CMS GEM H4 Test Beam Update

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On behalf of the CMS GEM collaboration

CMS GEM H4 Campaign: Original Plan

- **Originally targeted six detectors:**
  - **GE1/1-IV irradiated at GIF**
  - **GE1/1-IV not irradiated**
  - **GE1/1-V**
  - **GE1/1-III with multi-channel power supply**
  - **GE1/1-III with CMS 2016 slice test electronics**

- **Operating conditions:**
  - **Ar/CO2/CF4 (45/15/40)**
  - **Gain scanned from O (10^2) to O (10^4)**
  - **Muon beam (150 GeV)**

- **Main goals:**
  - **Detection efficiency vs HV**
  - **Time resolution (time efficiency) vs HV**
  - **Spatial resolution vs HV**
  - **Performance of CMS GEM superchambers**
  - **Repeated at three different (η, ϕ) sectors**

# CMS GEM H4 Campaign: Current Status

- **Five detectors (hopefully six):**
  - GE1/1-IV irradiated at GIF
  - GE1/1-IV not irradiated
  - GE1/1-IV not irradiated from INFN:LNF (Frascati)
  - ~~GE1/1-V~~
    - **Hope to install post scrubbing period**
  - ~~GE1/1-III with multi-channel power supply~~
    - **10x10cm2 triple-GEM detector with multi-channel power supply**
  - GE1/1-III with CMS 2016 slice test electronics

- **Operating conditions:**
  - Ar/CO2/CF4 (45/15/40)
  - Muon & pion beams (150 GeV)

- **Despite setbacks we have completed 2 out of 3 (η,φ) sectors for three of the GE1/1 detectors**
  - Hope to finish final sector after scrubbing period

To Control Room

Cable Routing

Rack 1

Rack 2

Euro-crate

PC 1

PC 2
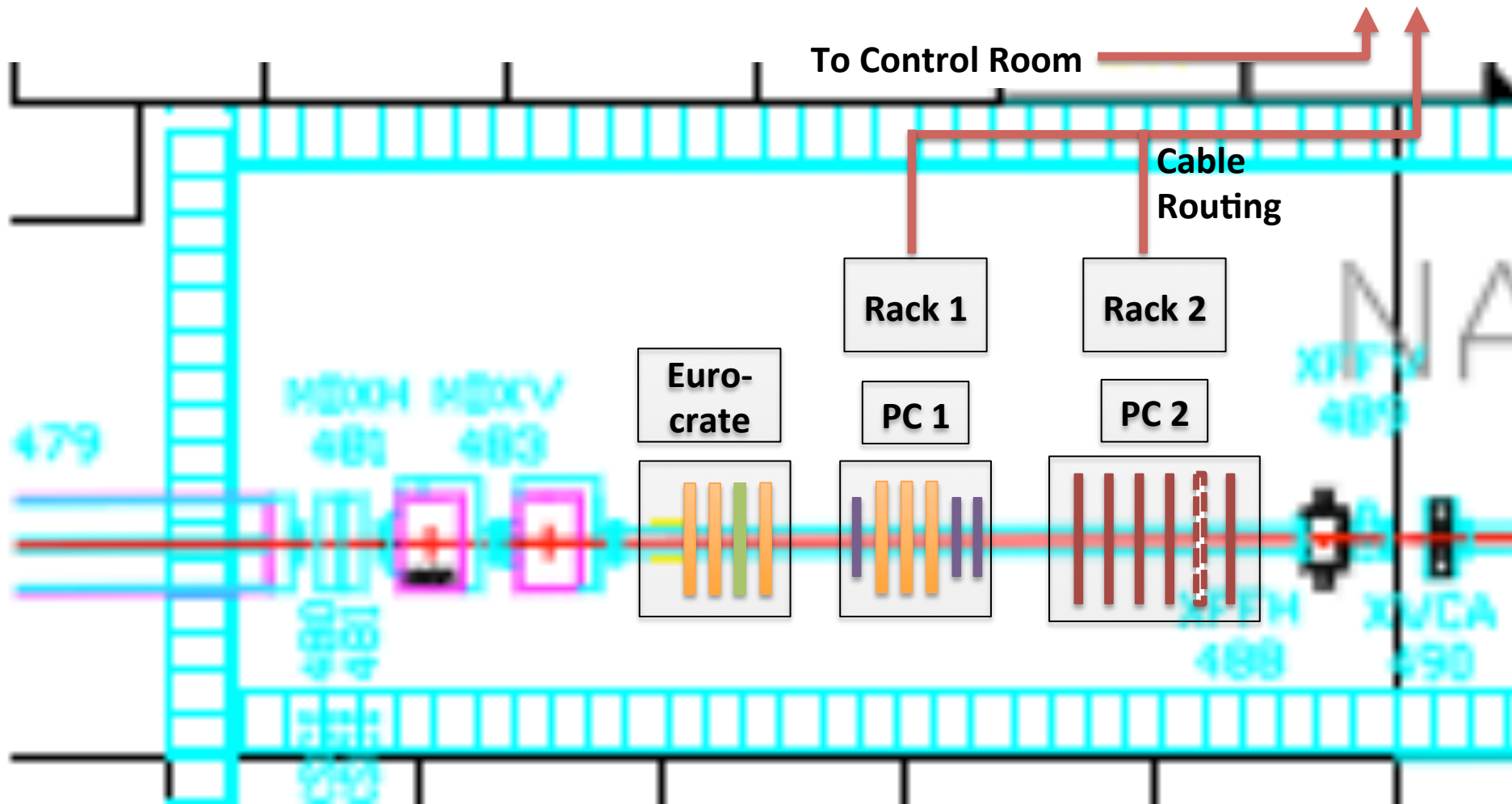
- **Asynchronous Mode**
  - **Triggers are *not* correlated with the clock**

