# Beam Collision Feedbacks

# for future Lepton Colliders

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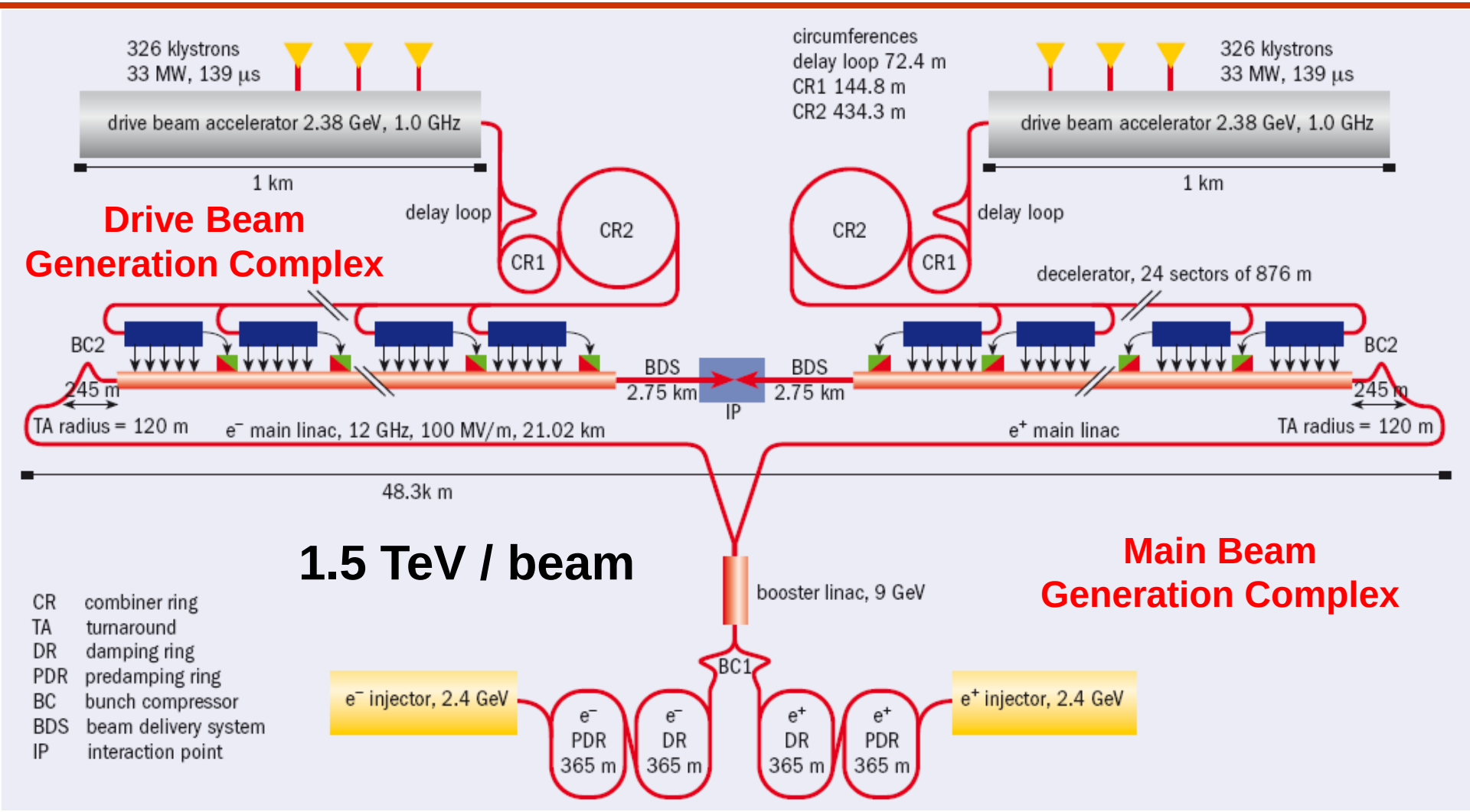
***John Adams Institute***

***Oxford University***

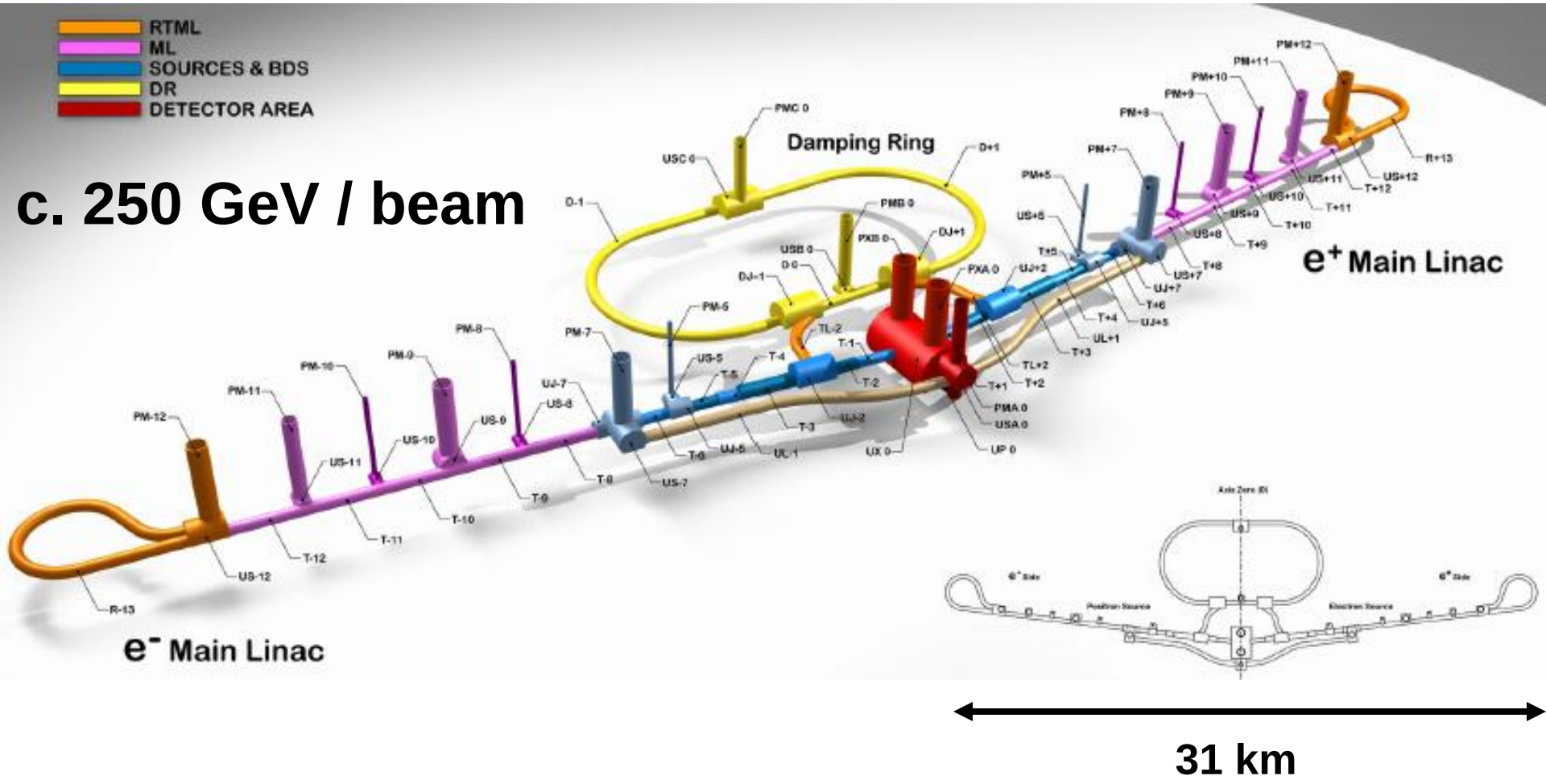
# Outline

- **Introduction and system concept**
- **ILC design status**
- **CLIC design status**
- **FONT prototype systems performance**
- **Outstanding technical issues**
- **Summary**

# Compact Linear Collider (CLIC)



# International Linear Collider



# Beam parameters

| | ILC (500) | CLIC (3 TeV) | |
|---|---|---|---|
| Electrons/bunch | 0.75 | 0.37 | 10**10 |
| Bunches/train | 2820 | 312 | |
| Train repetition rate | 5 | 50 | Hz |
| Bunch separation | 308 | 0.5 | ns |
| Train length | 868 | 0.156 | us |
| Horizontal IP beam size | 655 | 45 | nm |
| Vertical IP beam size | 6 | 0.9 | nm |
| Longitudinal IP beam size | 300 | 45 | um |
| Luminosity | 2 | 6 | 10**34 |

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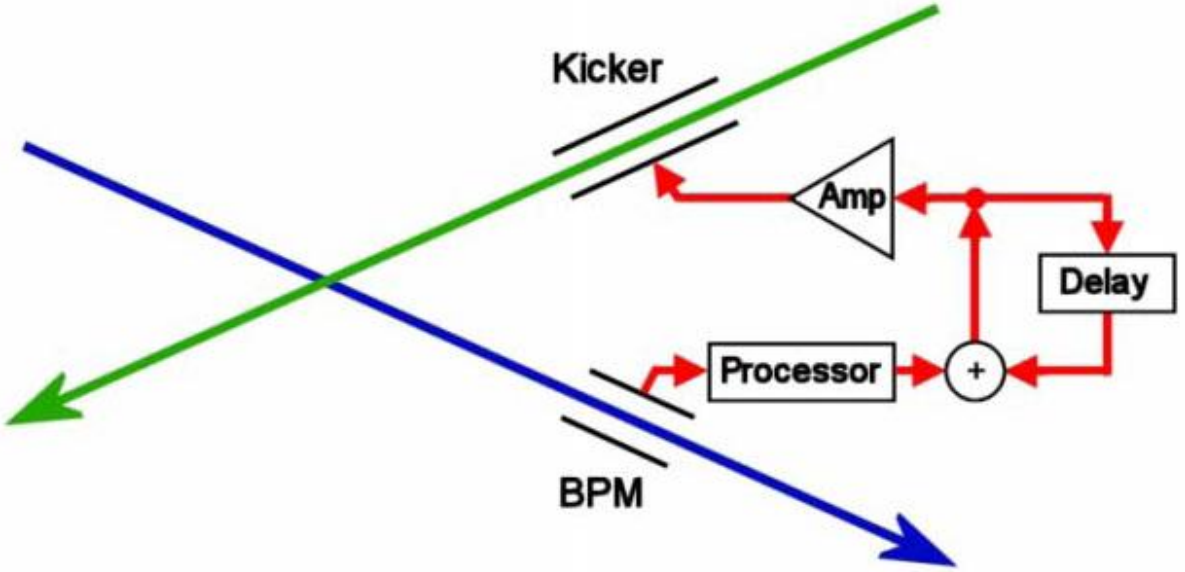
# IP beam feedback concept

