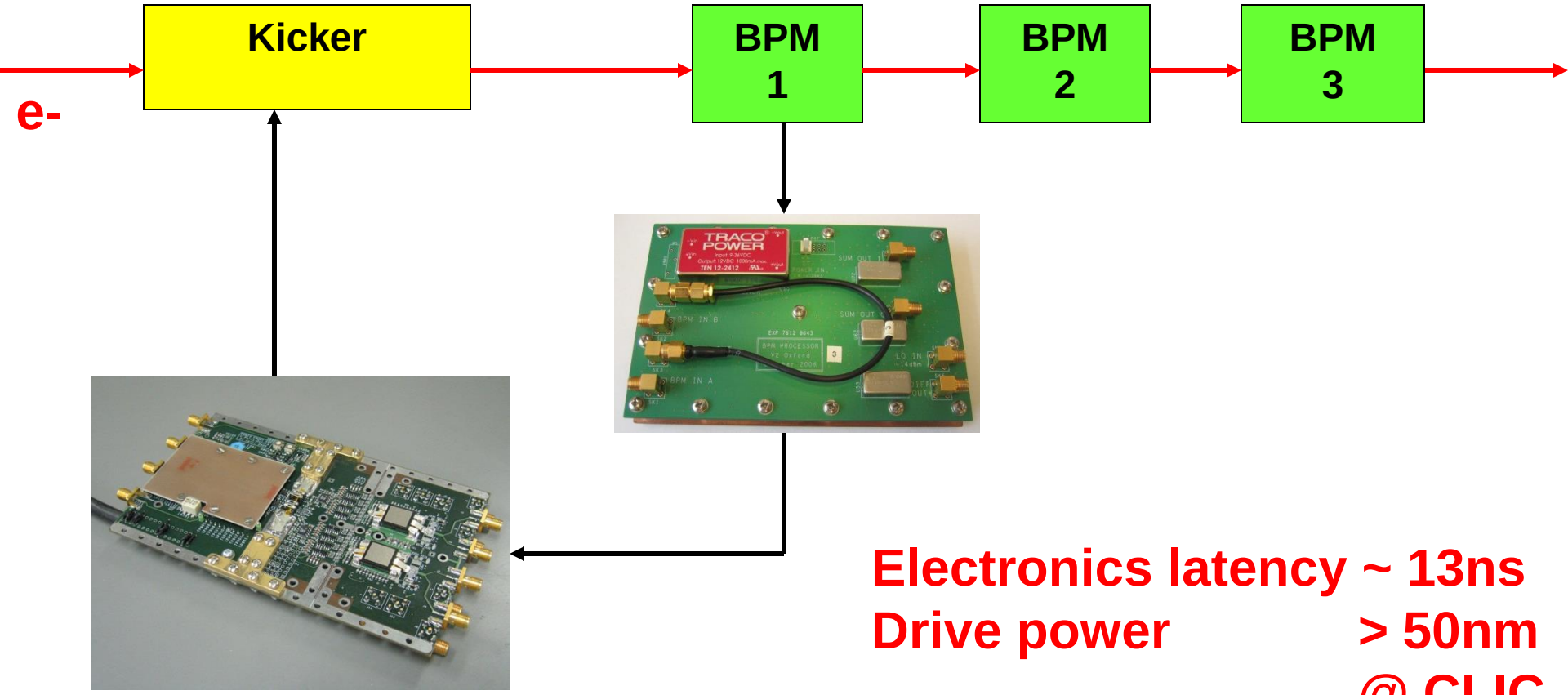
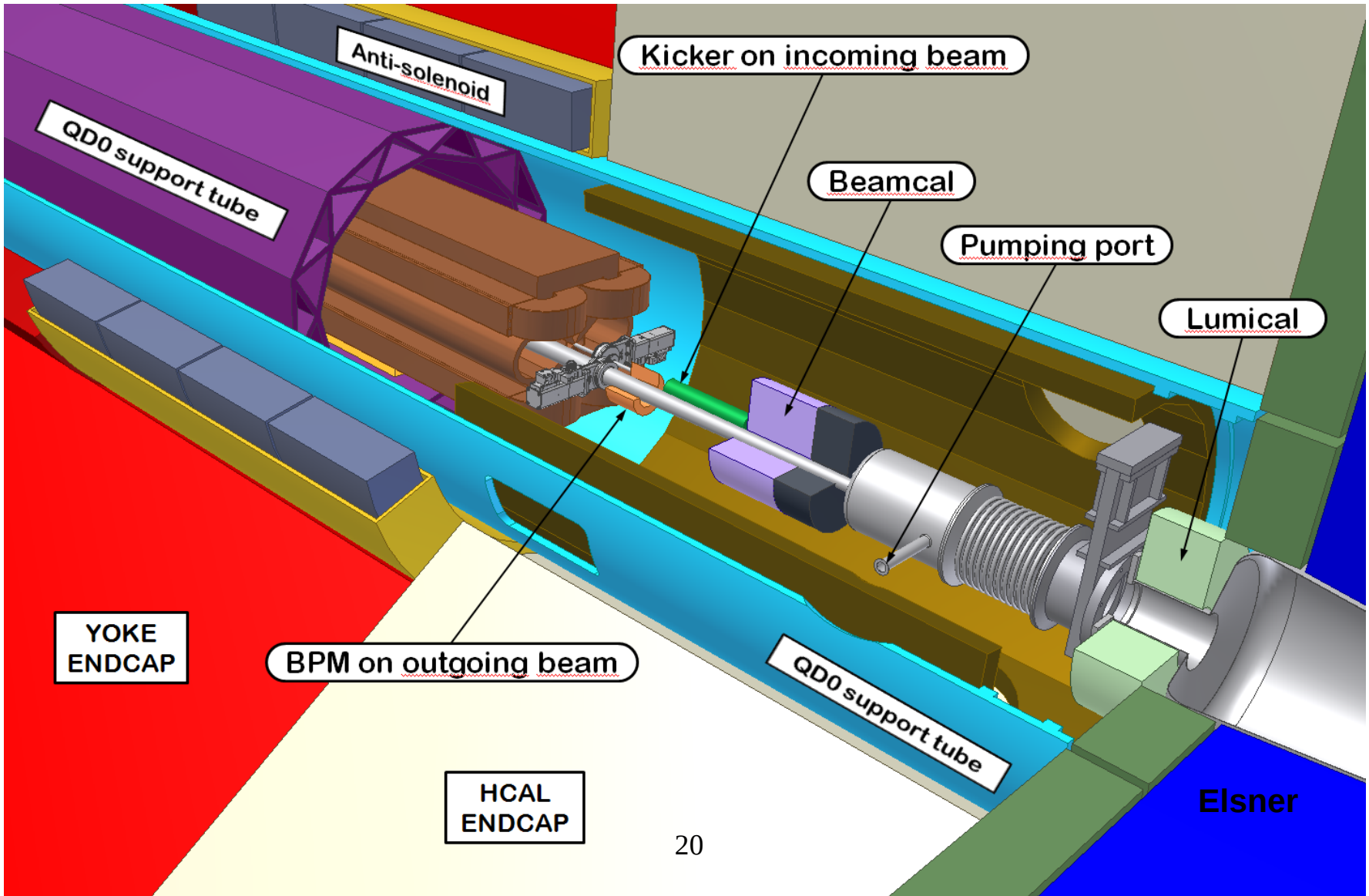


Electronics latency ~ 13ns
Drive power > 50nm @ CLIC

CLIC Final Doublet Region



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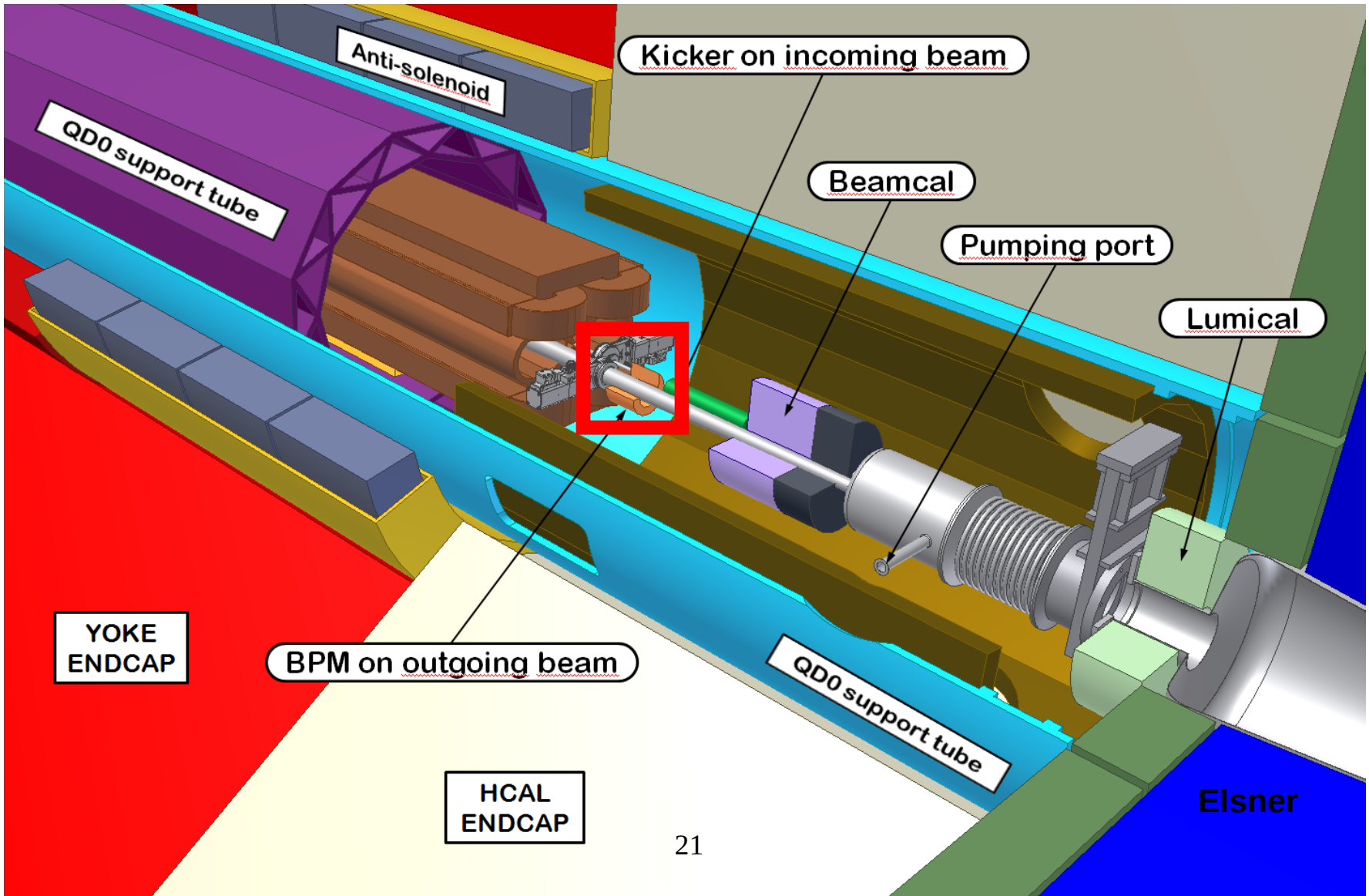
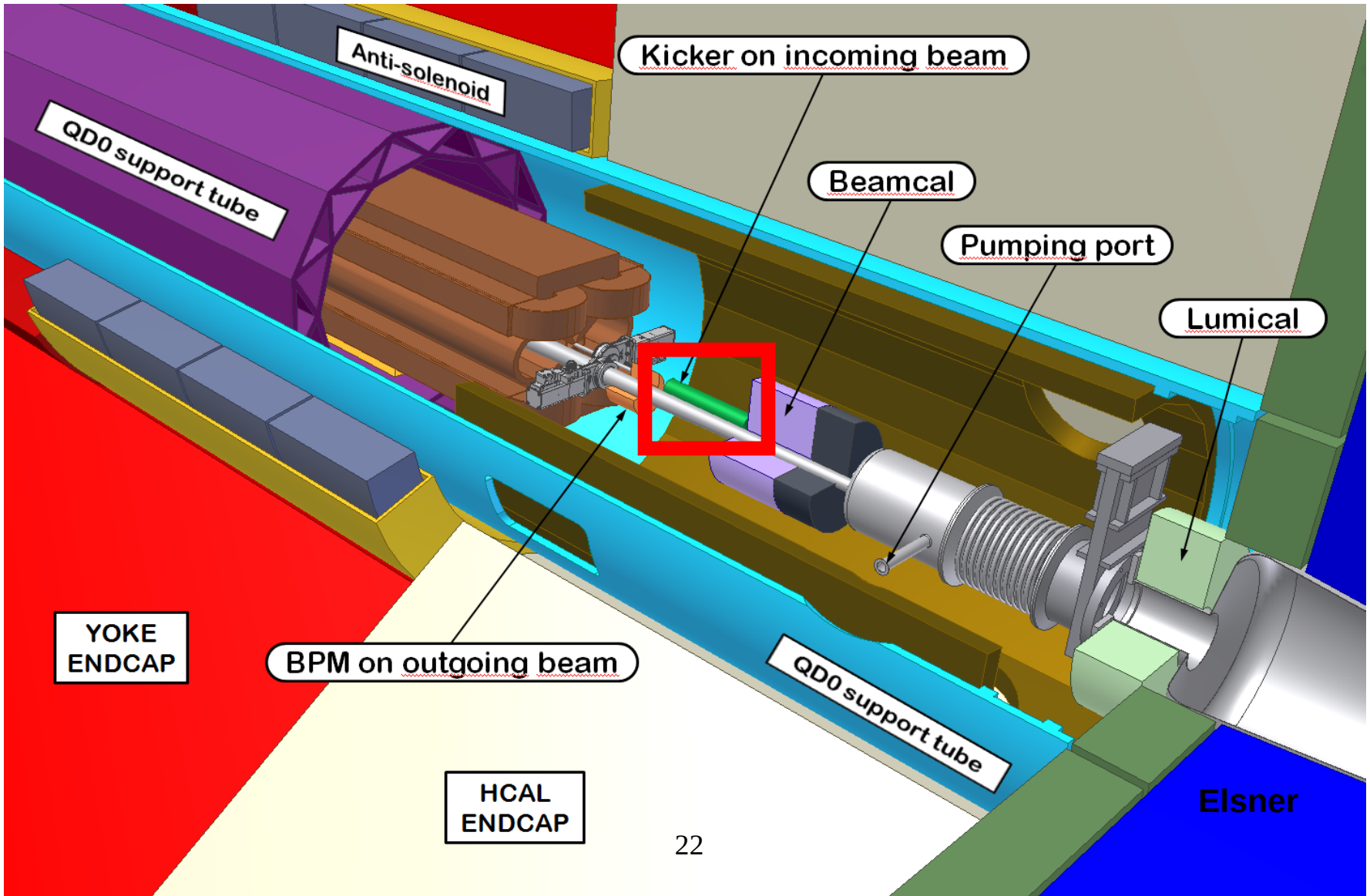
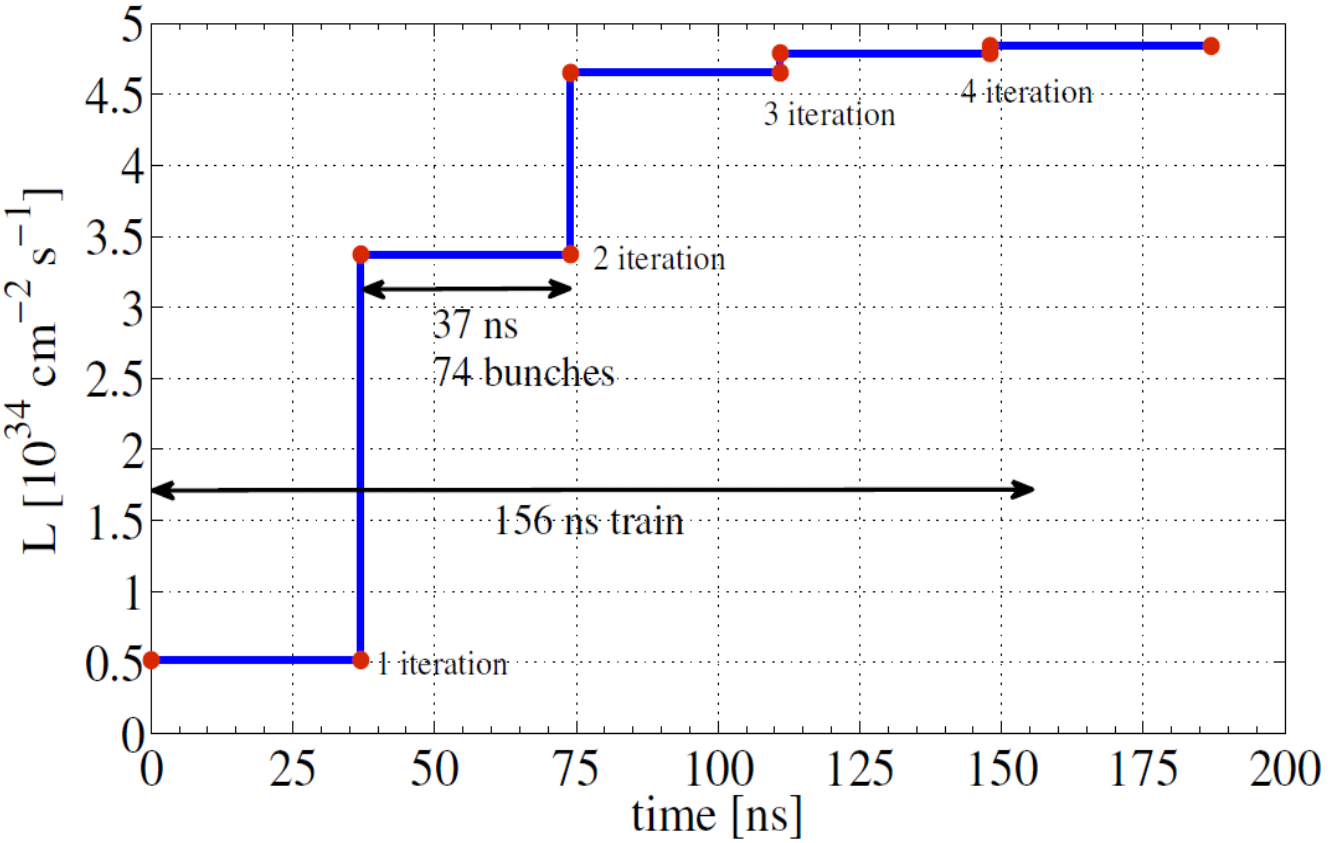