- **Synchronous Mode**
  - **Triggers are correlated w/leading edge of the clock**
  - **i.e. *LHC mode***

Asynchronous Mode…

- **Triggers random w/respect to leading edge of clock**

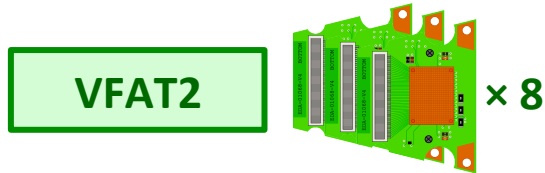**25ns**

Clock

Triggers (rand. w.r.t clock)
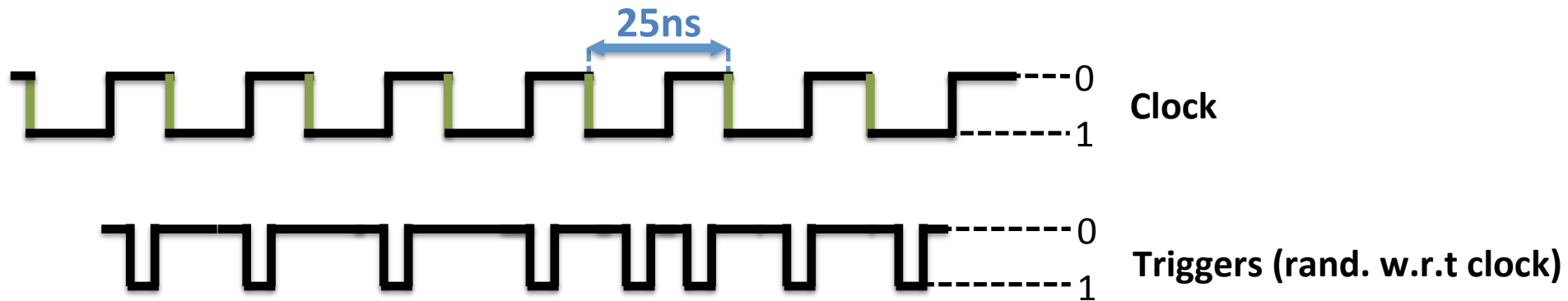
- **Any triggers accepted regardless of clock position**
- **The random position of the trigger with respect to leading clock edge can cause an artificial change in latency**
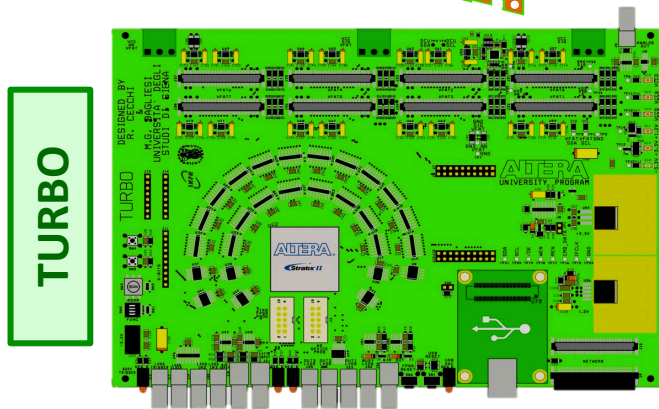
- **Triggers correlated with leading edge of clock**