- 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**

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# General considerations

**Time structure of bunch train:**

**ILC (500 GeV):** **c. 3000 bunches w. c. 300 ns separation**

**CLIC (3 TeV):** **c. 300 bunches w. c. 0.5 ns separation**

**Feedback latency:**

**ILC:** **O(100ns) latency budget allows digital approach**

**CLIC:** **O(10ns) latency requires analogue approach**

**Recall speed of light: c = 30 cm / ns:**

**FB hardware should be close to IP (especially for CLIC!)**

**Two systems, one on each side of IP, allow for redundancy**

# IP FB Design Status: ILC

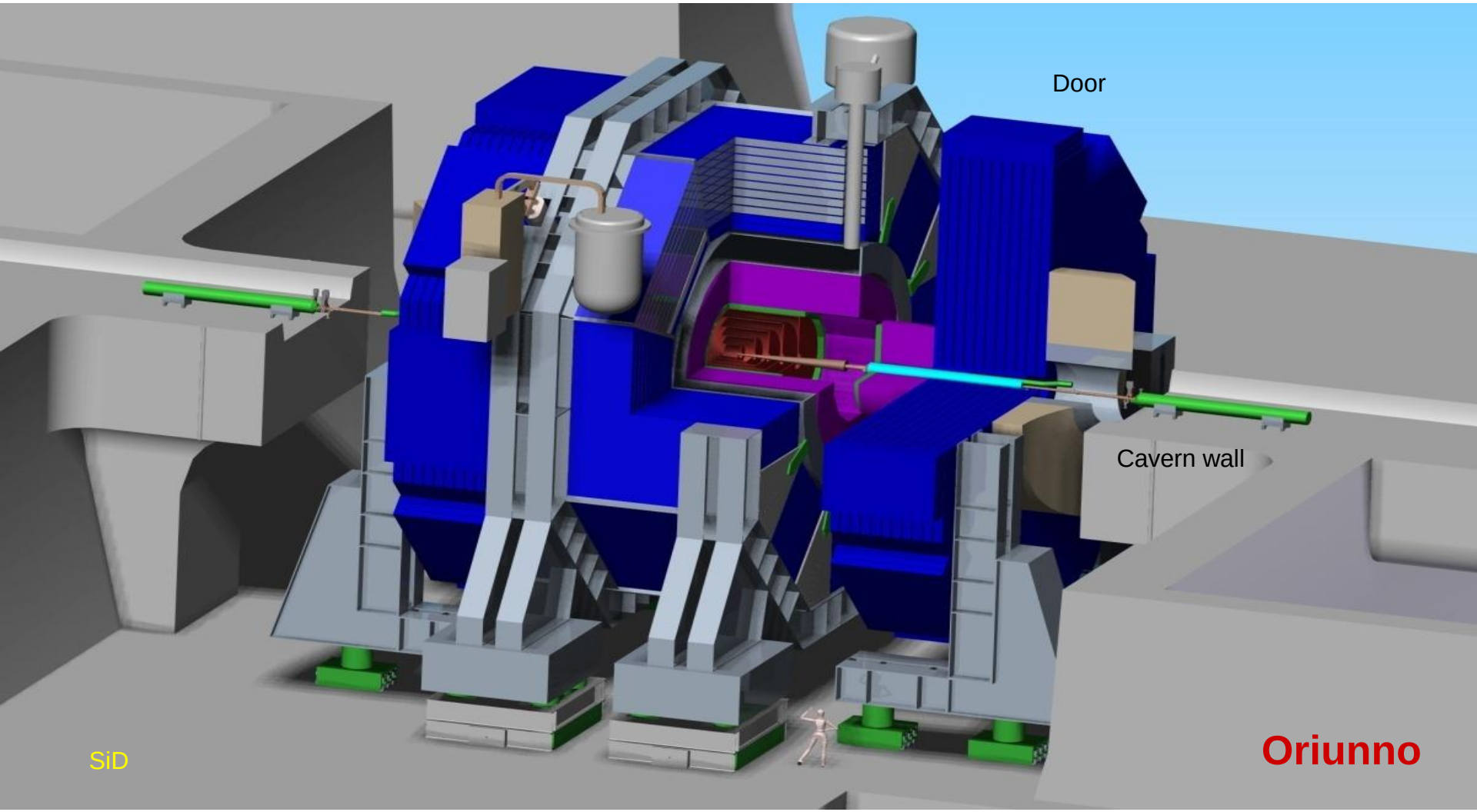
**Conceptual design documented in ILC RDR (2007):**

**1. IP position feedback:**
**beam position correction up to +- 300 nm vertical at IP**
**2. IP angle feedback: hardware located few 100 metres upstream**
**conceptually very similar to position FB, less critical**
**3. Bunch-by-bunch luminosity signal (from BEAMCAL)**

**'special' systems requiring dedicated hardware + data links**

**More realistic engineering design in progress for TDP report (2012)**

# ILC IR: SiD for illustration



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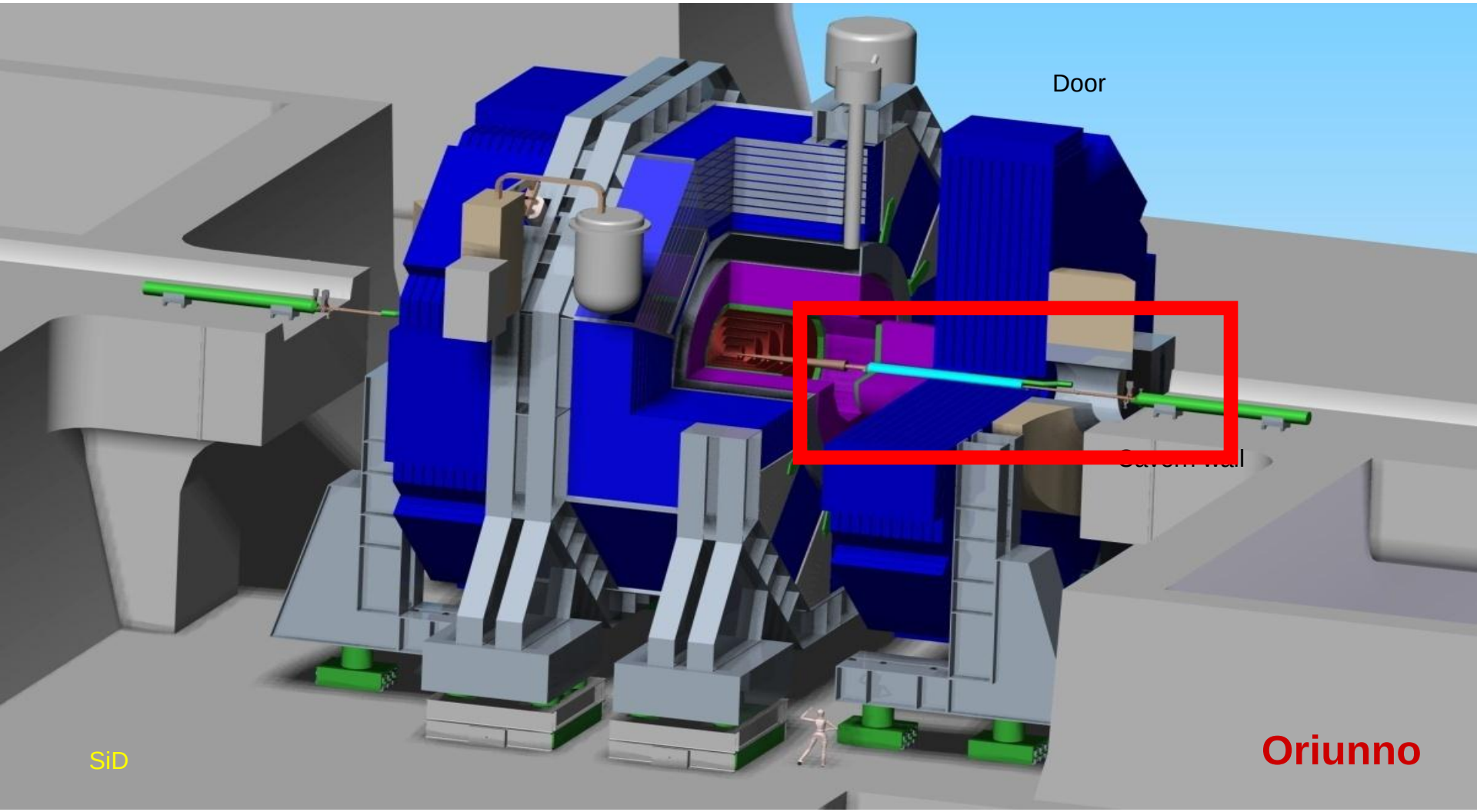
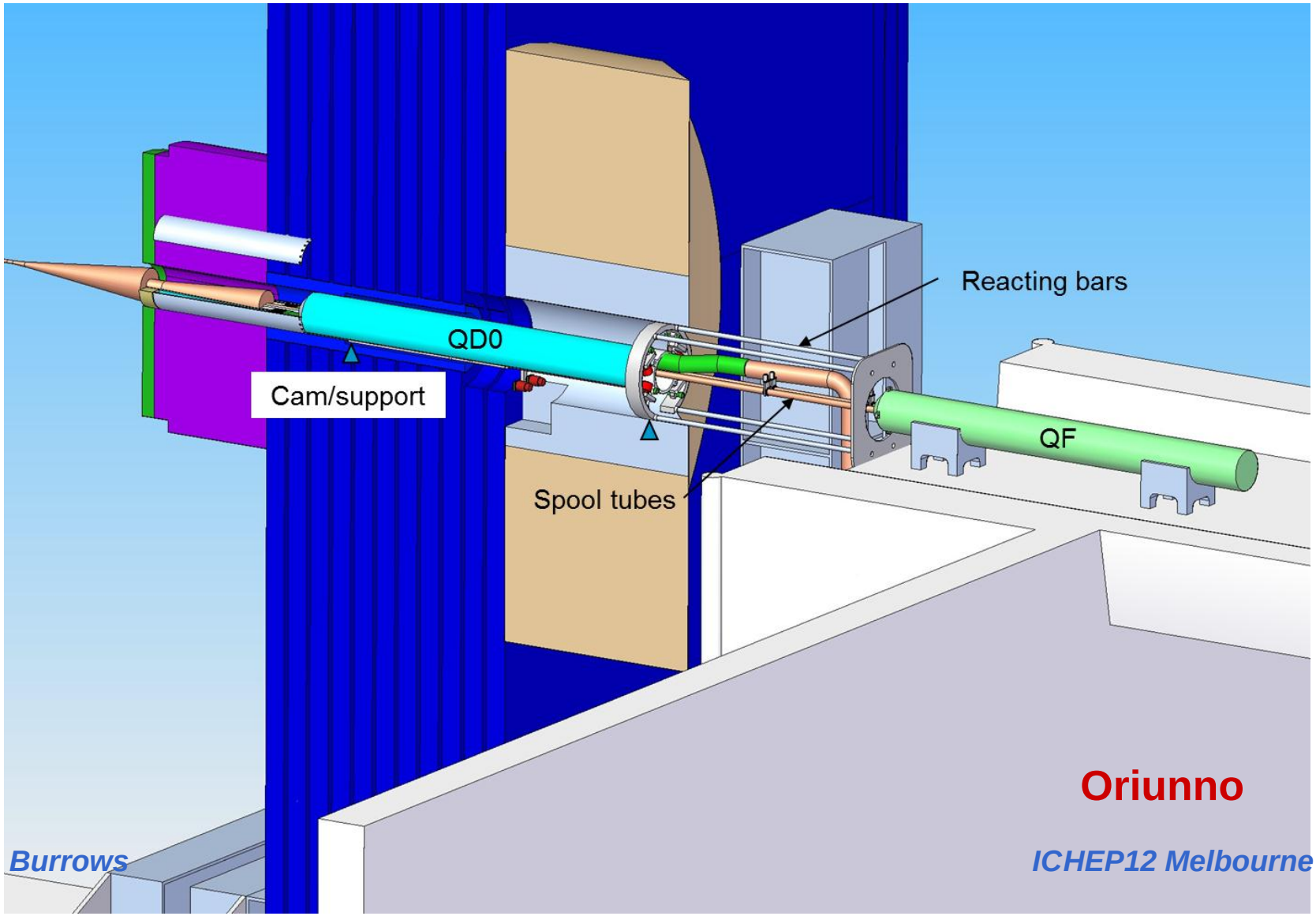