CLIC Final Doublet Region



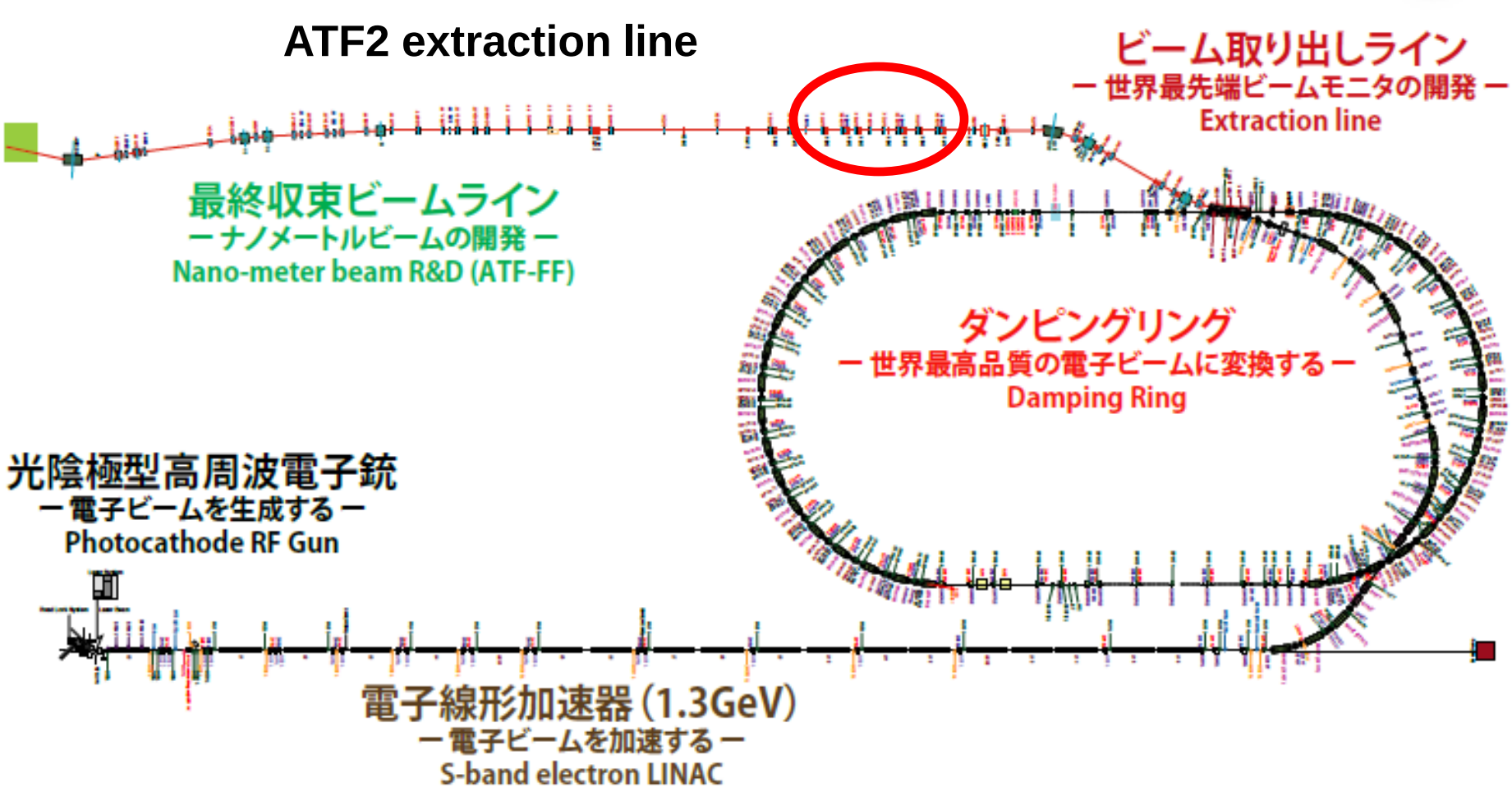
CLIC IP FB performance

Single random seed of GM C

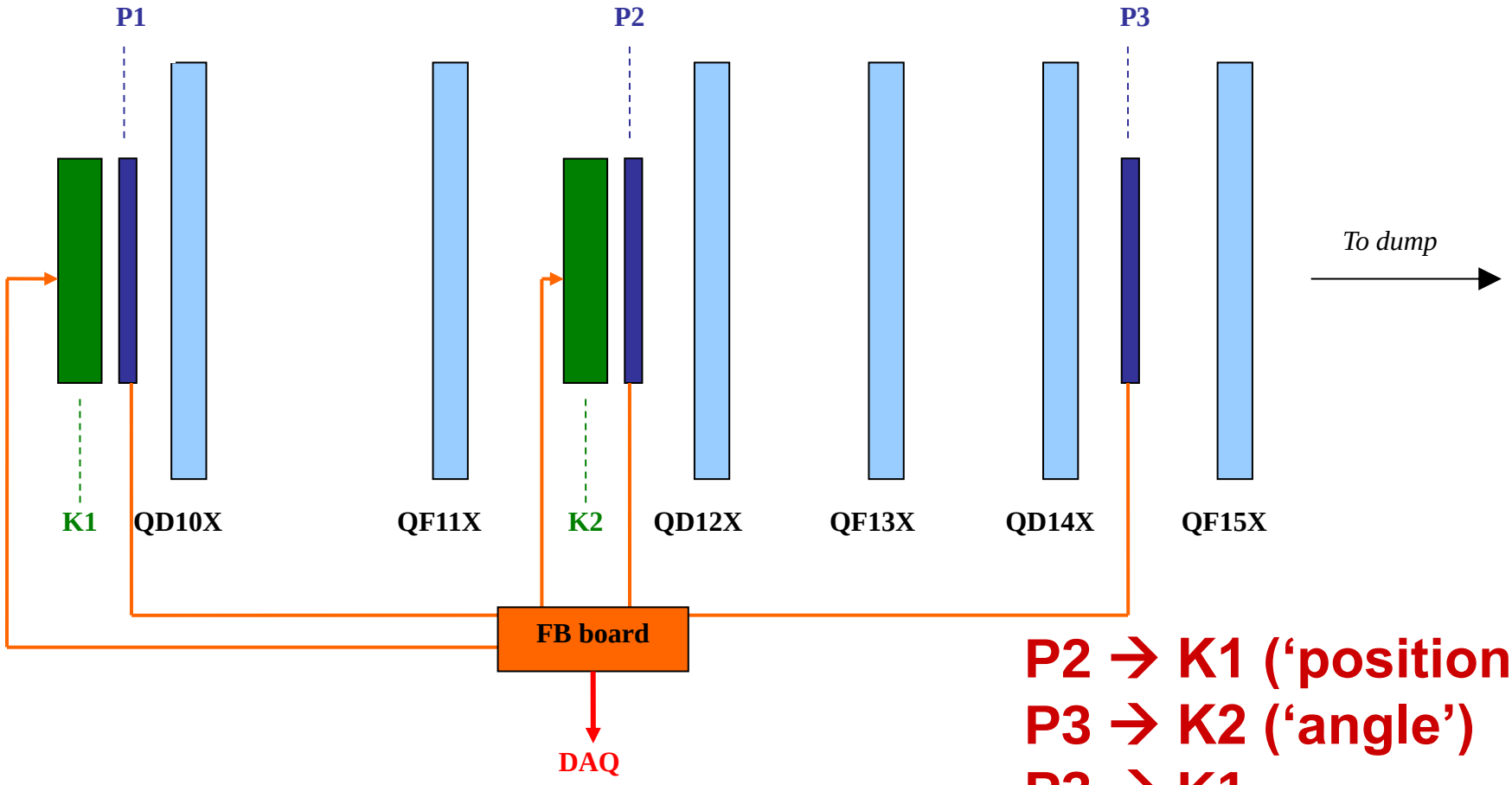


Resta Lopez

FONT5 location



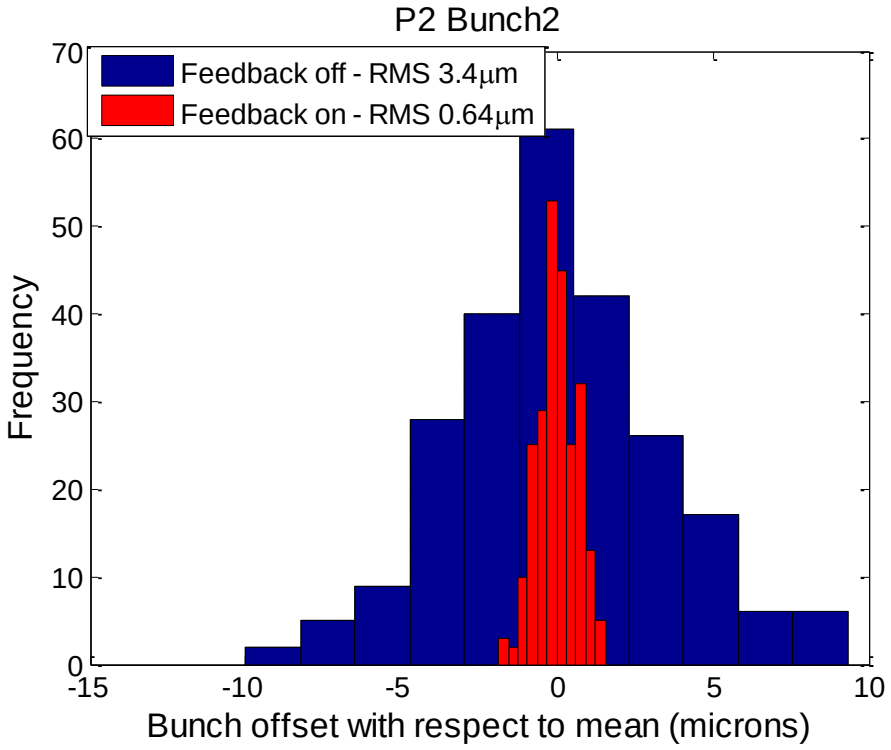
FONT5 setup

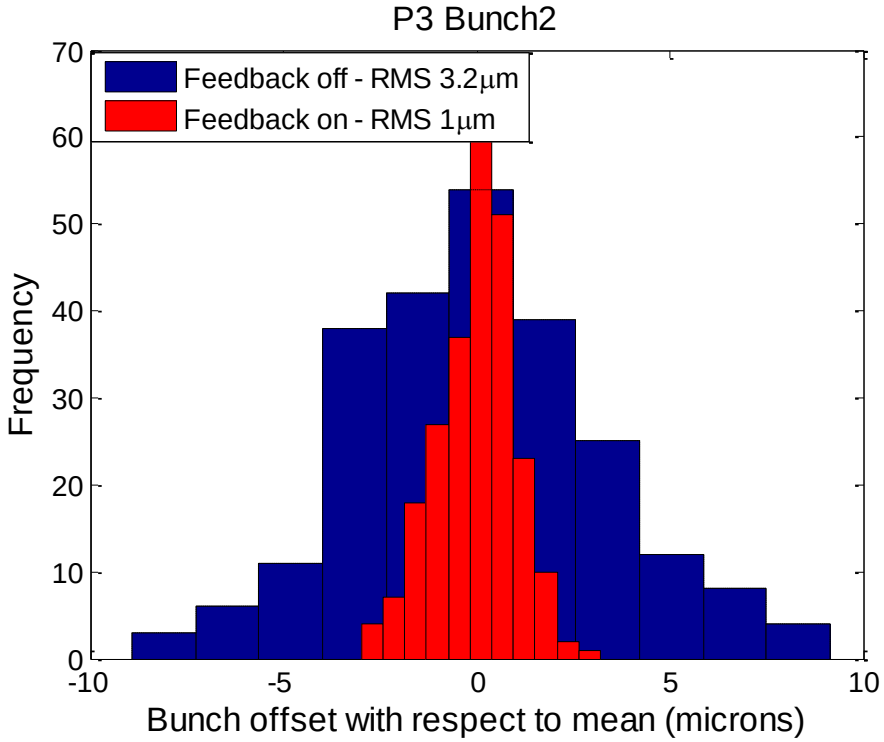


P2 → K1 ('position')
P3 → K2 ('angle')
P3 → K1
P2 → K2

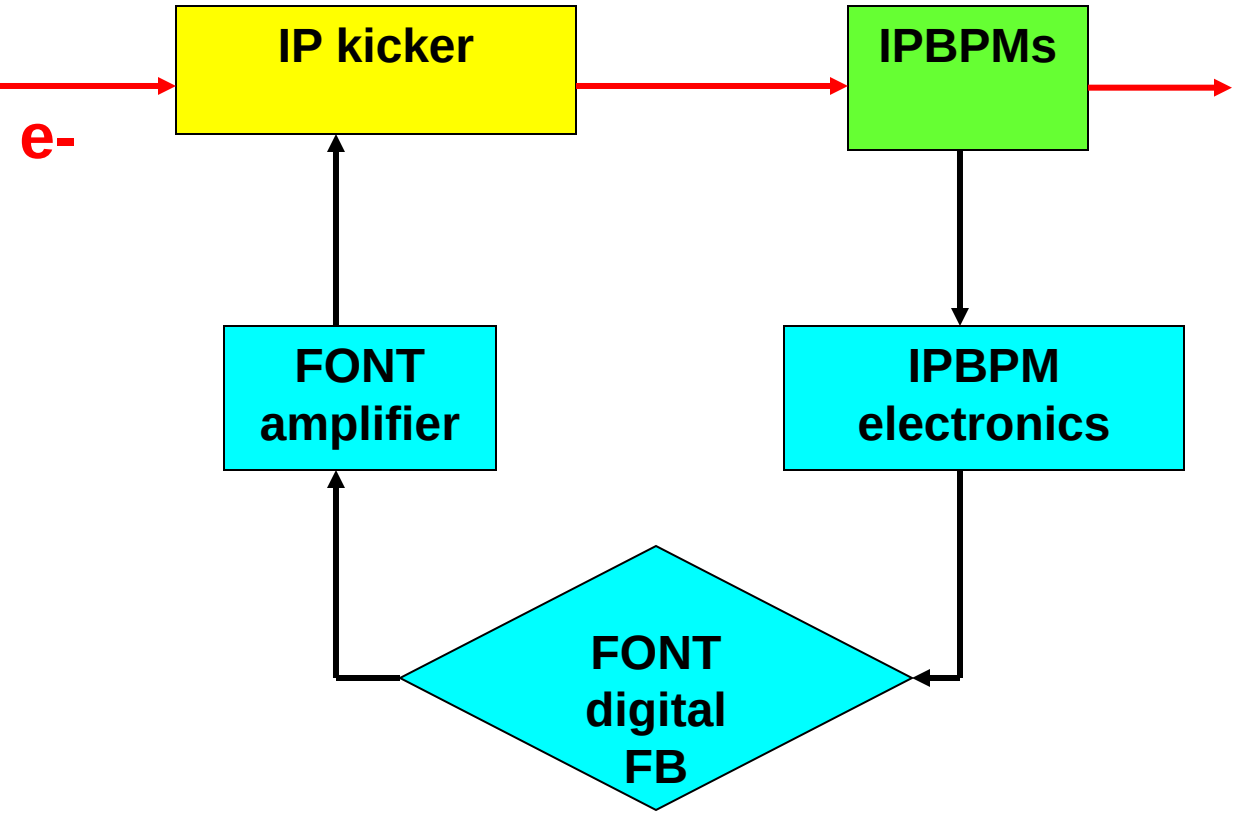
Feedback Performance

(example FB Run 6 13/12)





ATF2 IP FB loop scheme



General Issues for IPFB at ATF2

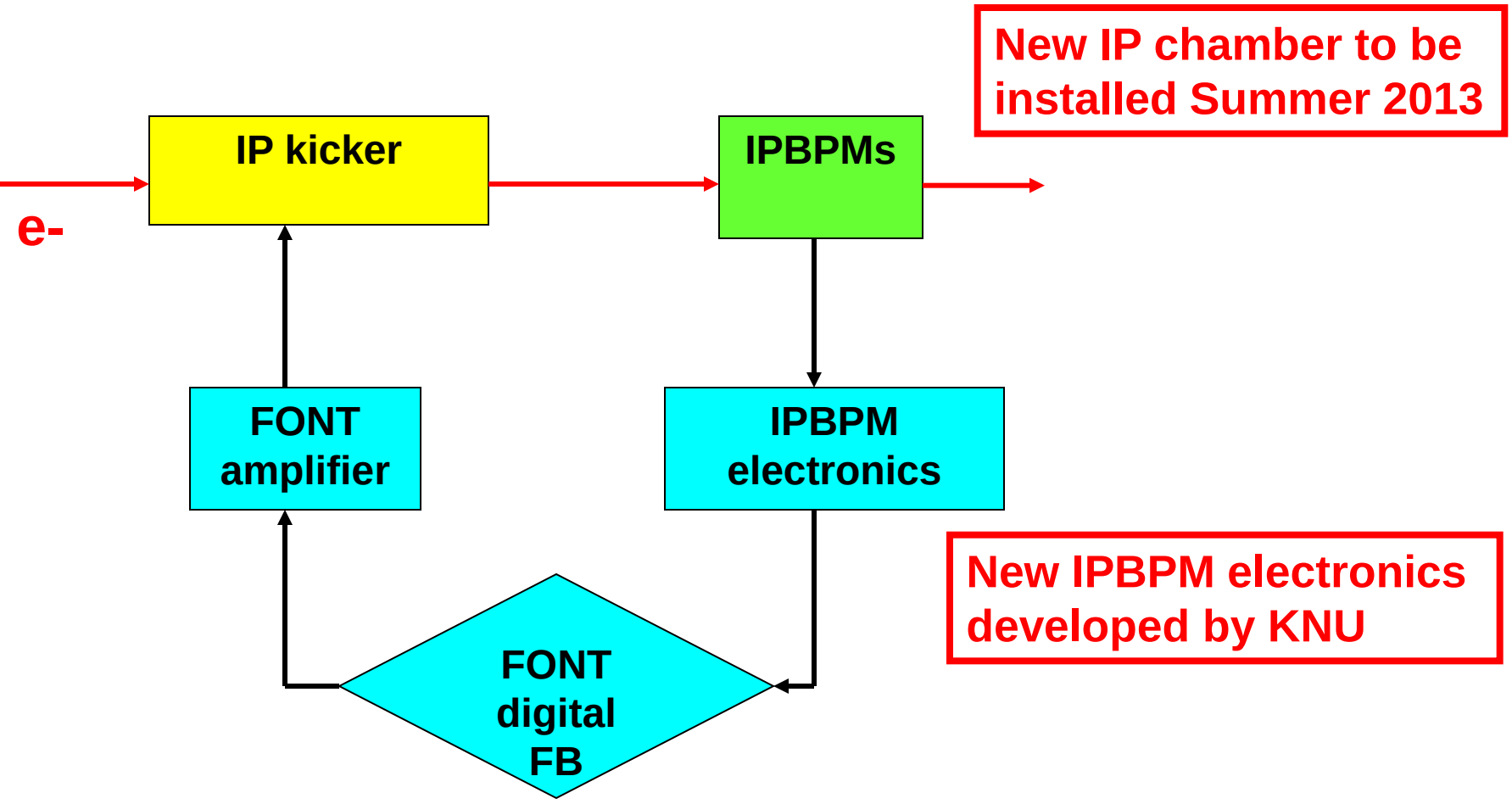
- **Much harder than IPFB at ILC!**
- **Only 1 beam → must measure beam position directly**
- **nm-level stabilisation requires nm-level position meas.**

  → Cavity BPMs (rather than striplines)
- **Cavities intrinsically slow, signal processing complicated**
- **Cavities required to resolve 2 bunches within << 300ns**

  → Low-Q cavities and low-latency signal processing

  → KNU group, new IP chamber (LAL)

ATF2 IP FB loop scheme



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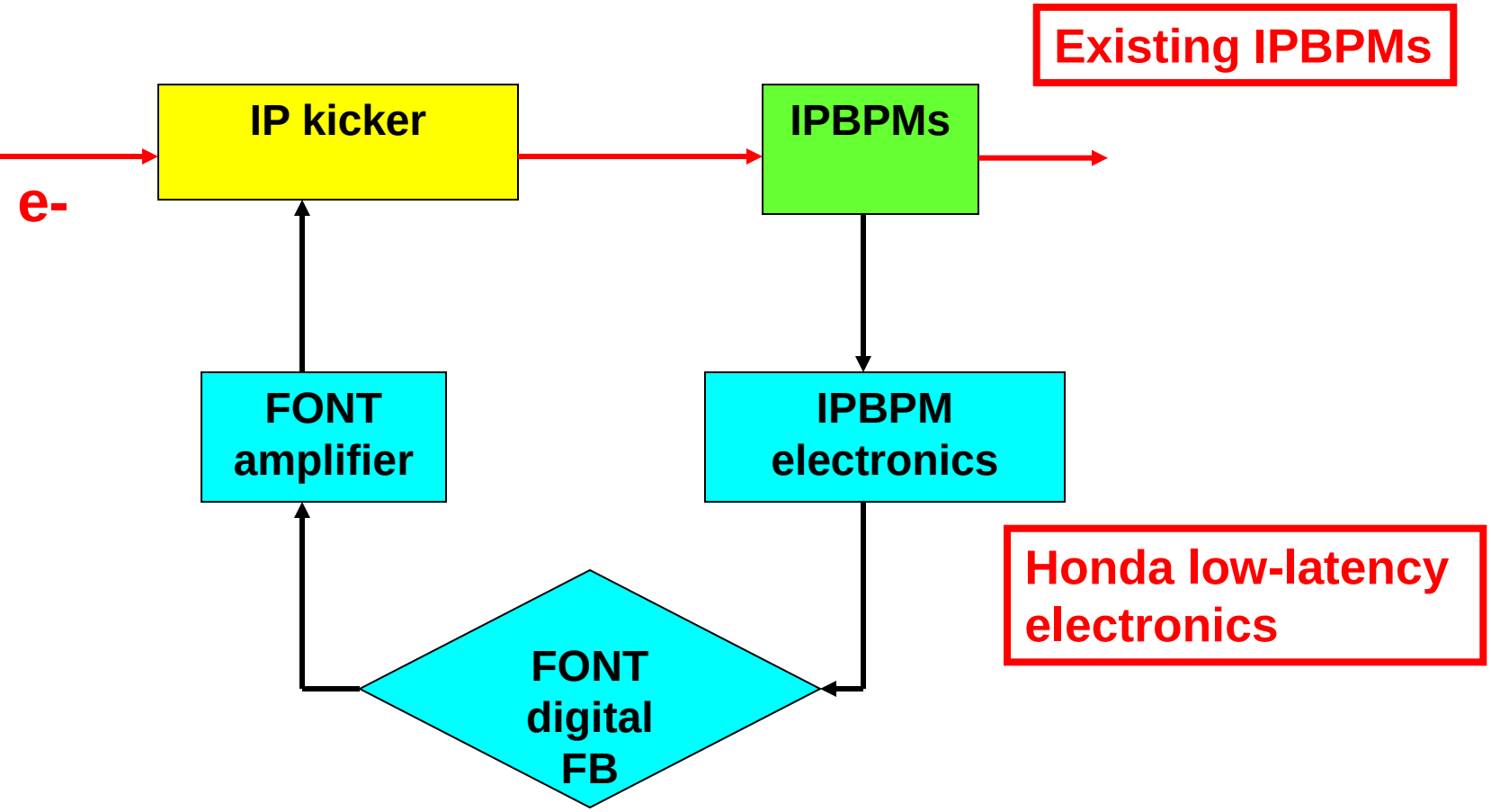
  → KNU group, new IP chamber (LAL)
- **We decided to make preparations with existing hardware …**