# Final Doublet Region (SiD)




Oriunno

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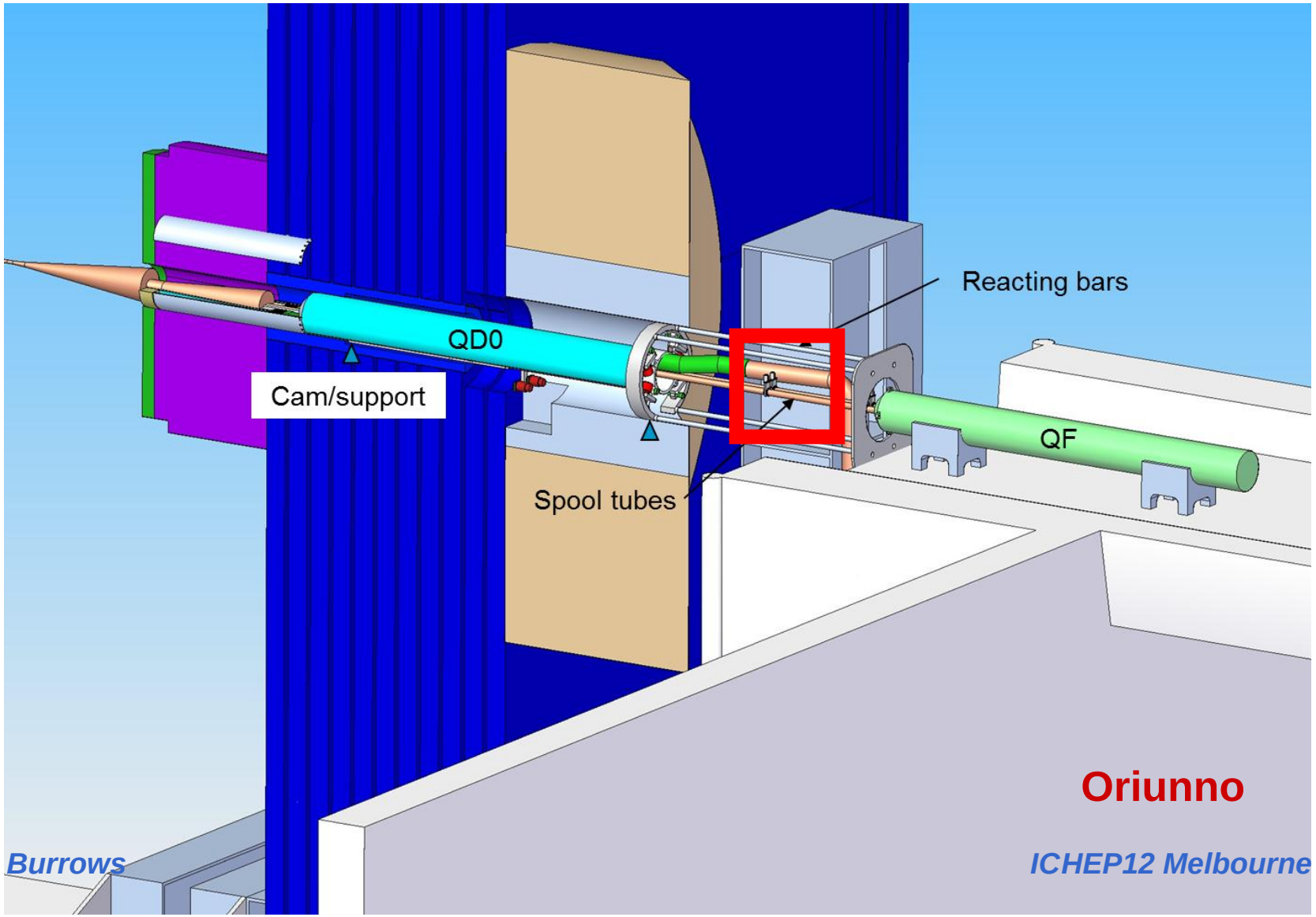


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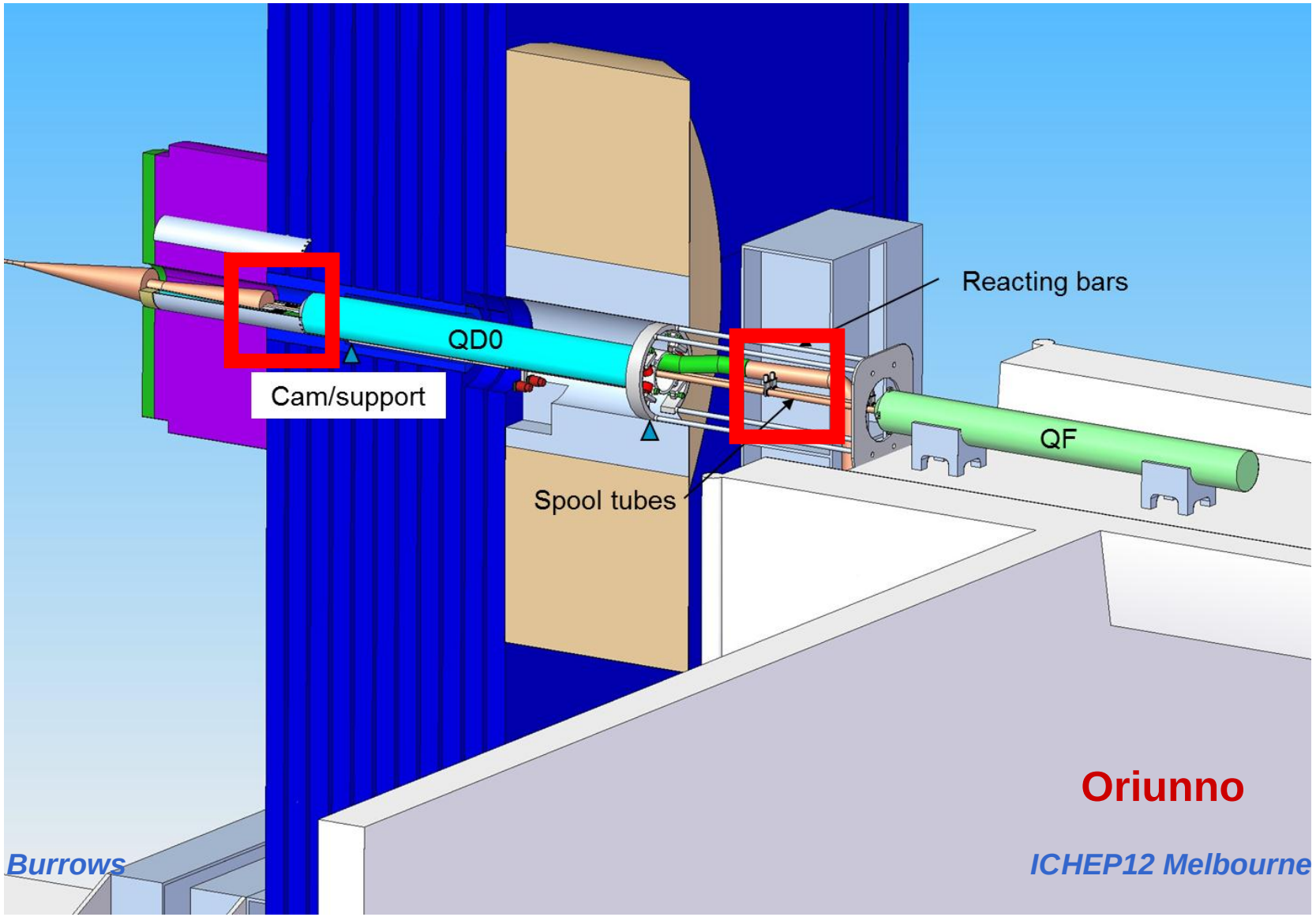


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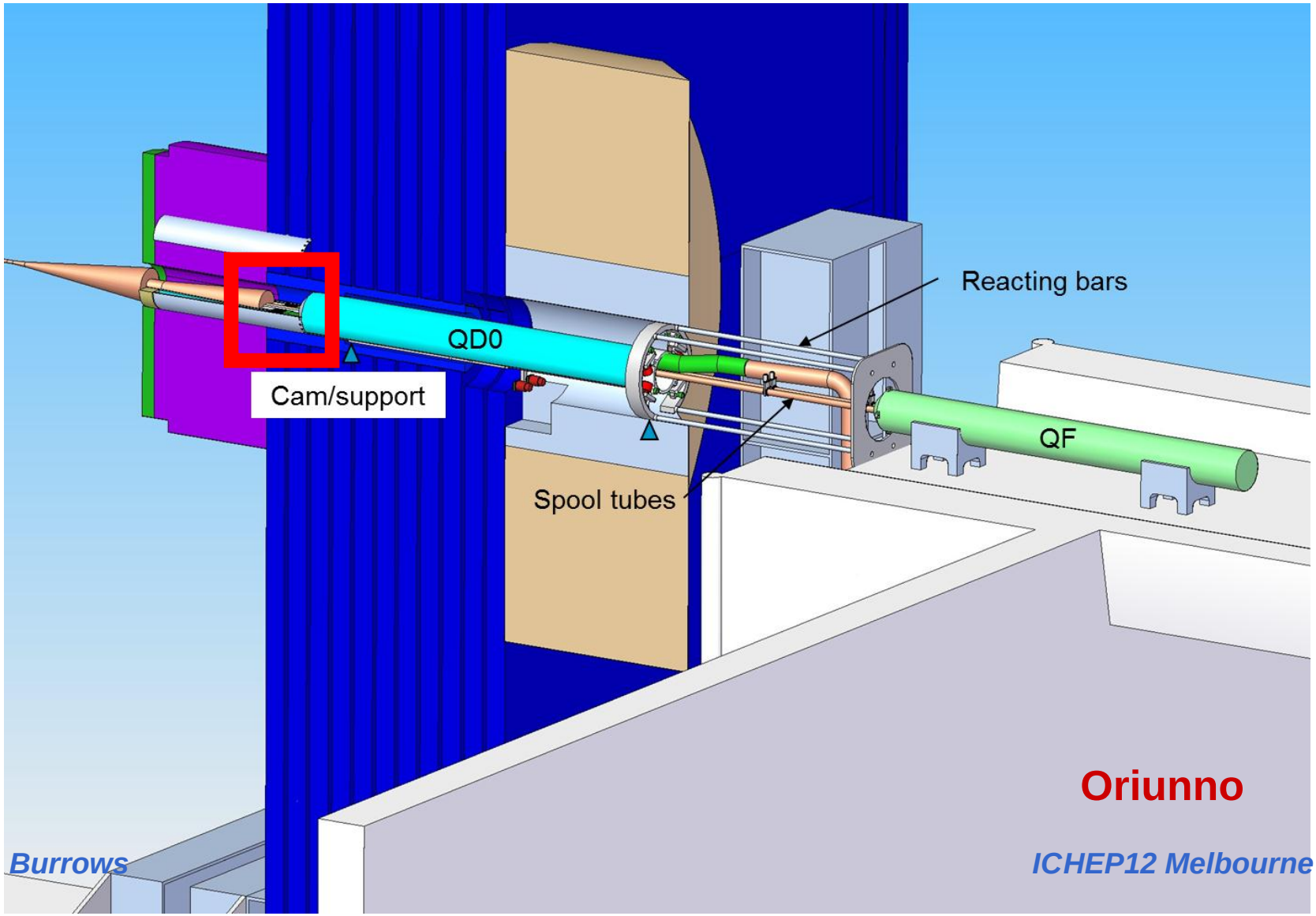