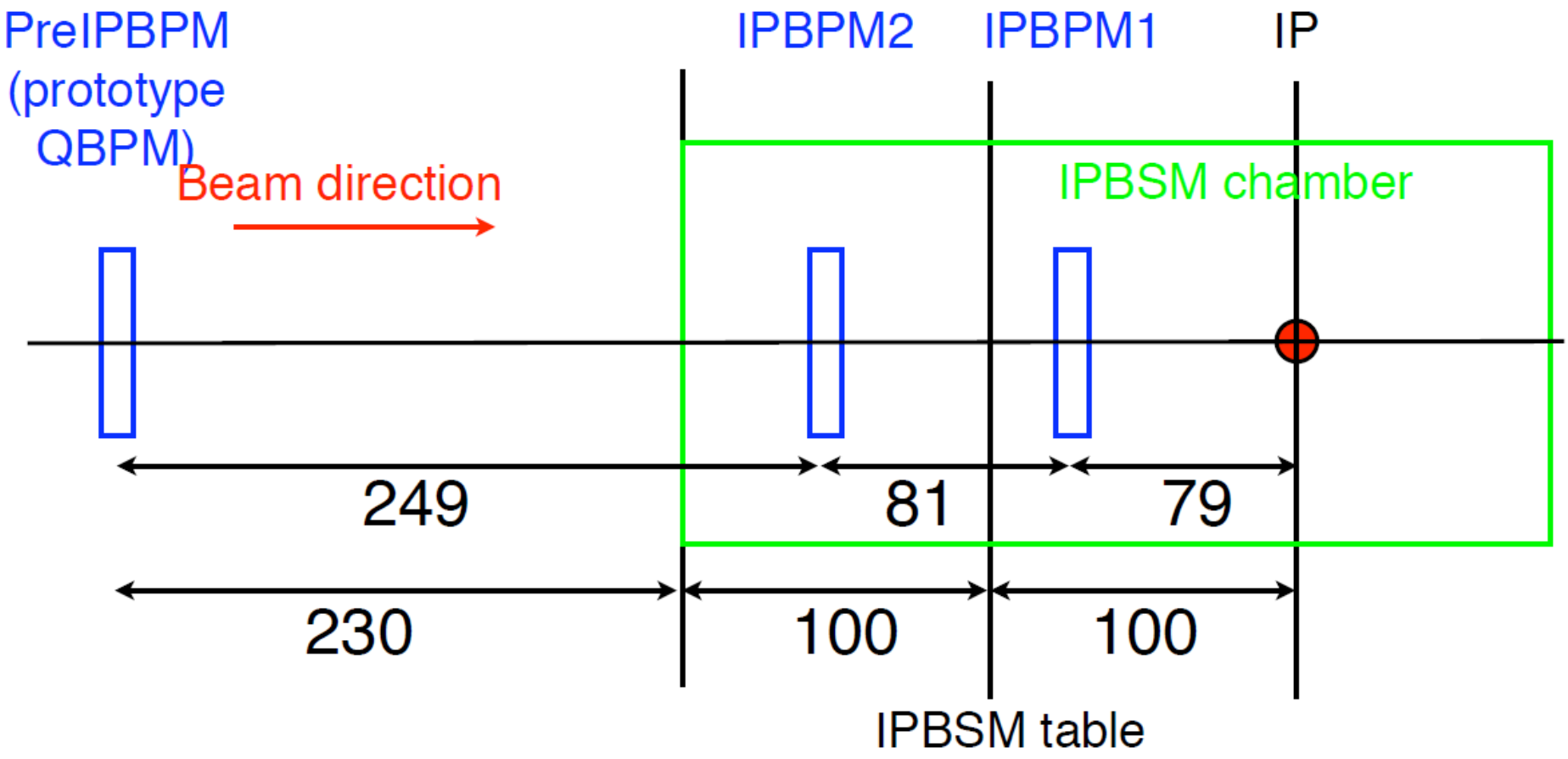
ATF2 IP FB loop scheme



Existing IP-BPM geometry

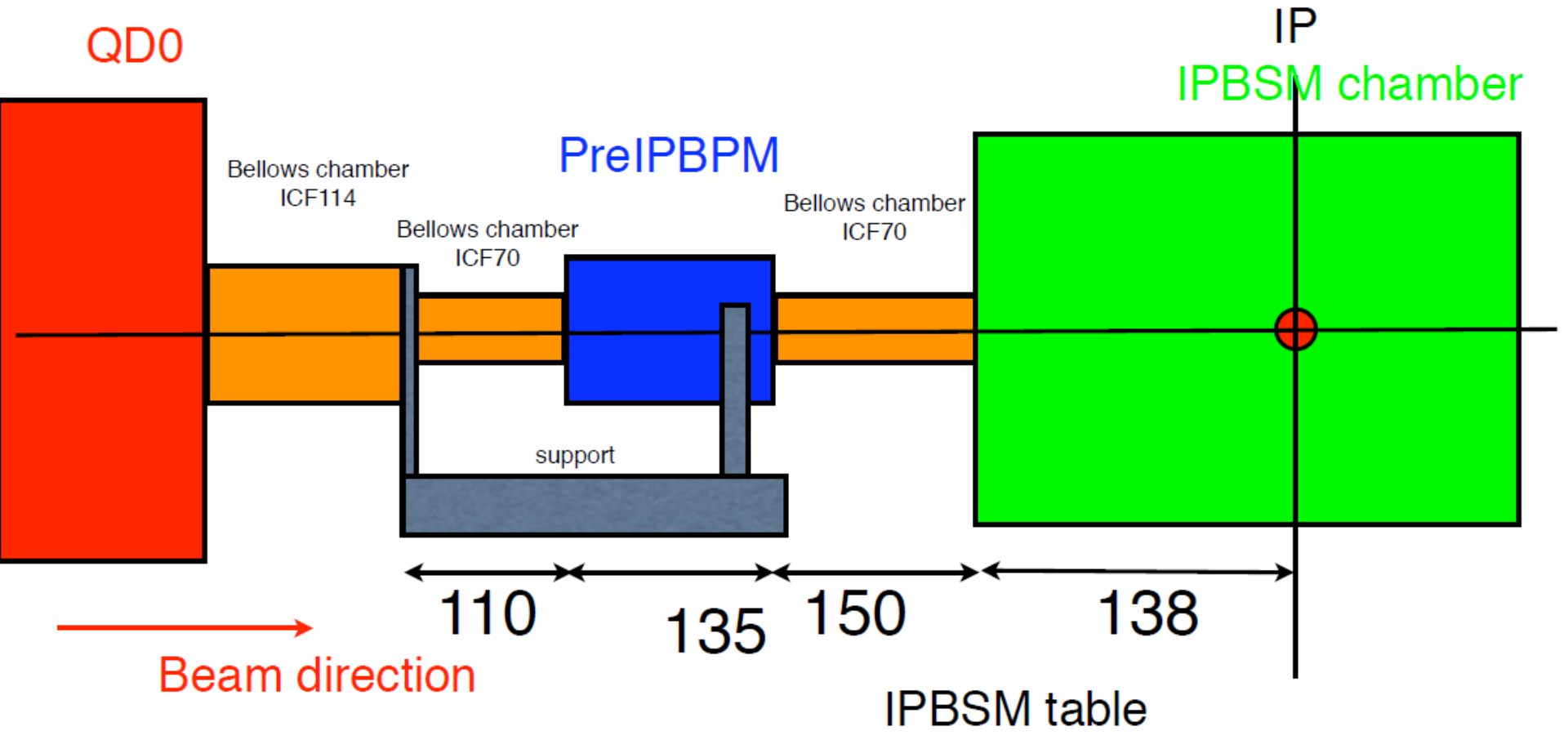
2011.6.29 Y.Honda

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

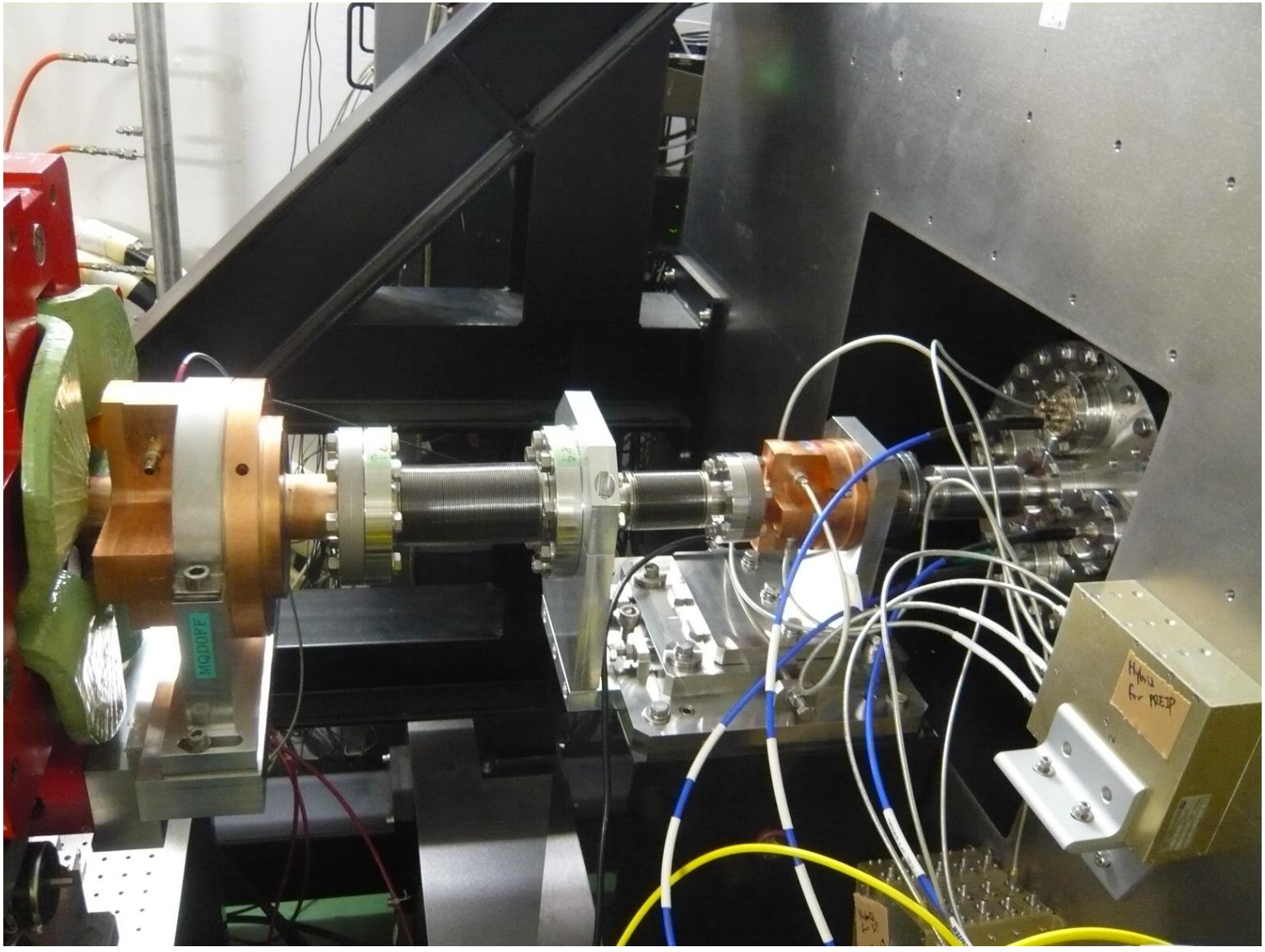


Chamber geometry

- PreIPBPM is connected with ICF70 bellows at both ends for position adjustment.
- QD0 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)

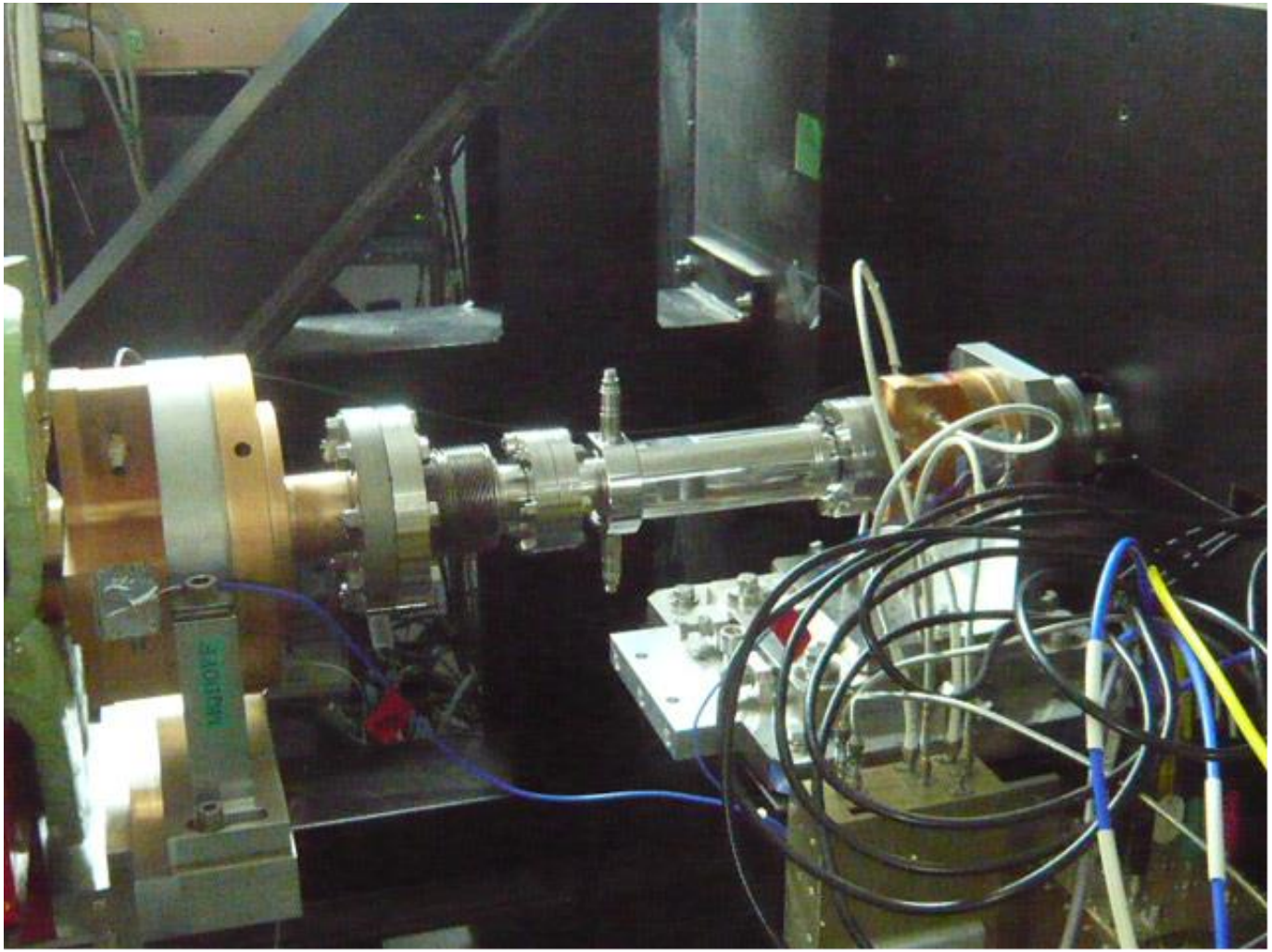


New IP kicker

Designed by Oxford

Fabrication arranged by KEK

Installed May 2012



Preparations with existing setup

- **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

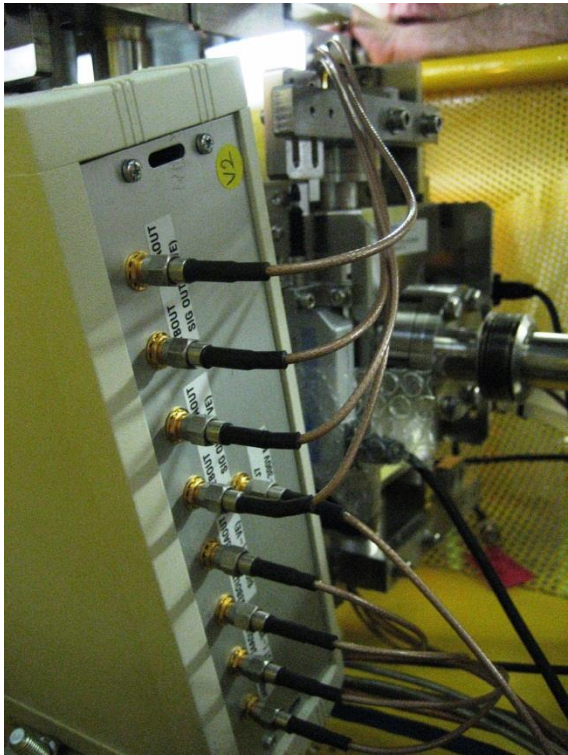
  exercise system in preparation for IPFB

FONT drive amplifier

FONT5 amplifier, built by TMD Technologies

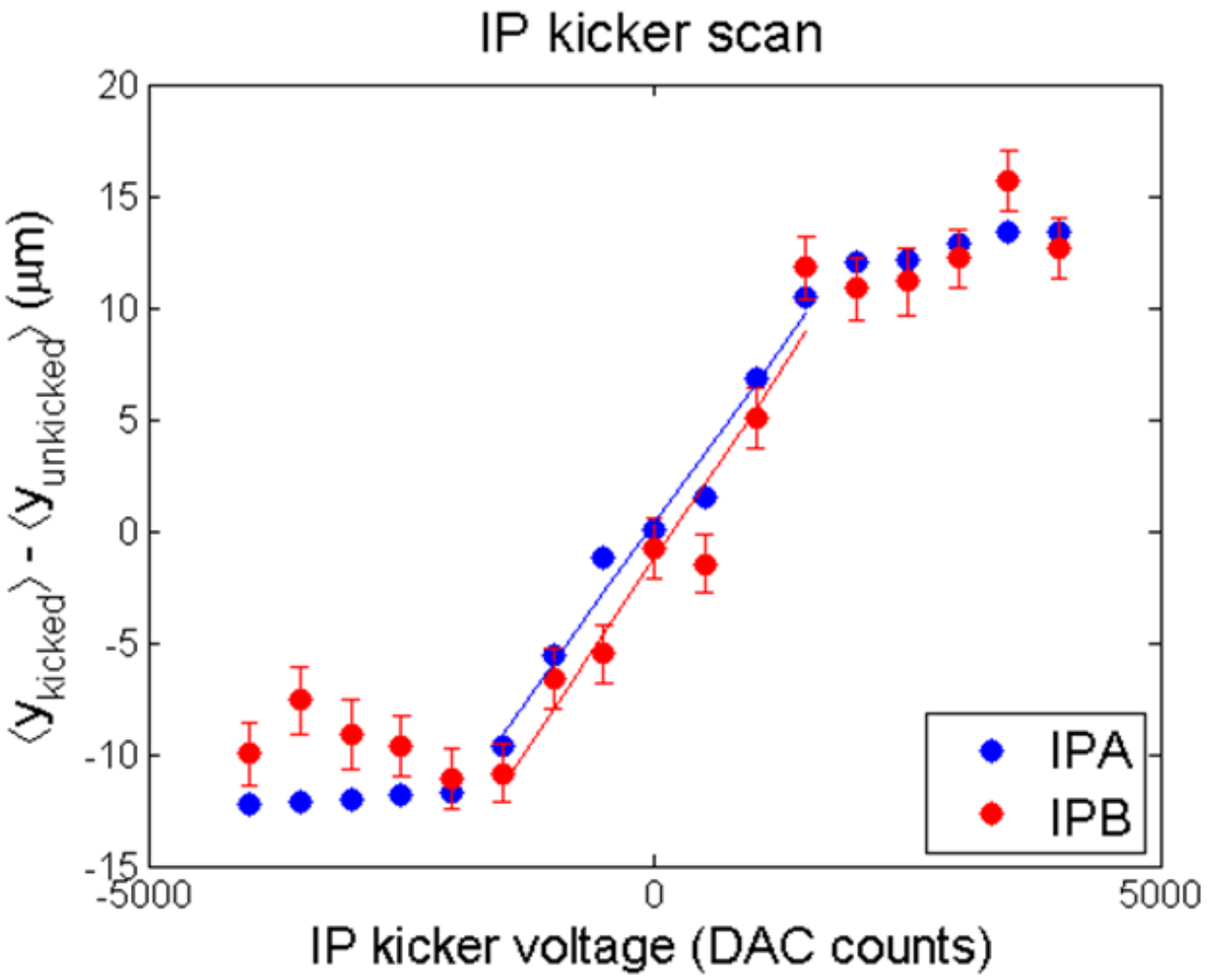
Specifications:

- **+- 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

- **Kicker is working well**
- **FONT amplifier is able to drive kicker**
- **Dynamic kick range almost +- 15 um at IPBPMs**
- **Linear kick range > +- 10 um**

→ plenty of drive for beam stabilisation @ IP

IPBPM tests (single bunch)