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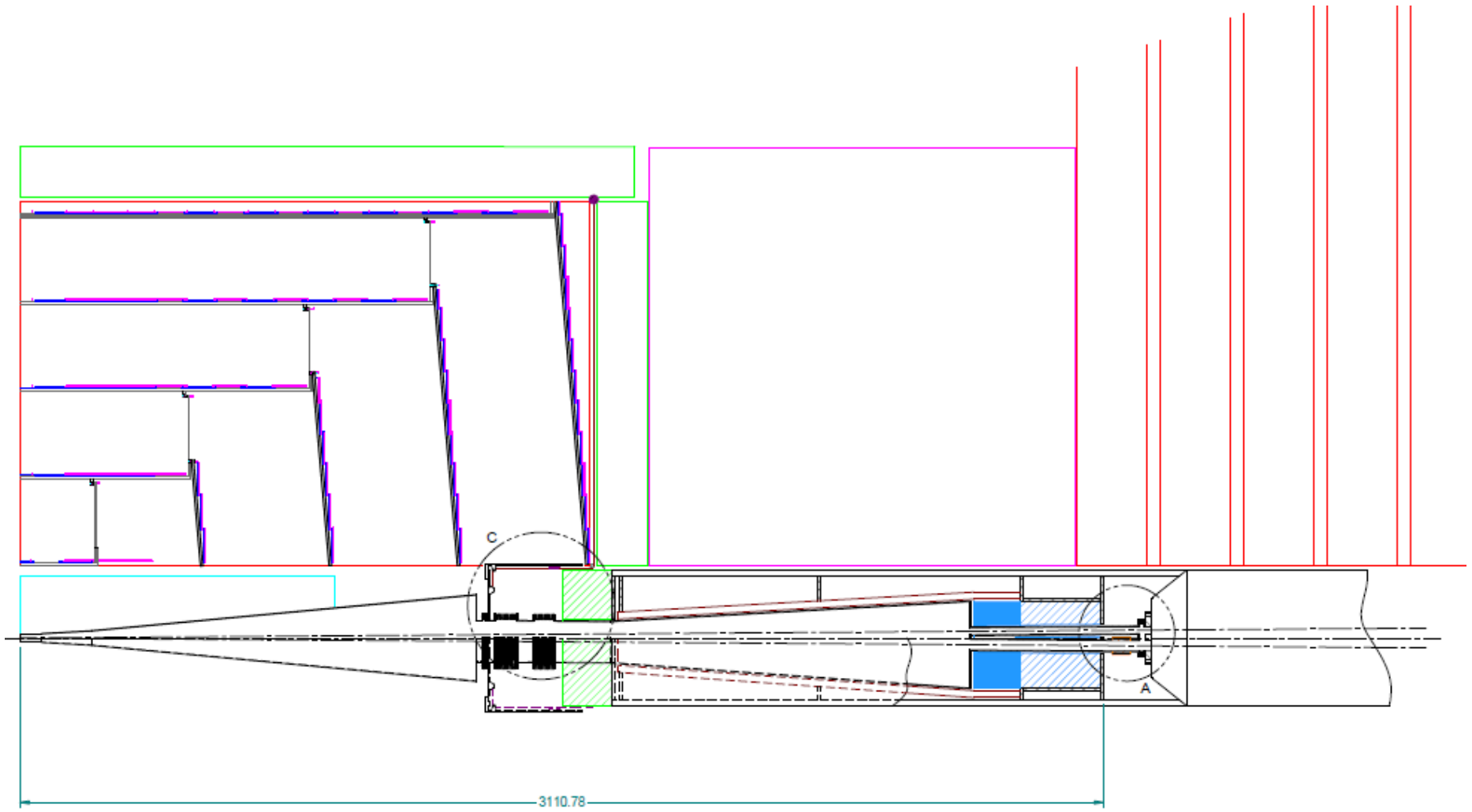

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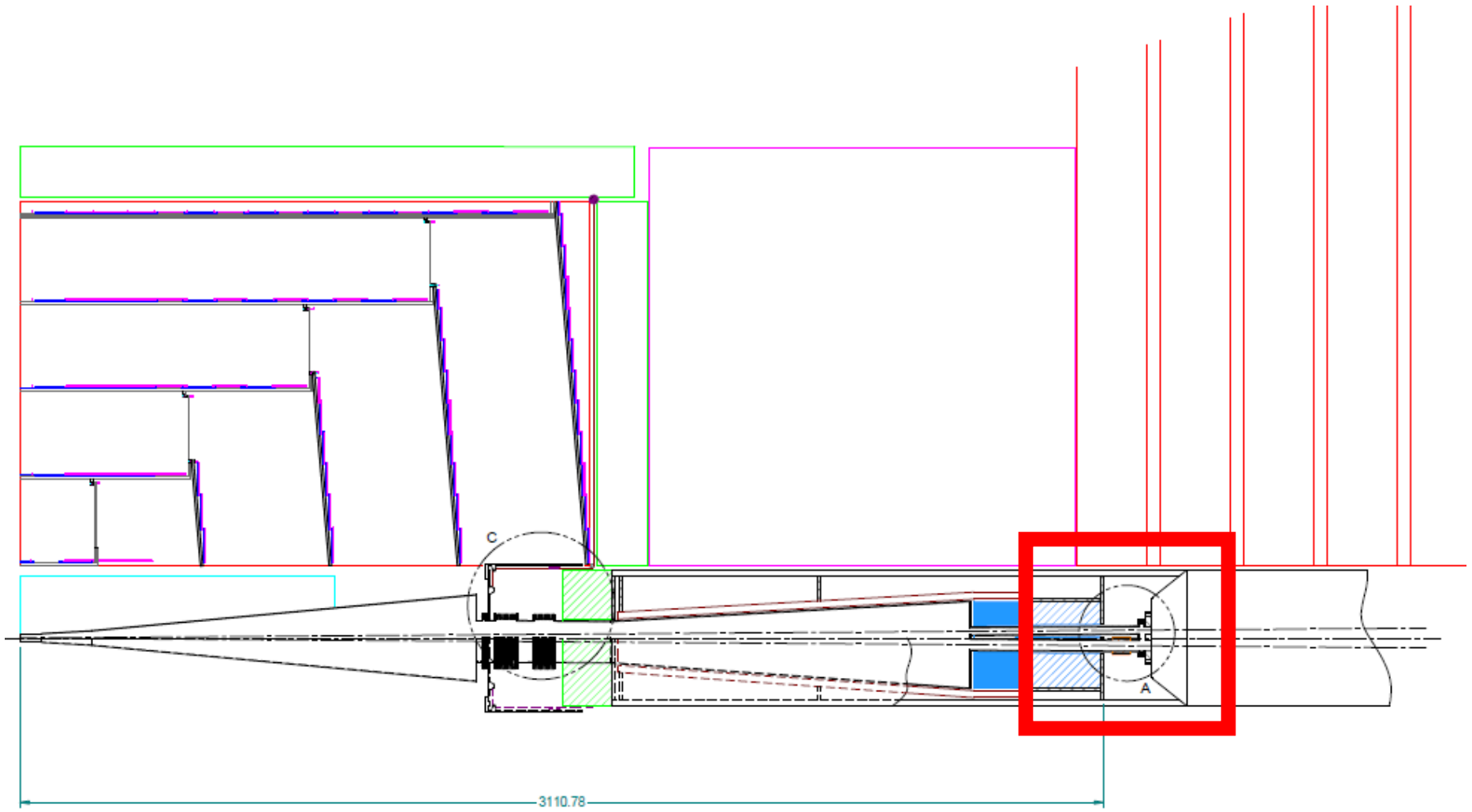
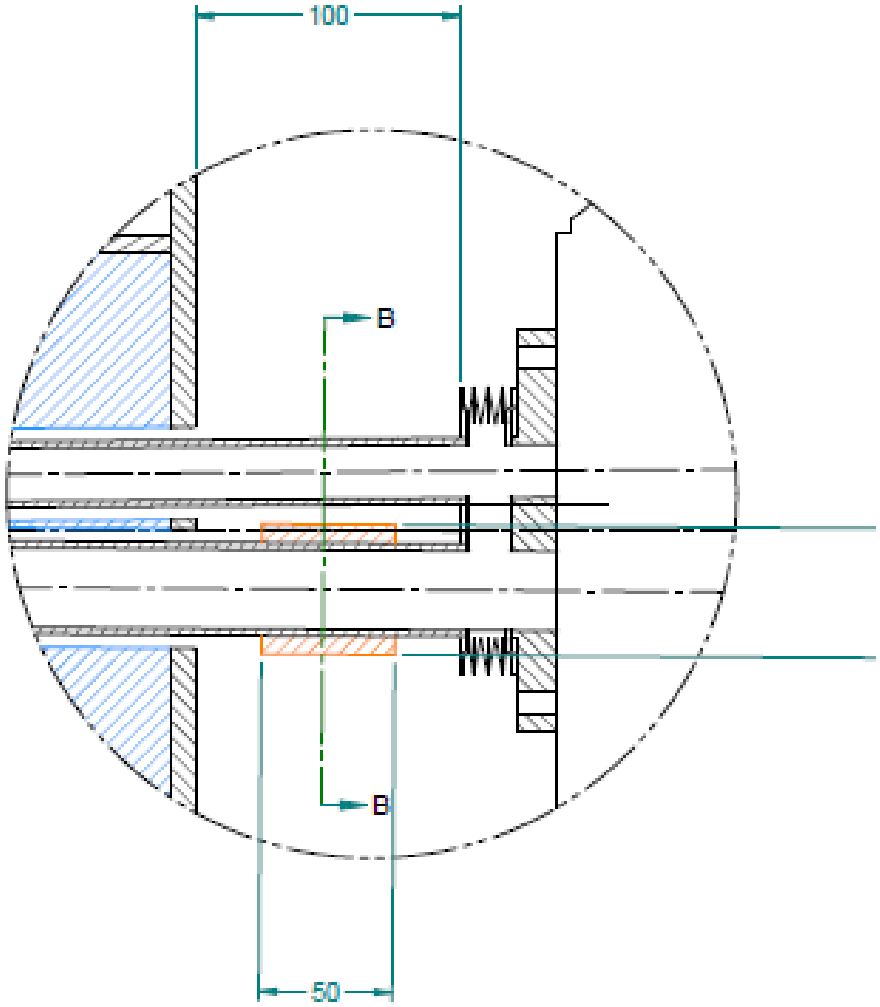
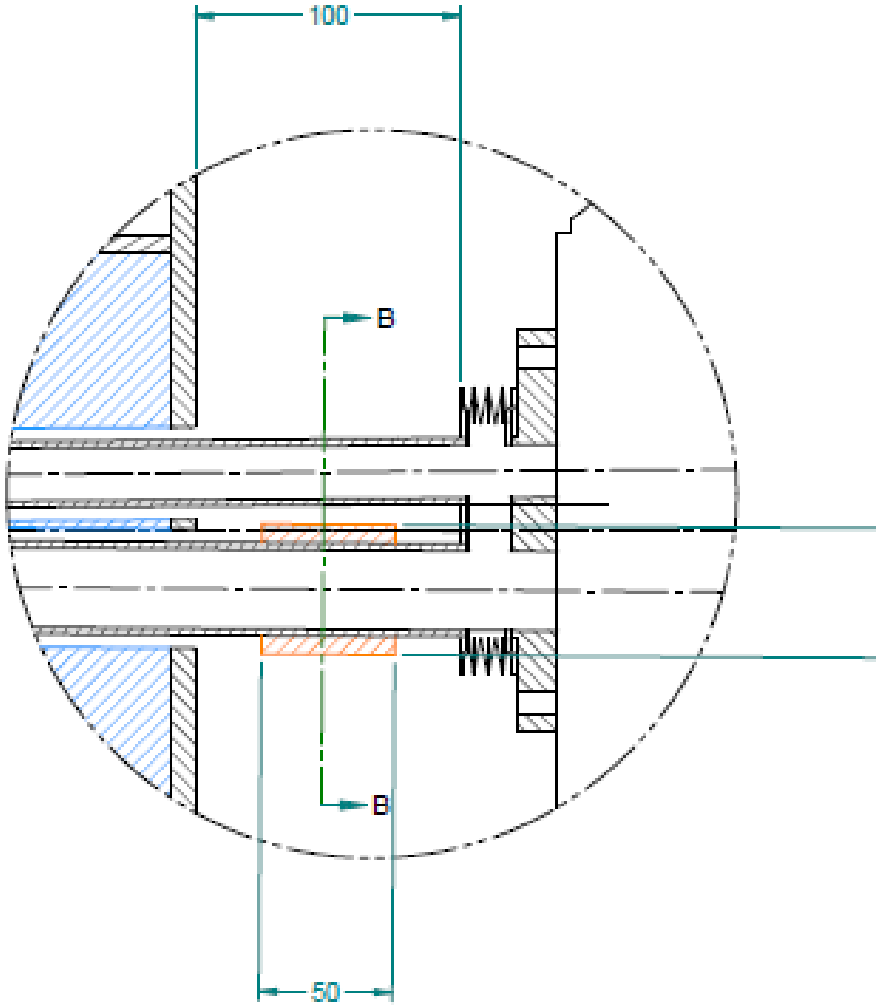


# Beamcal – QD0 Region (SiD)




DETAIL A
SCALE 4:1

# IP FB BPM Detail (SiD)

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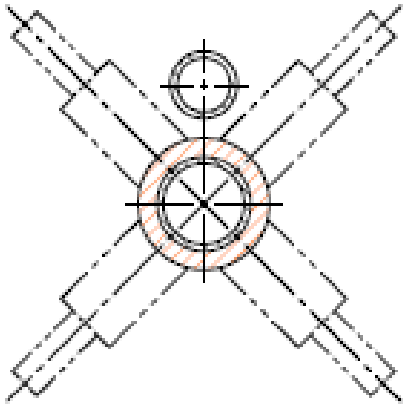
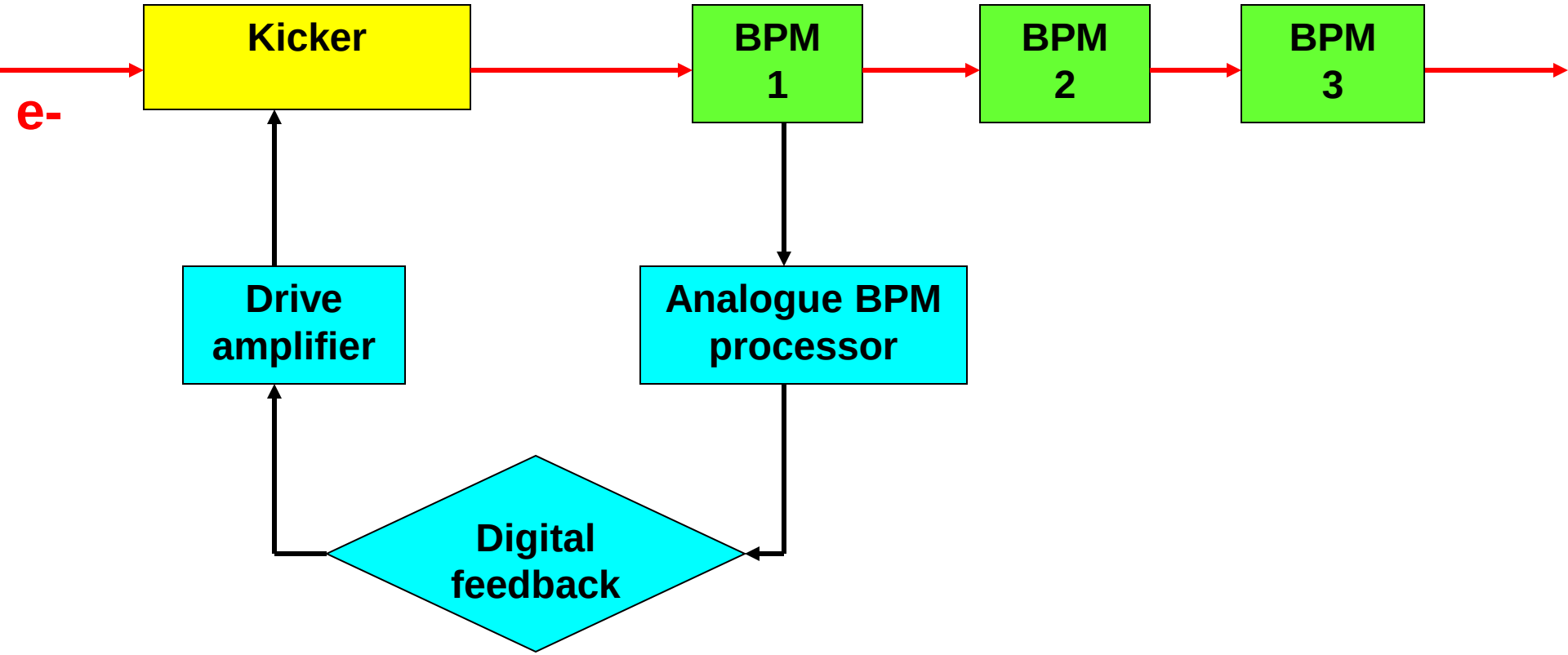
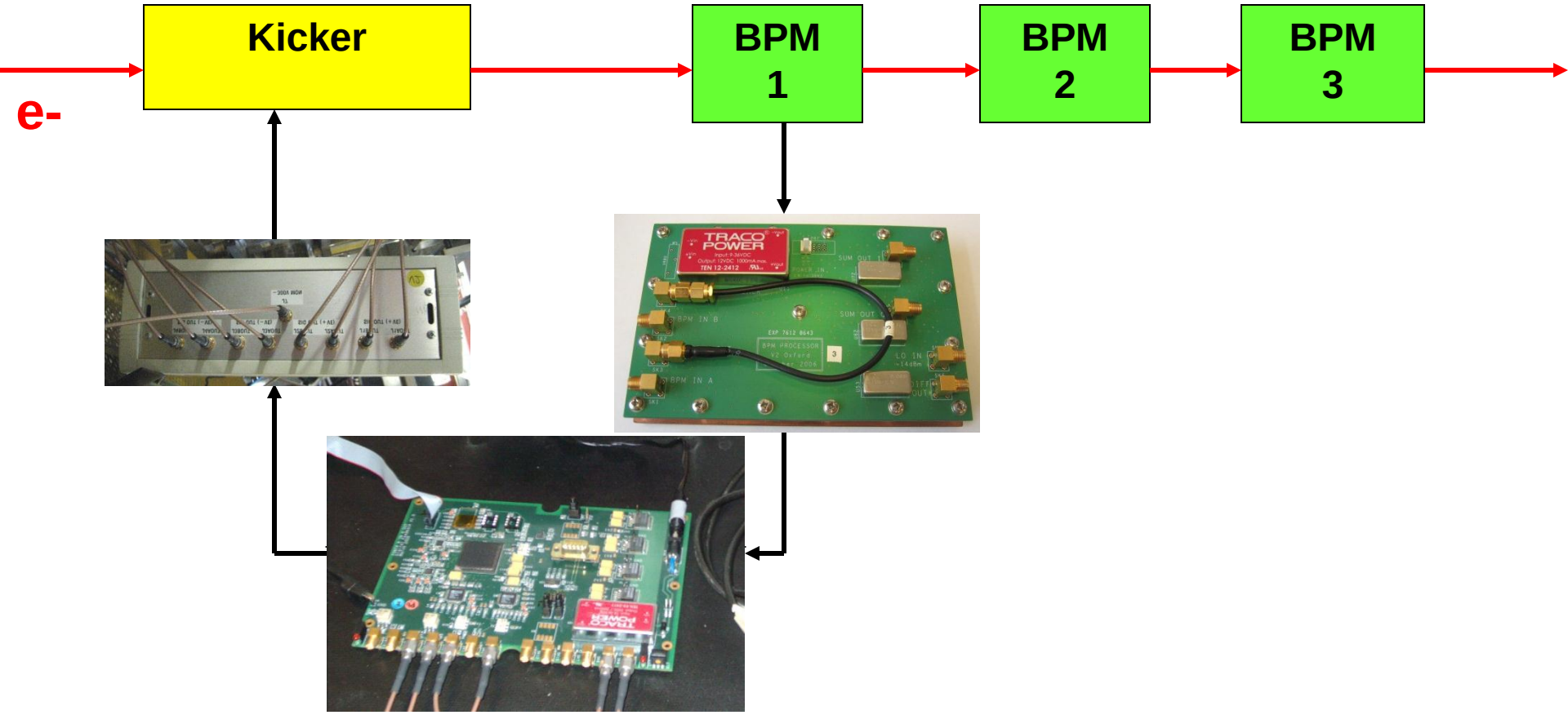