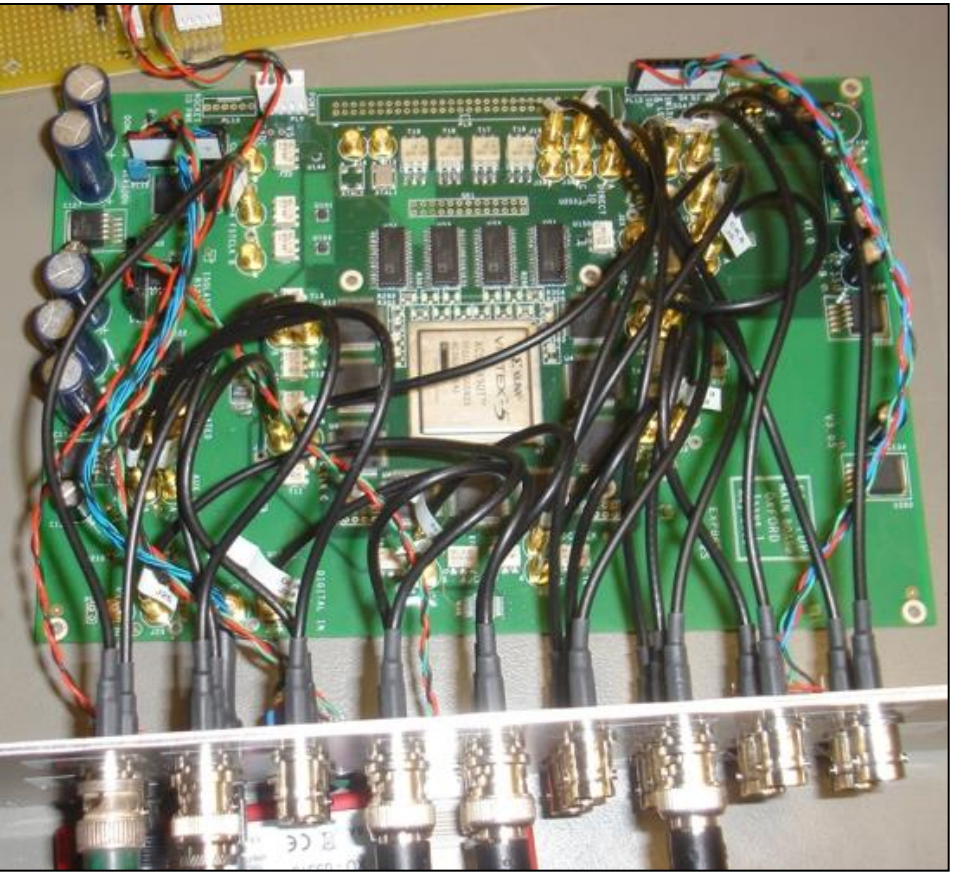
- **IPBPM A+B signals split:**

  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



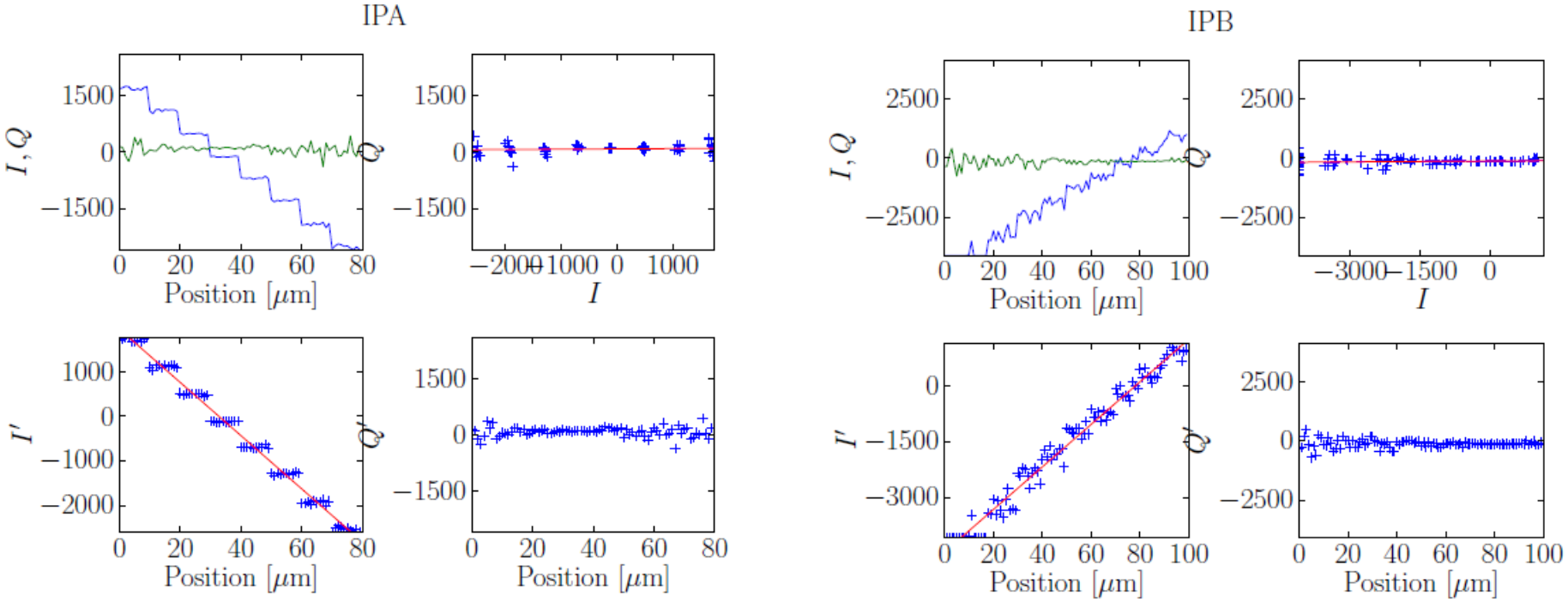
Xilinx Virtex5 FPGA

9 ADC input channels (TI ADS5474)

4 DAC output channels (AD9744)

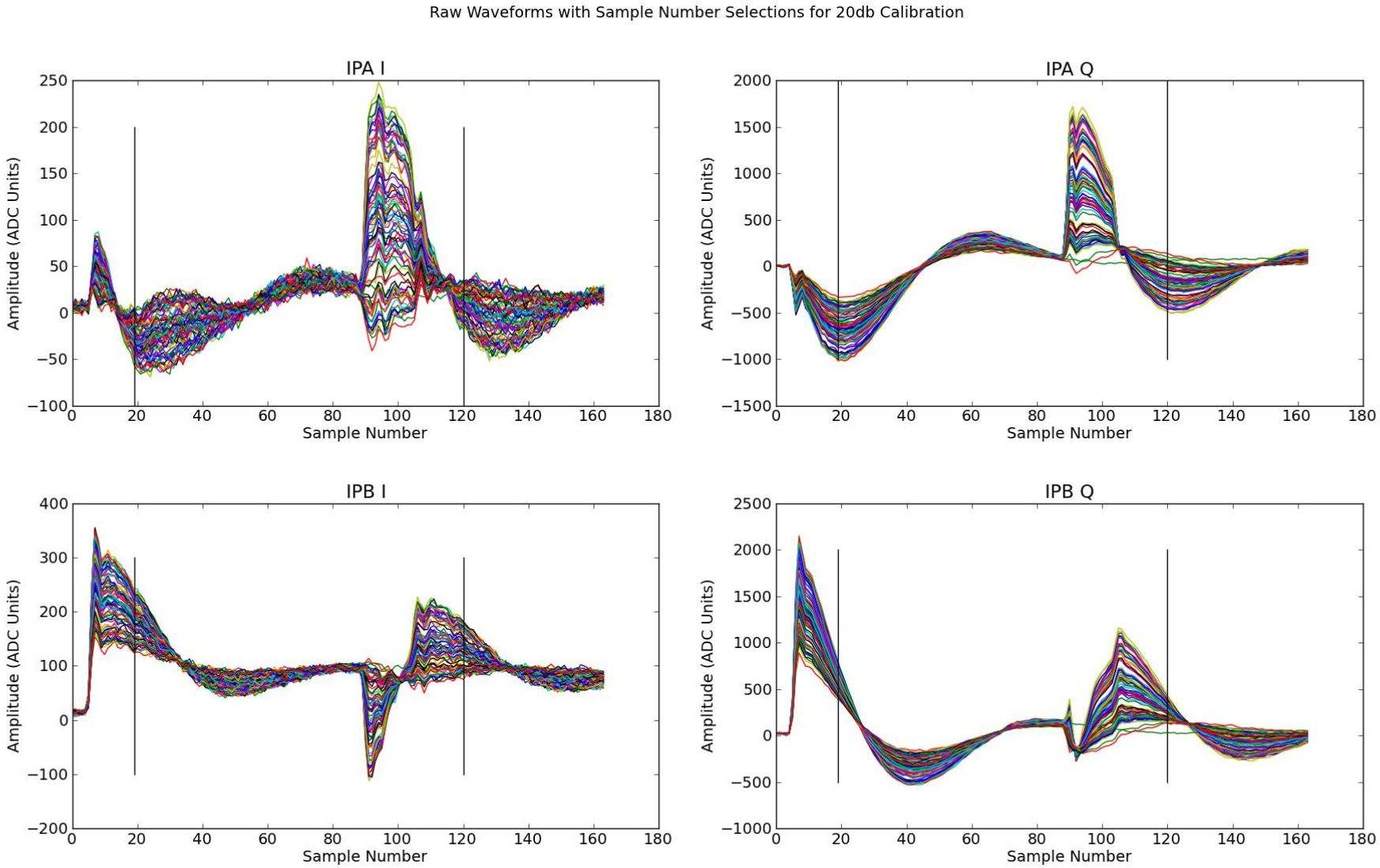
Clocked at 357 MHz phase-locked to beam

FONT digitisation of IPBPMs



Digitisation and calibration successful, with single-bunch beam

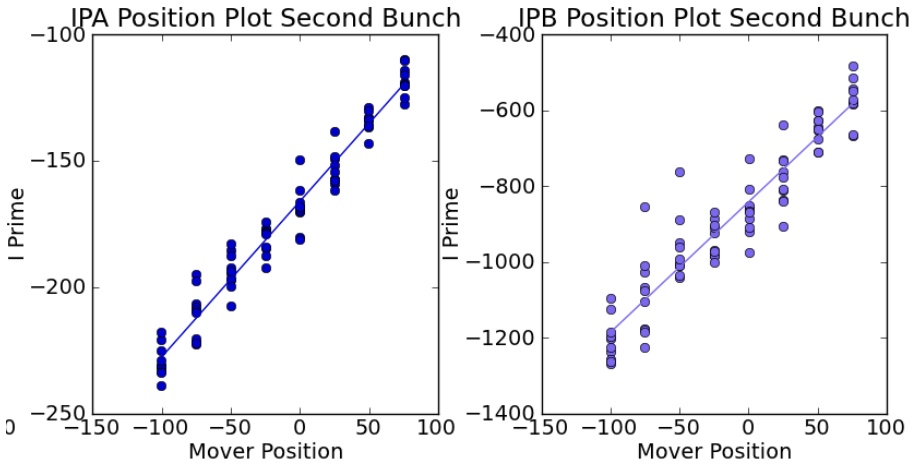
Digitised waveforms: 2 bunches



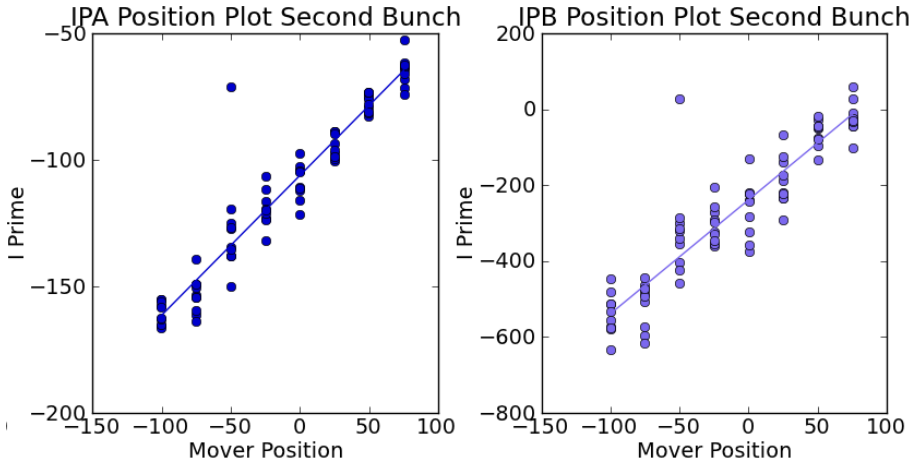
Calibrations: 2 bunches

IPBPM A **IPBPM B**

Bunch 1



Bunch 2



IPBPM digitisation conclusions

- **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

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

Preparations for beam stability in IP region with 2-bunch beam:

1. Readout of IPBPMs with 2-bunch beam ✓

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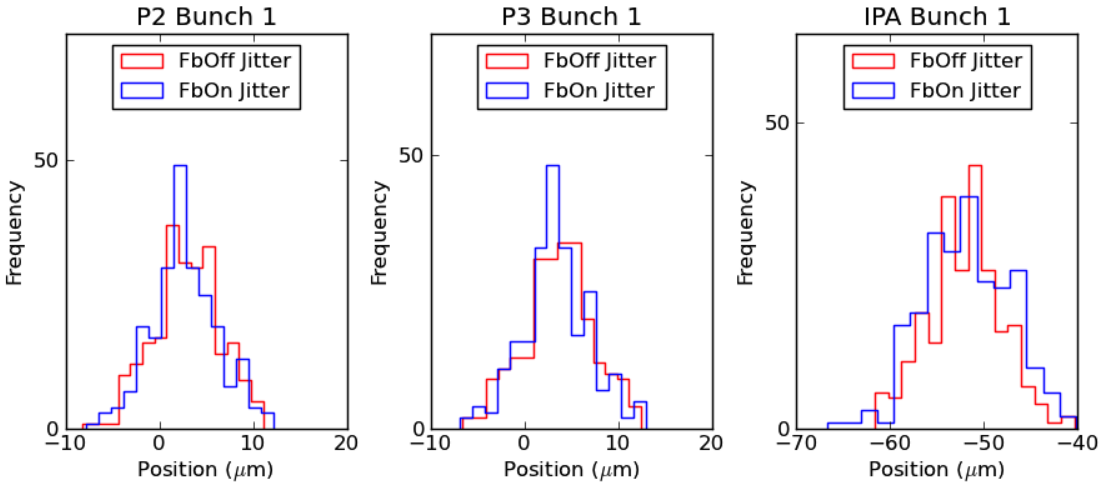
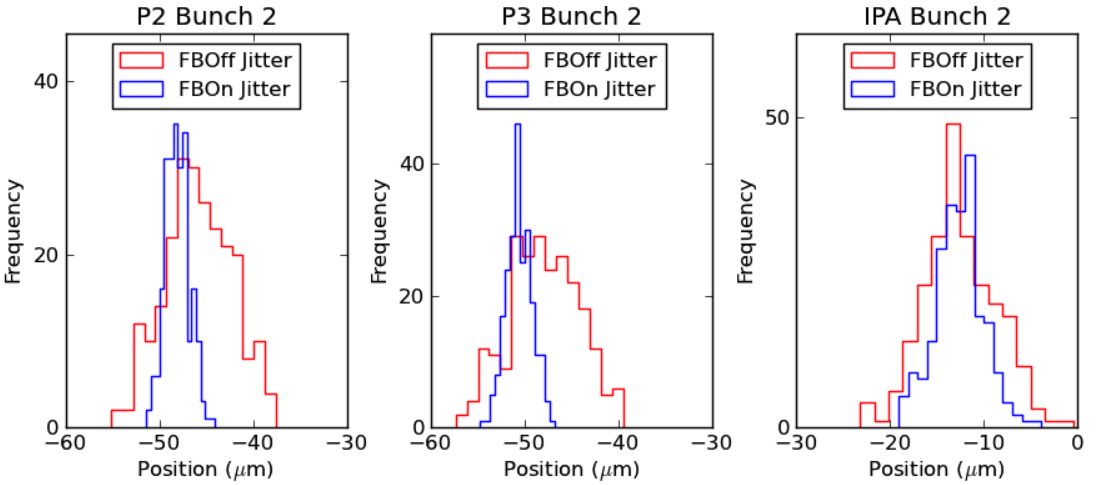
4. IP FB using IPBPM signal and IP kicker

Effect of upstream FB at IPBPM A

Bunch 1 (not corrected)



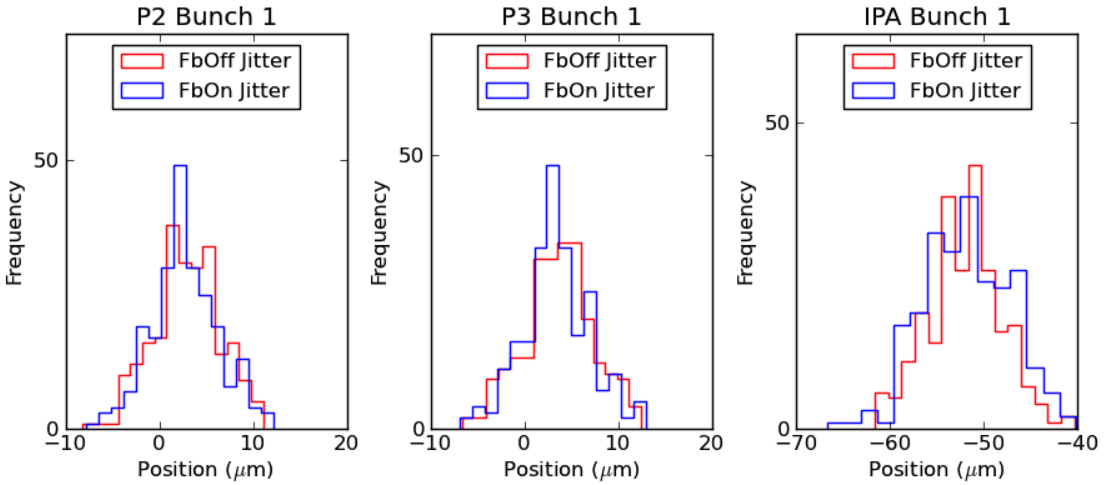
Bunch 2 (corrected)



Beam conditions not good

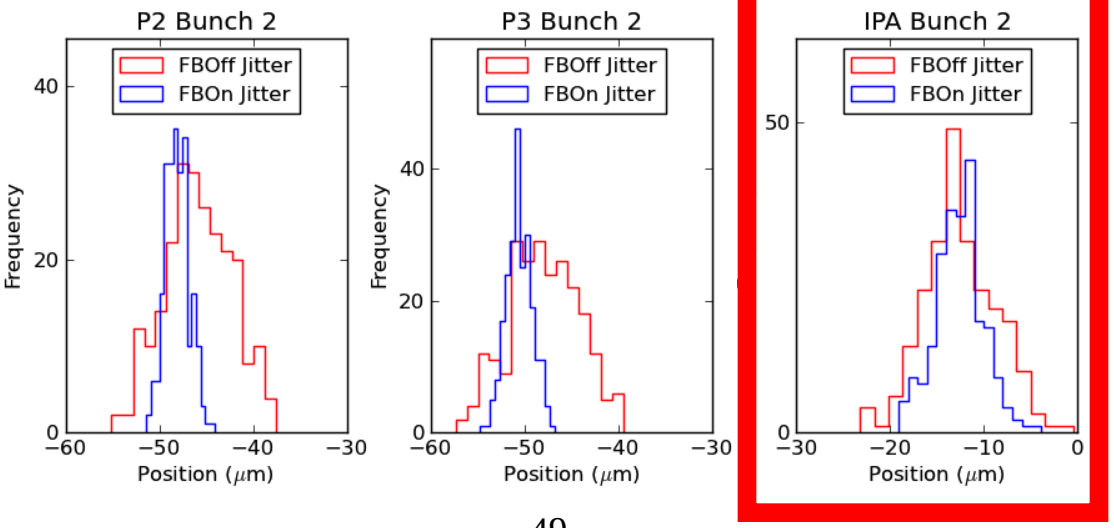
Effect of upstream FB at IPBPM A

Bunch 1 (not corrected)



Beam conditions not good

Bunch 2 (corrected)