SECTION B-B
SCALE 4:1

# FB prototypes: FONT at KEK/ATF



# ILC prototype: FONT4 at KEK/ATF



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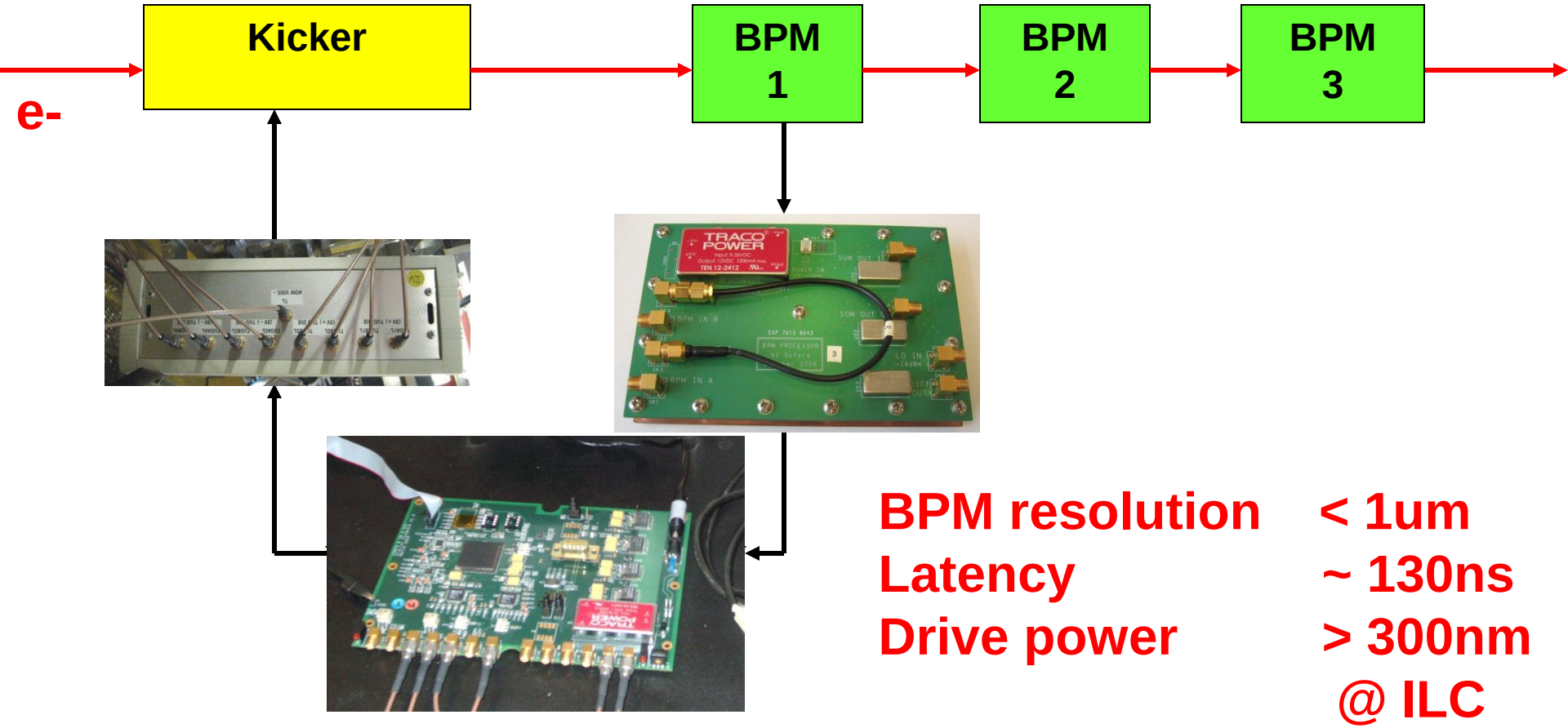



**BPM resolution** **< 1um**
**Latency** **~ 130ns**
**Drive power** **> 300nm @ ILC**

# Latency

- Time of flight kicker – BPM: 12ns
- Signal return time BPM – kicker: 32ns

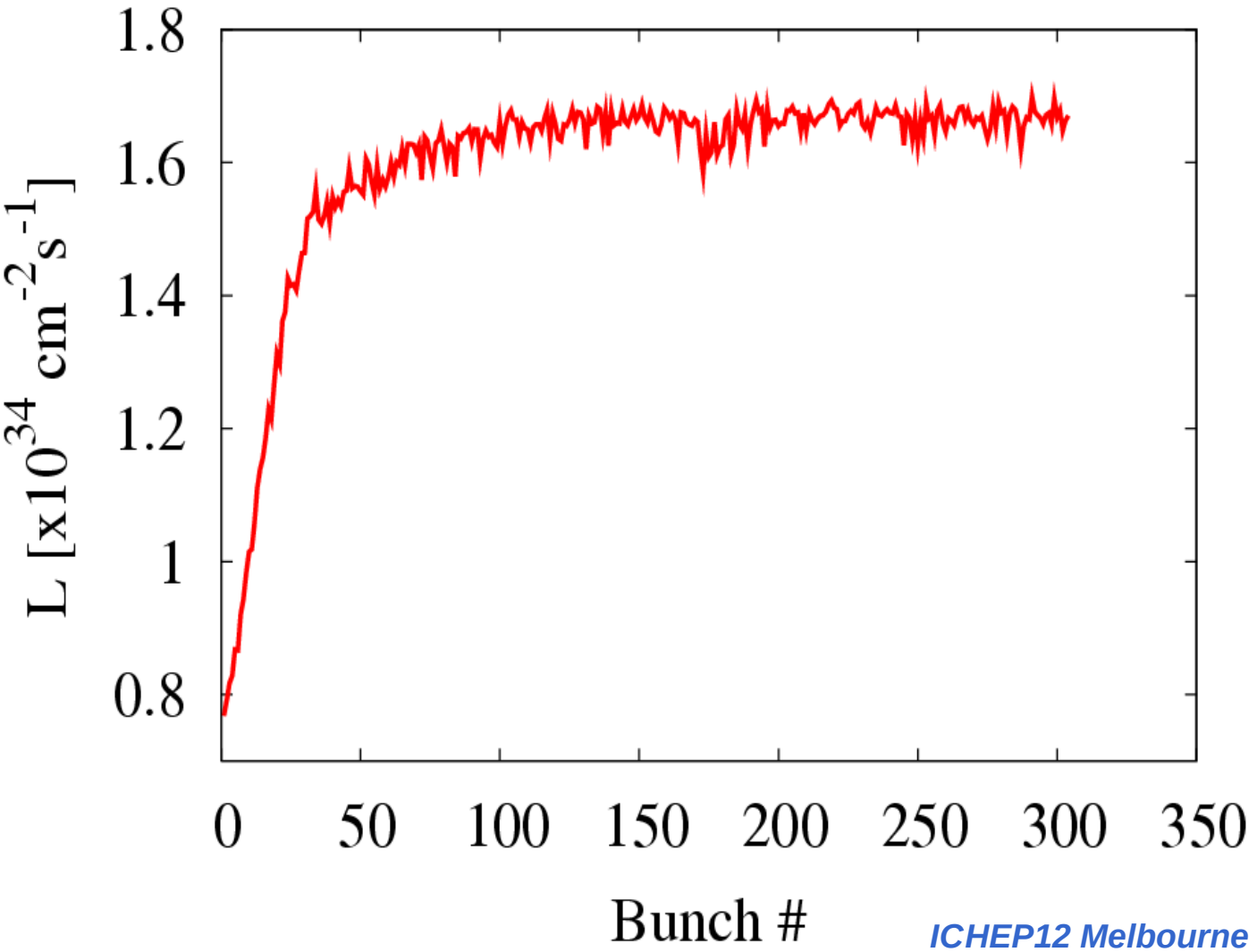
  Irreducible latency: 44ns

- BPM processor: 10ns
- ADC/DAC (4.5 357 MHz cycles) 14ns
- Signal processing (8 357 MHz cycles) 22ns
- FPGA i/o 3ns
- Amplifier 35ns
- Kicker fill time 3ns

  Electronics latency: 87ns

- Total latency budget: 131ns

# ILC IP FB performance

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*ICHEP12 Melbourne 7/7/12*

# IP FB Design Status: CLIC

**Conceptual design developed and documented in CLIC CDR (2011)**

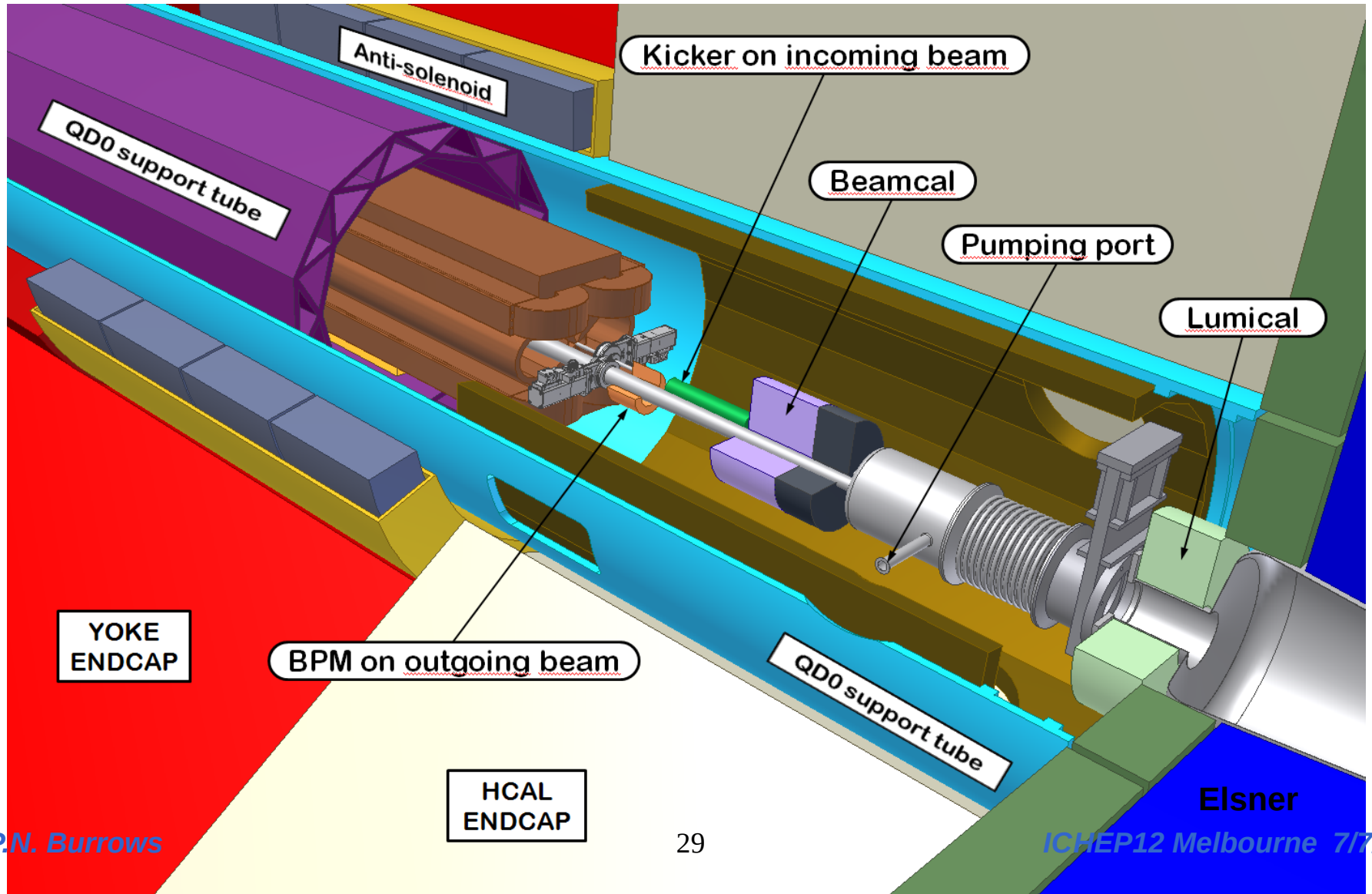
**NB primary method for control of beam collision overlap is via vibration isolation of the FF magnets, and dynamic correction of residual component motions**

**IP position feedback:**

**beam position correction up to +- 50 nm vertical at IP**

**More realistic engineering design can be developed in next project phase**

# CLIC Final Doublet Region



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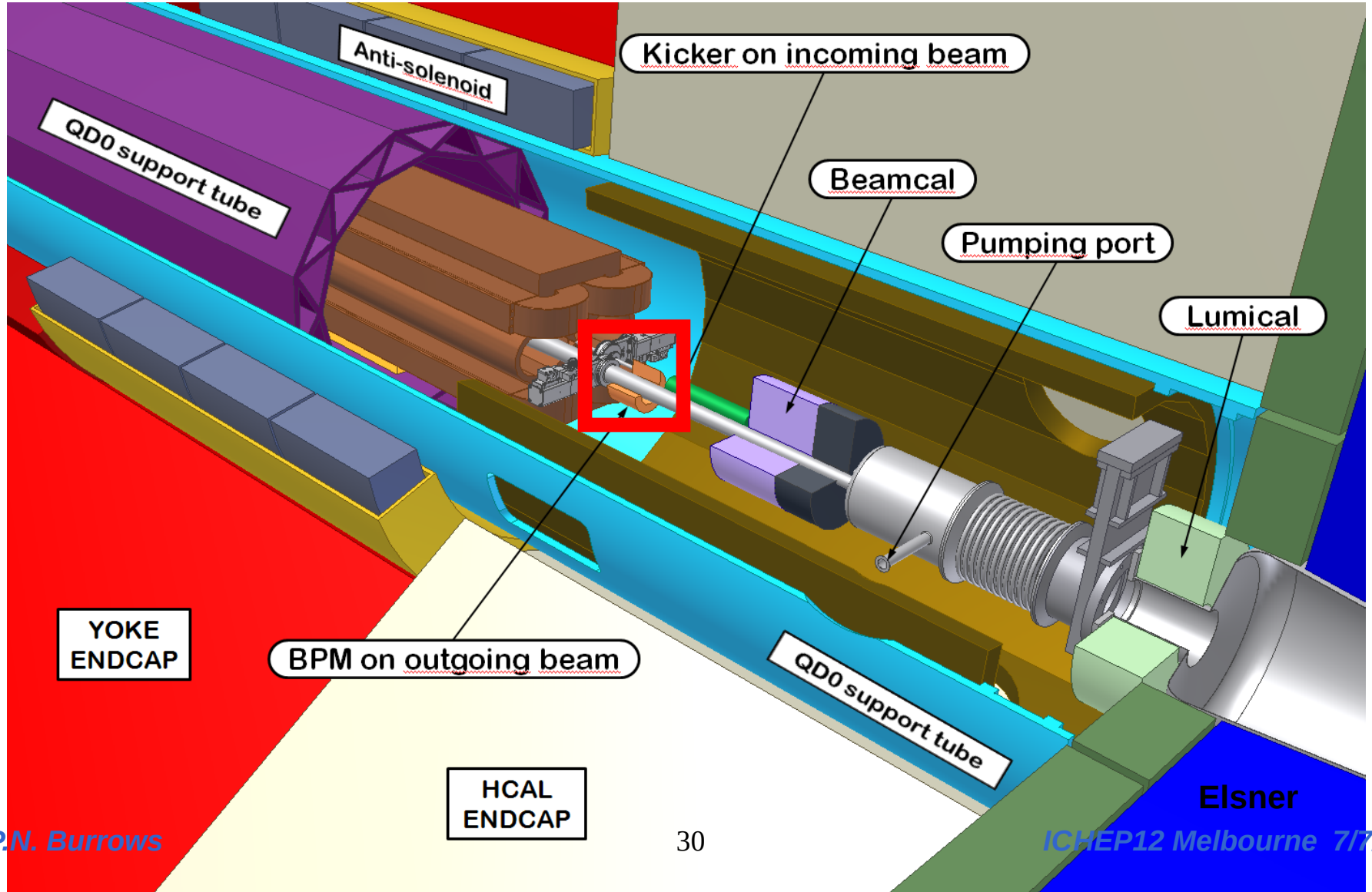

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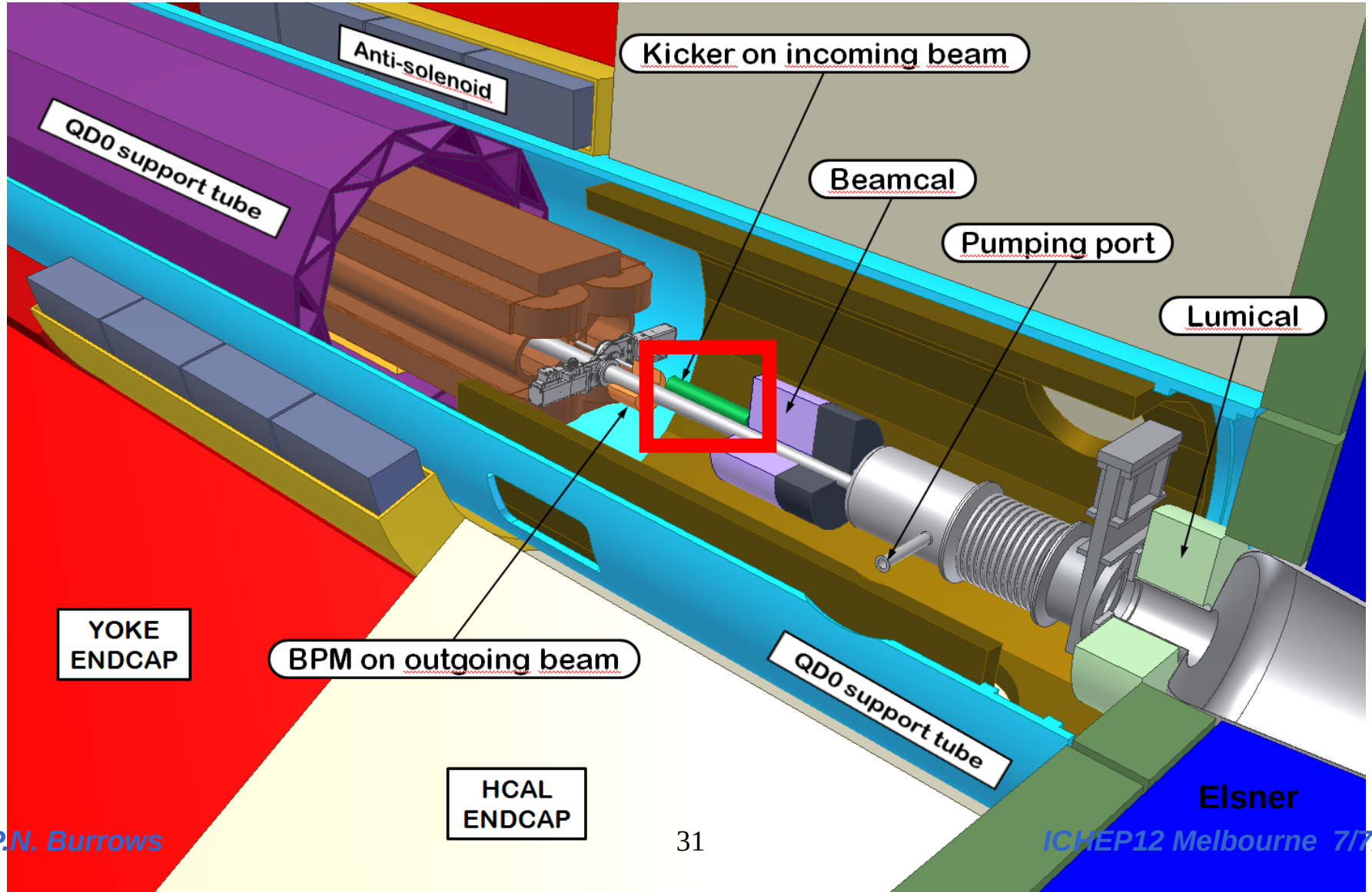

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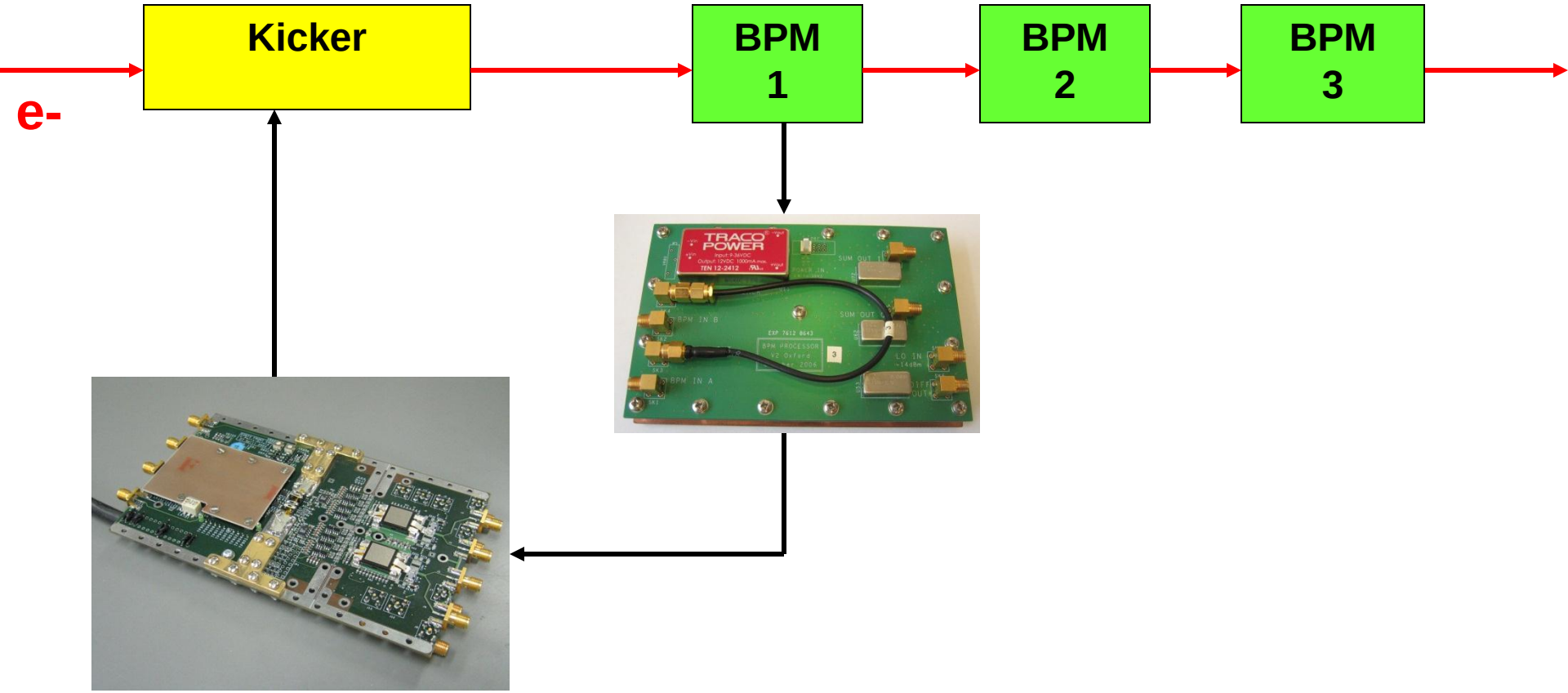