Off:
3.9 +- 0.2 um

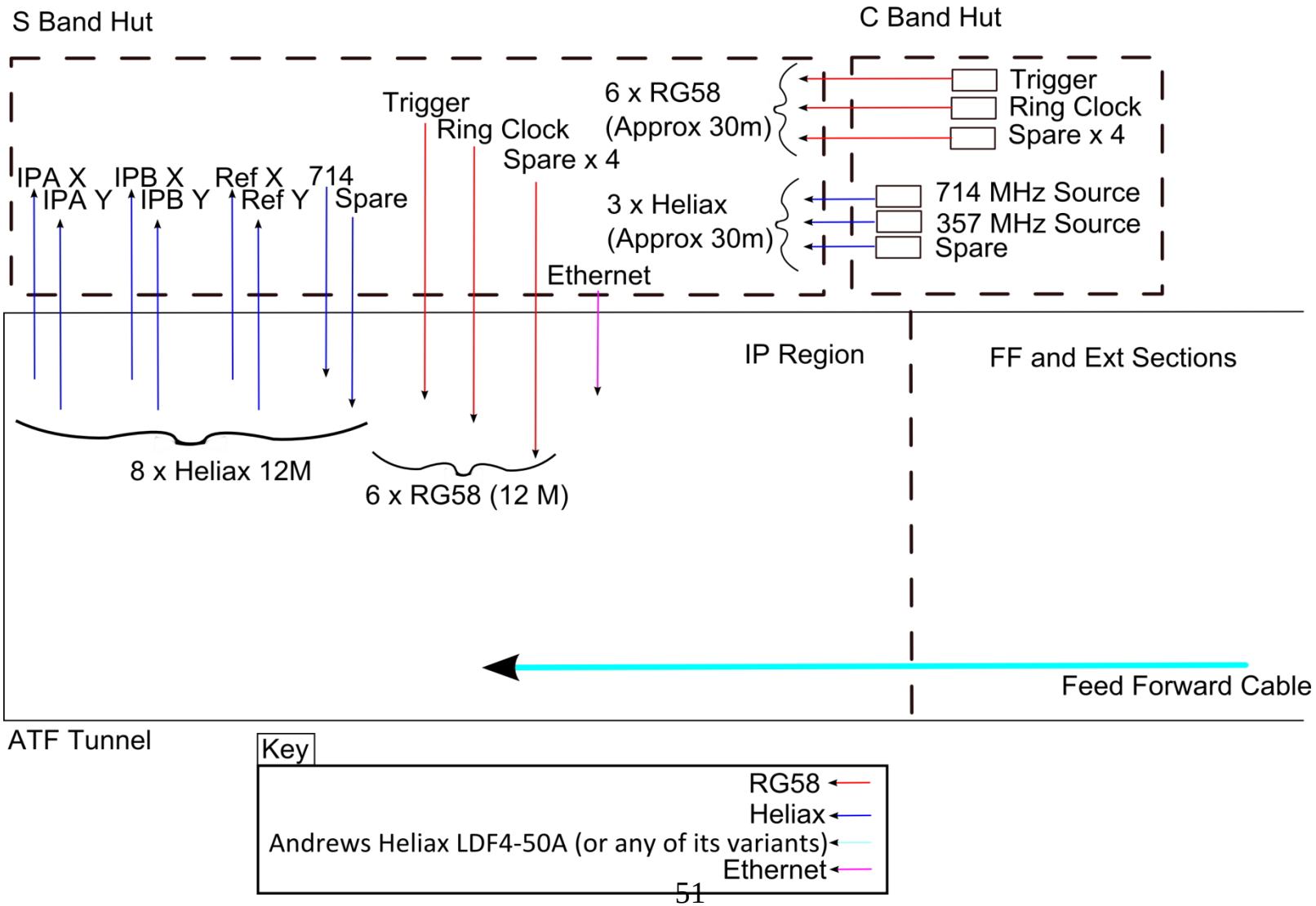
On:
2.6 +- 0.1 um

Test programme

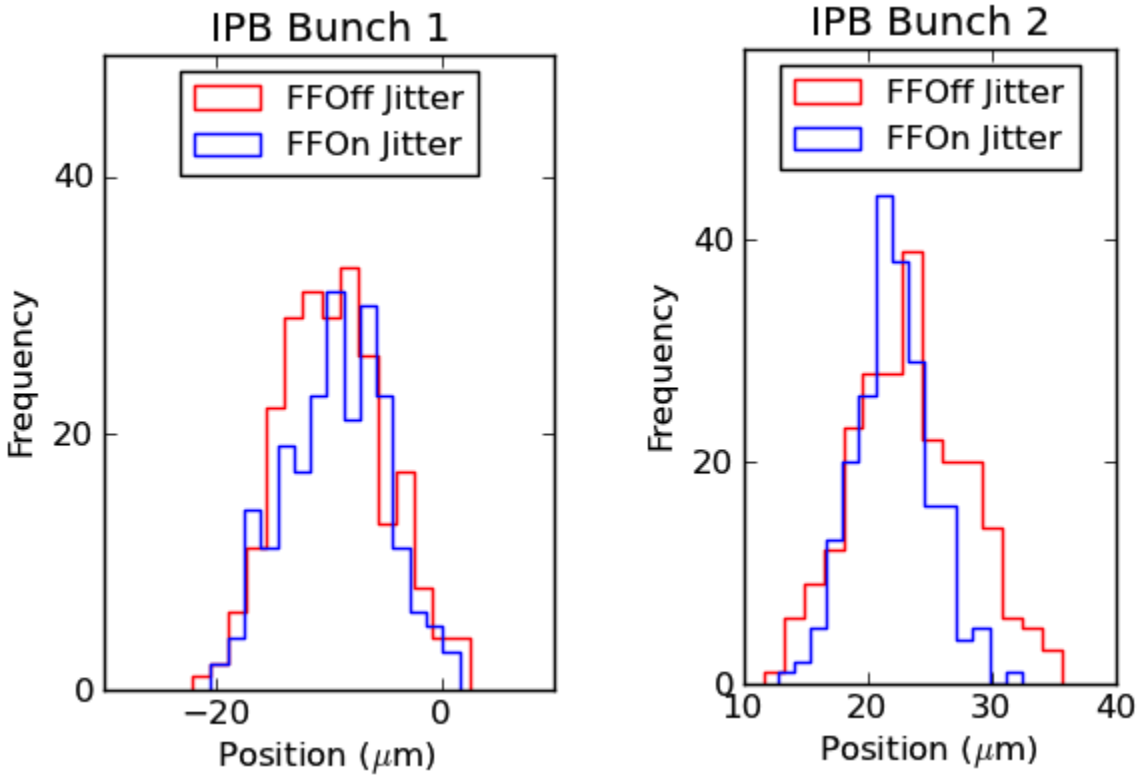
Preparations for beam stability in IP region with 2-bunch beam:

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**

Feed-forward setup



Feed-forward: effect at IPB (best)



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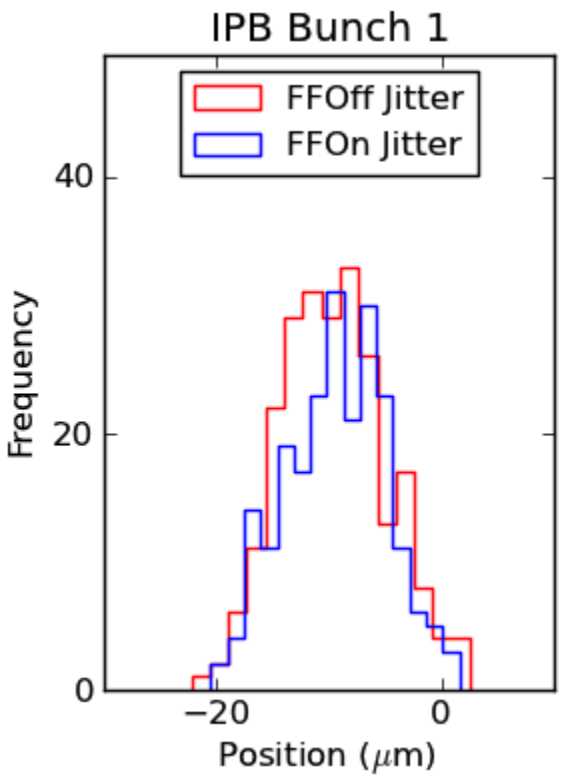
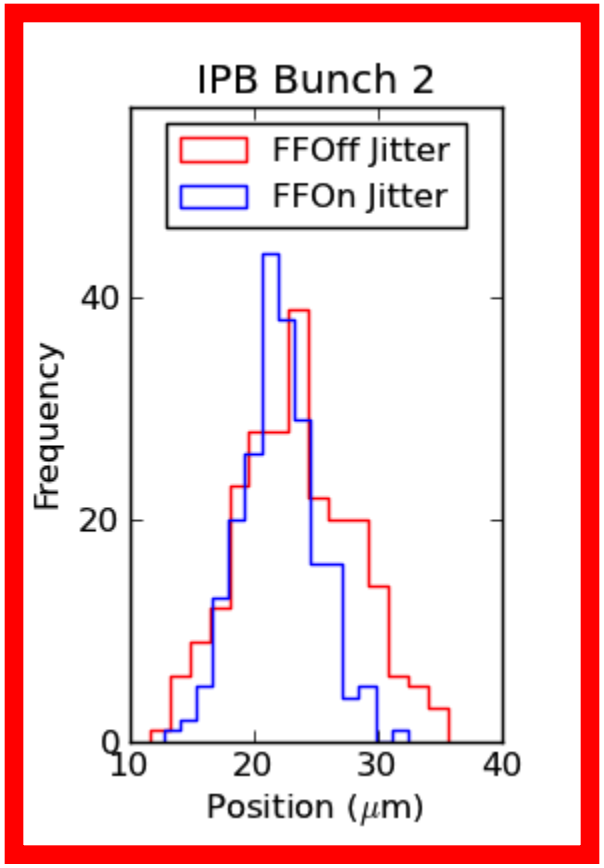
Feed-forward: effect at IPB (best)



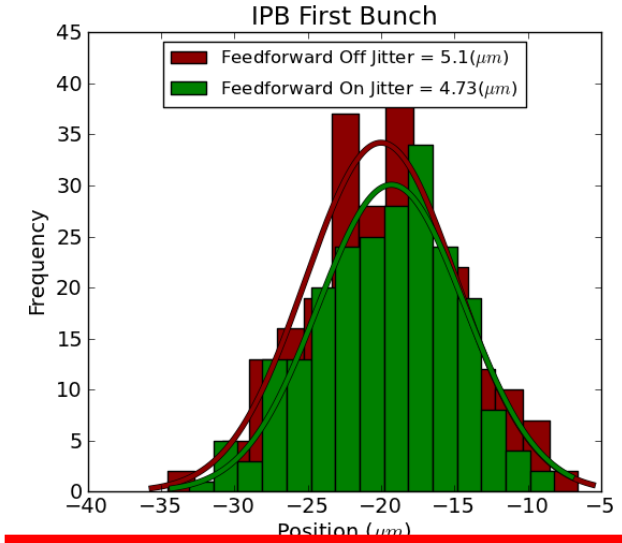


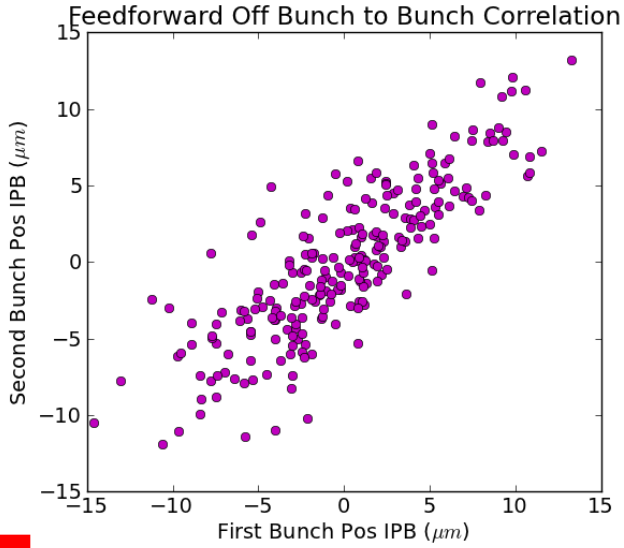
Beam conditions not good

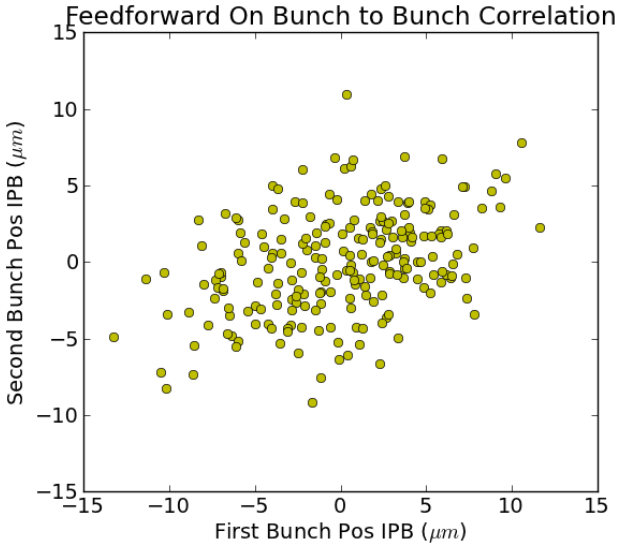
Off:
4.7 +- 0.2 um

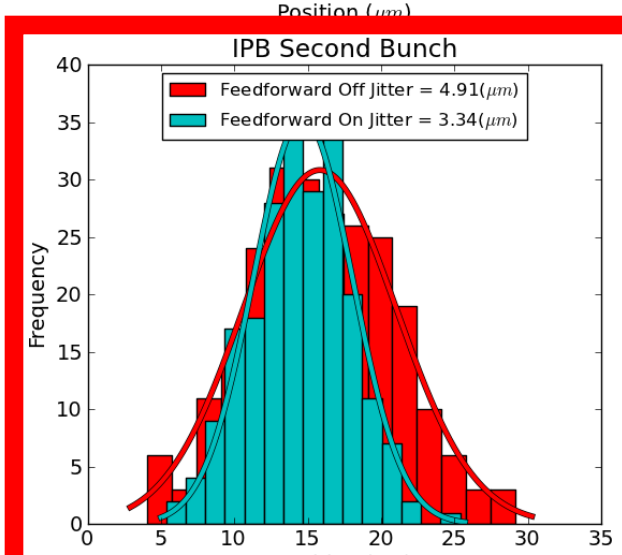
On:
3.0 +- 0.1 um

Feed-forward: effect at IPB







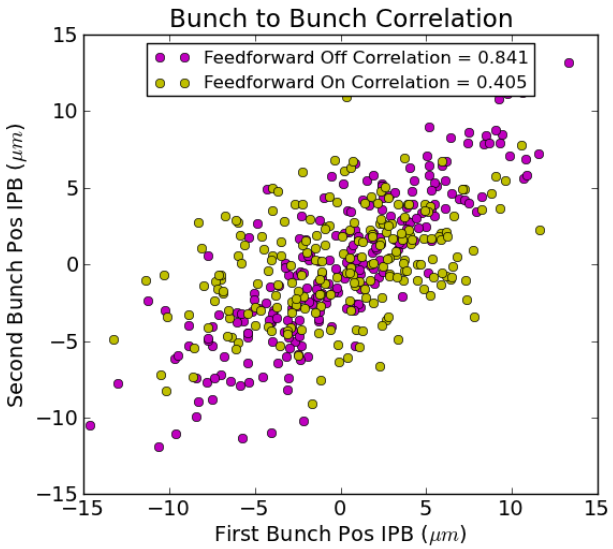


Jitters
P2 = 3.73 (μm)
P3 = 3.7 (μm)
IPB = 5.1 (μm)