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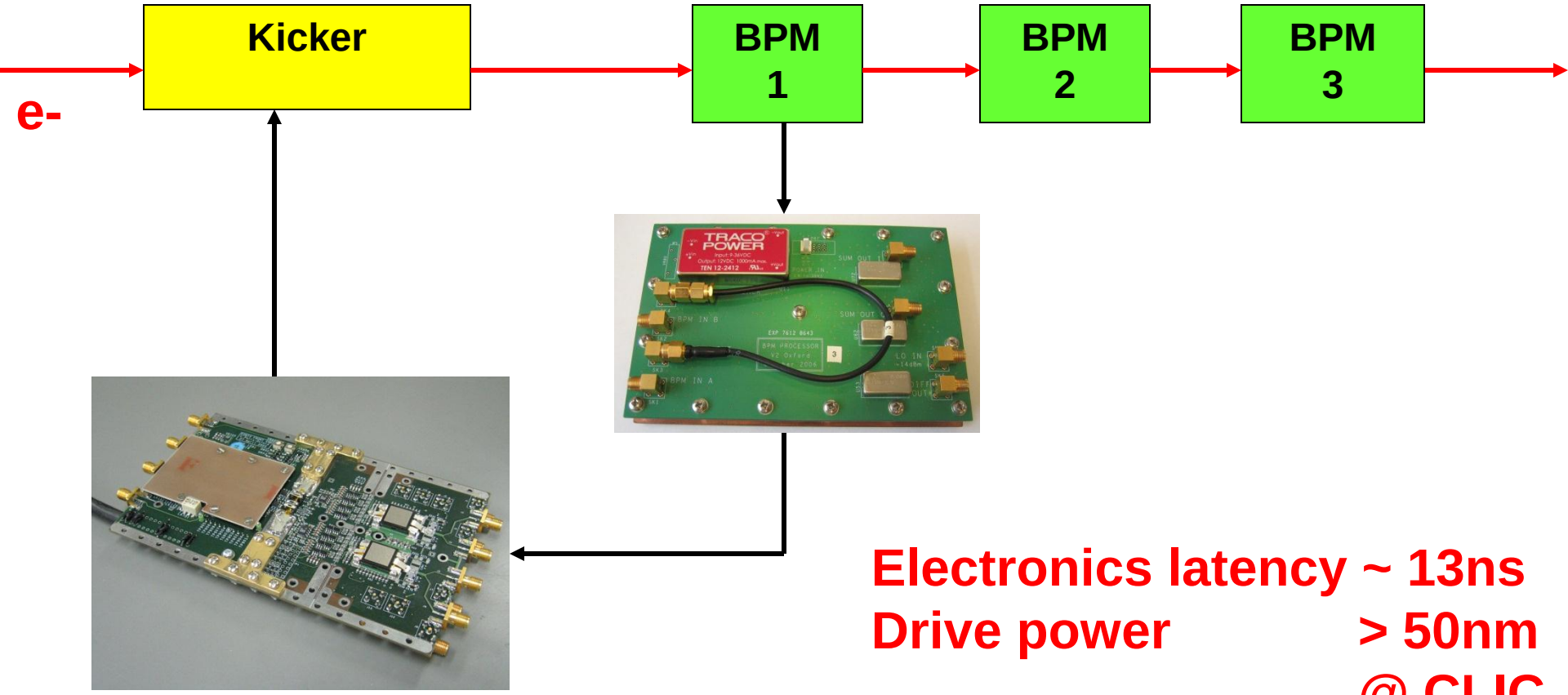
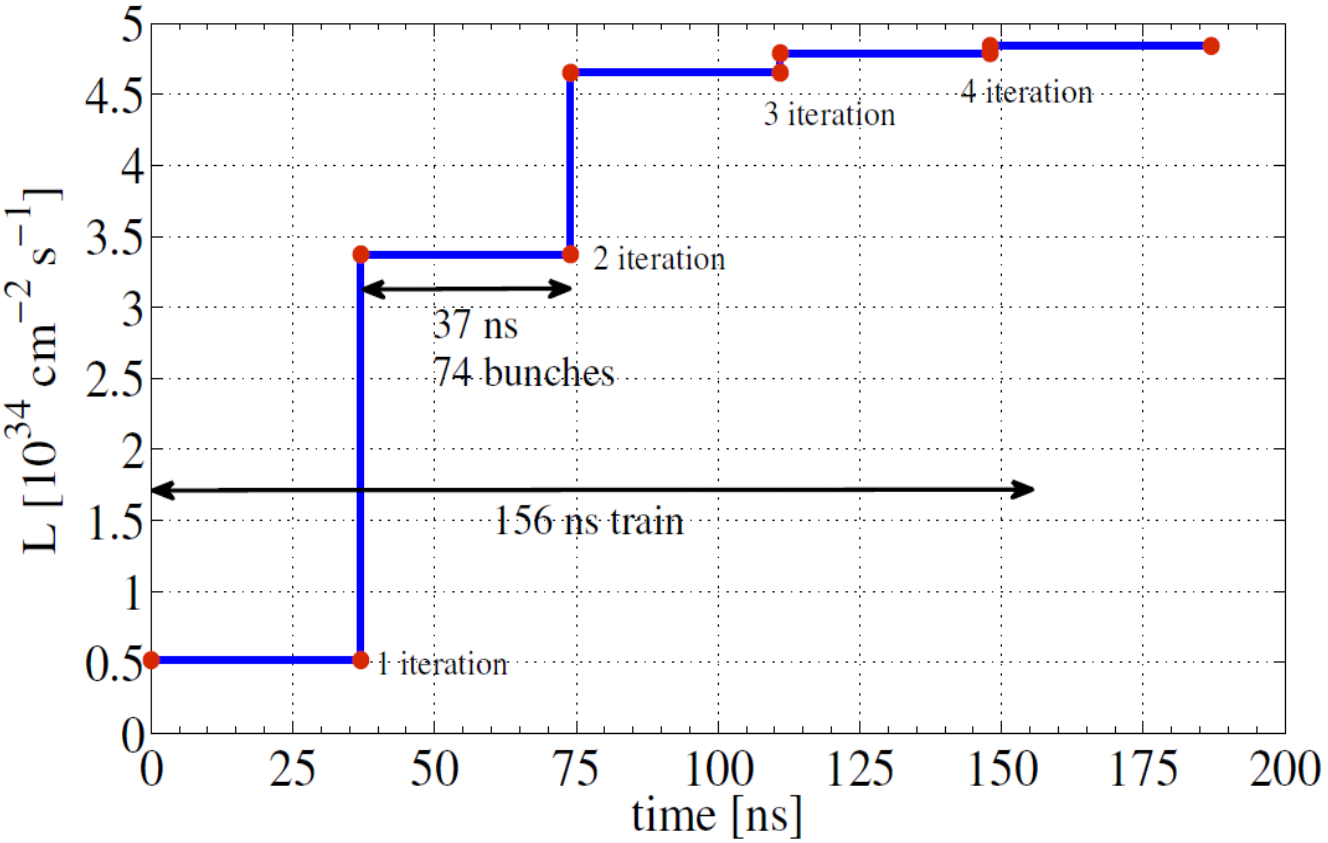



**Electronics latency ~ 13ns**
**Drive power > 50nm @ CLIC**

# CLIC IP FB performance

**Single random seed of GM C**

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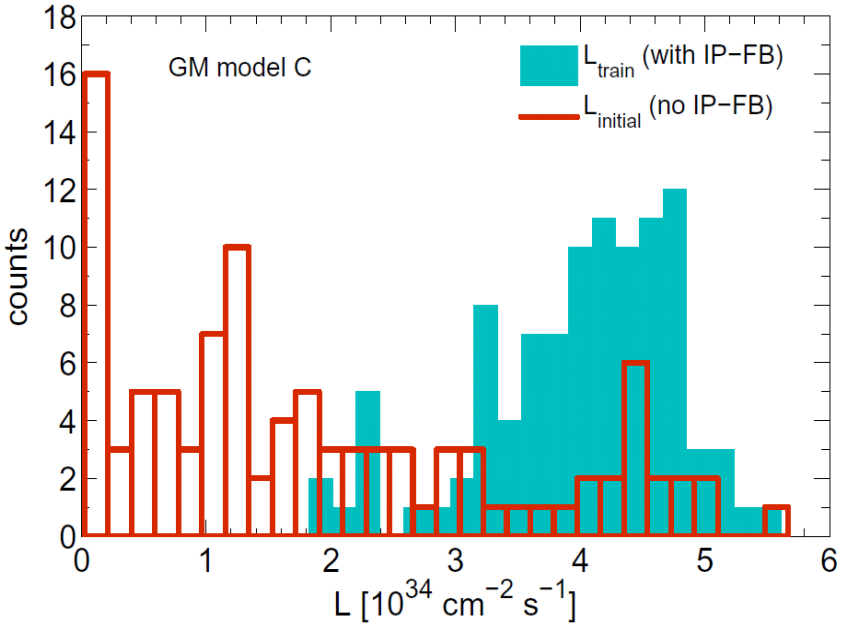
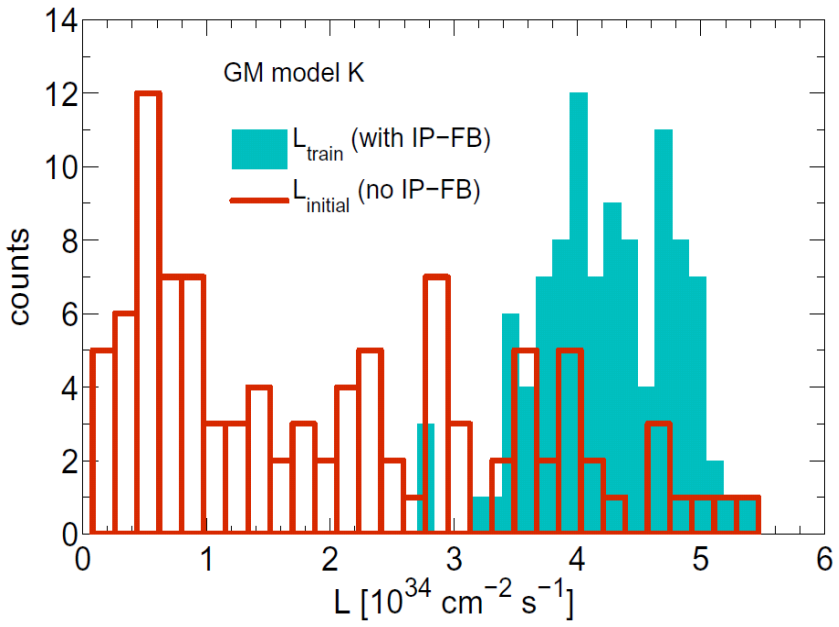
# CLIC IP FB performance

**For noisy sites:**




→ **factor 2 - 3 improvement**

# Outstanding Technical Issues

- **Component designs optimised for tight spatial environment**
- **Routing of cables**
- **Operation of (ferrite) devices in large, spatially-varying B-field**
- **Further studies of radiation environment**
- **Electronics location, rad hardness, shielding**
- **RF interference: beam ←→ FB electronics**

  **kicker ←→ detector**

# Summary

- **Well developed IP collision FB system designs for both ILC and CLIC**
- **Simulations demonstrate luminosity recovery capability**
- **Demonstrated prototypes with required performance parameters**
- **Progress on designing customised beamline components (ILC)**