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

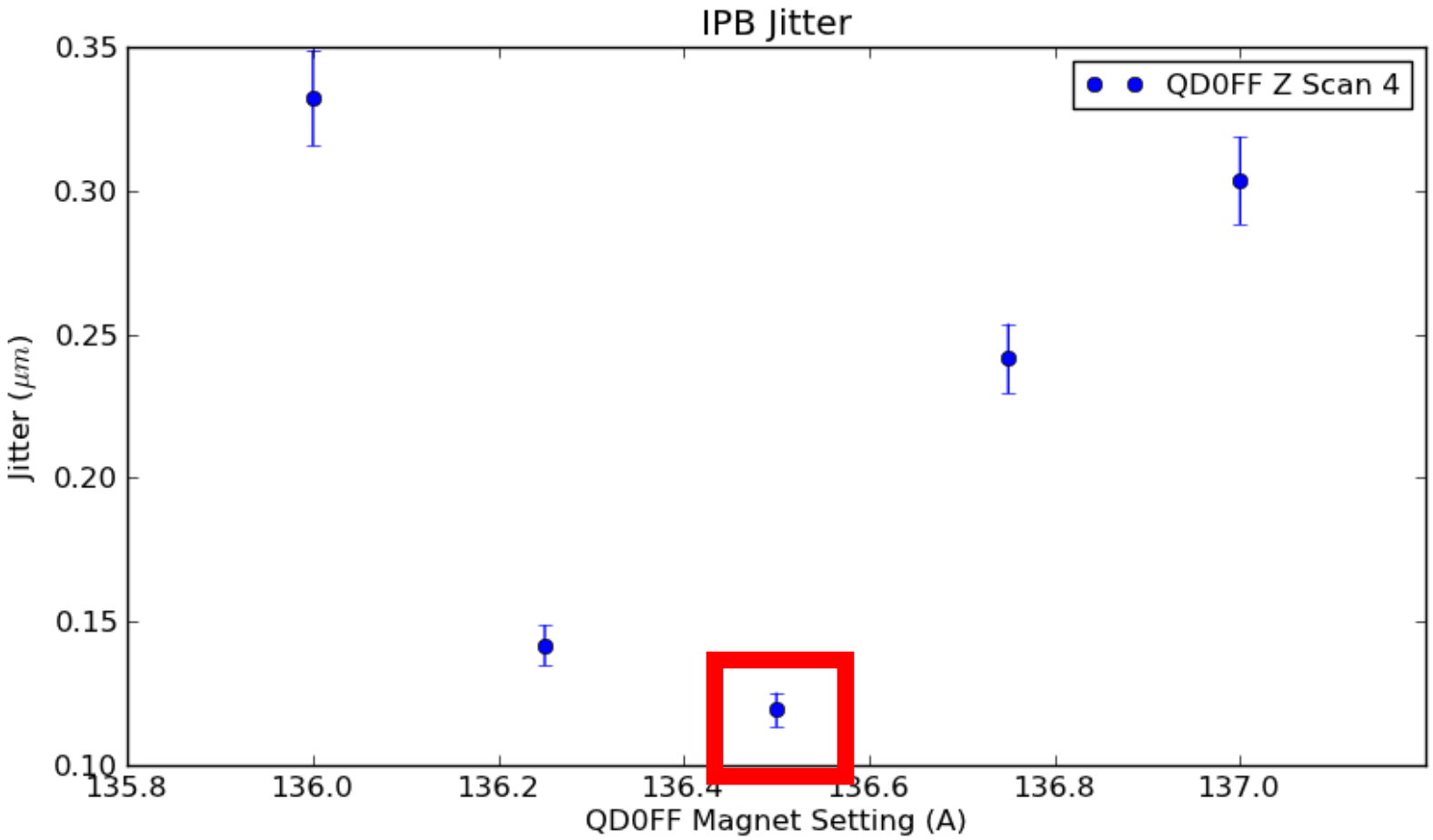


Test programme

Preparations for beam stability in IP region with 2-bunch beam:

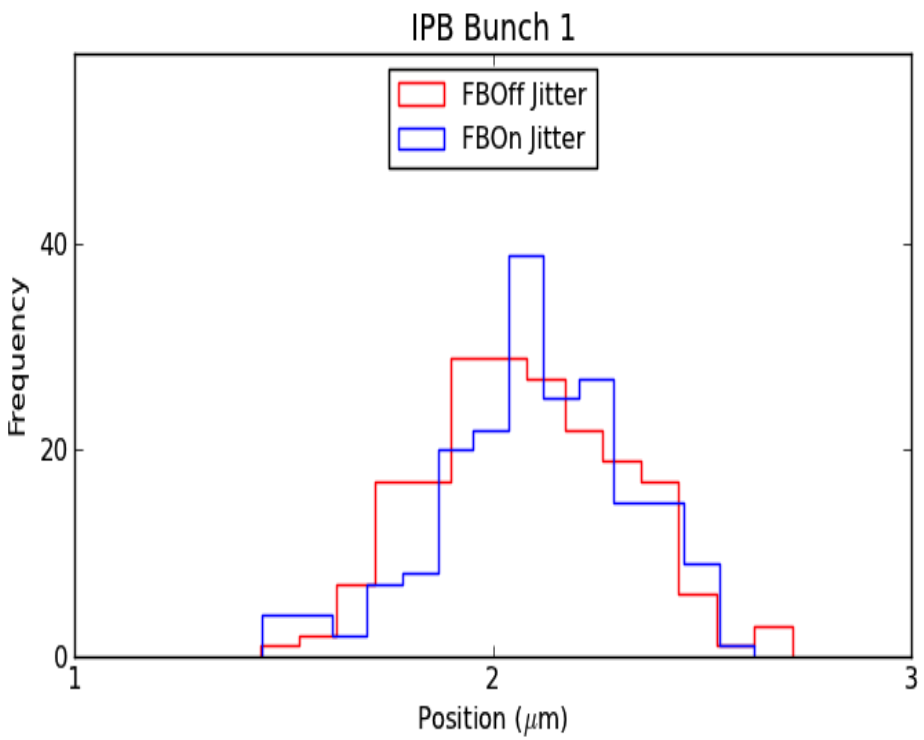
1. **Readout of IPBPMs with 2-bunch beam** ✓
2. **Upstream FONT FB: record beam in IPBPMs** ✓
3. **Feed-forward from upstream FONT BPMs → IP kicker: record beam in IPBPMs** ✓
4. **IP FB using IPBPM signal and IP kicker**

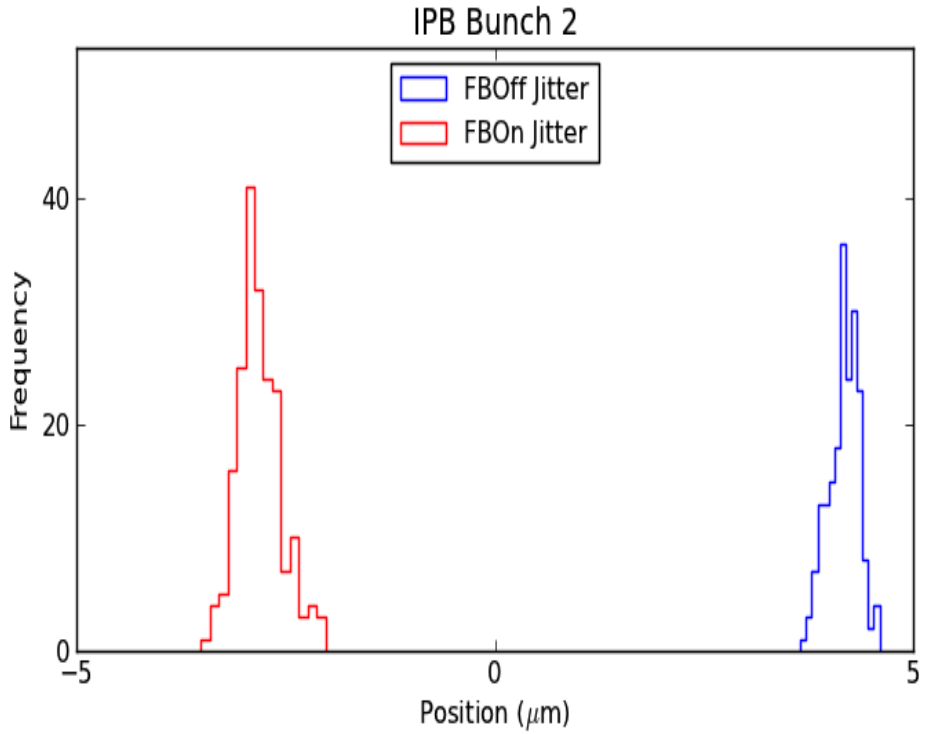
Resolution of IP BPMs: < 120nm



First IP FB attempt at IPB (i)

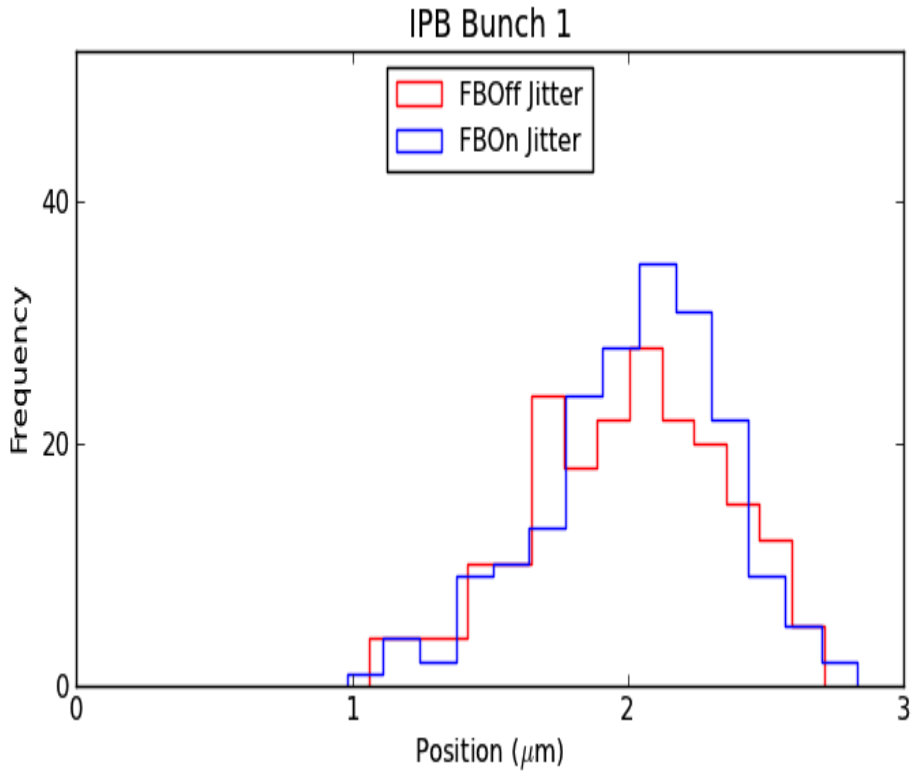
Last ½ hour of last (owl) shift April 25 (beam conditions much better)

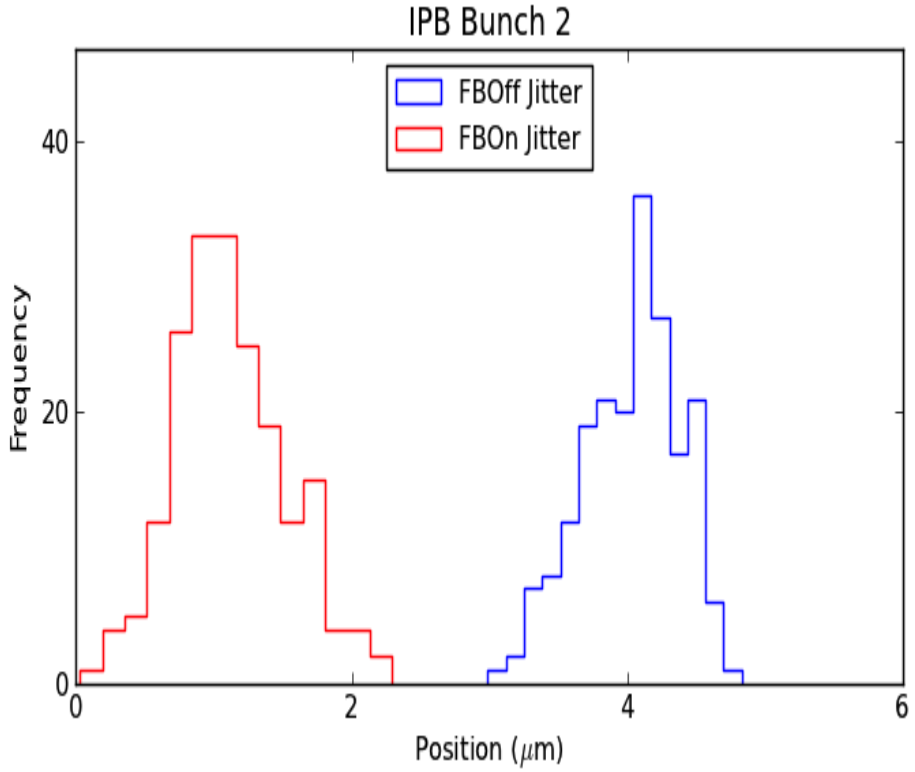




First IP FB attempt at IPB (ii)

Last 10 minutes of last (owl) shift April 25 (beam conditions much better)





Test programme

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 ✓

June beamtime: repeat, try to optimise system performance and quality of correction