25ns

Clock

Clock (delayed)

Clock Scan Gate

t_c

t_{dly} t_{dly} t_{dly}

Triggers (rand. w.r.t clock)
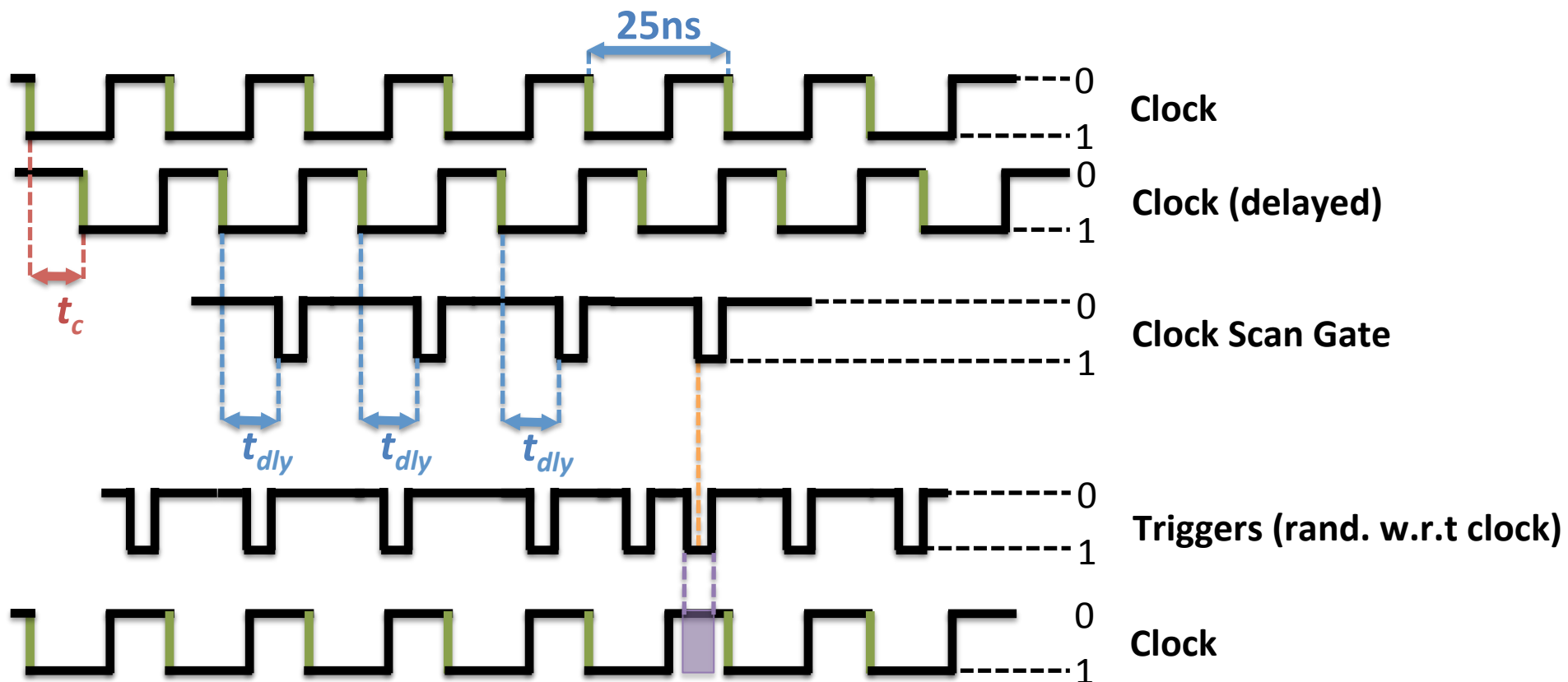
Clock

- **Triggers accepted only in a certain position of clock**

VFAT2

× 8

TURBO

- **Controls up to 8 VFATs per TURBO**
- **Only capable of forwarding one SBIT signal out to rack**
- **Clock frequency: *40 MHz***

- **Master board controls multiple boards**
  - **Creates clock and sends via external cable to all boards**
- **Not possible to monitor clock created by master**
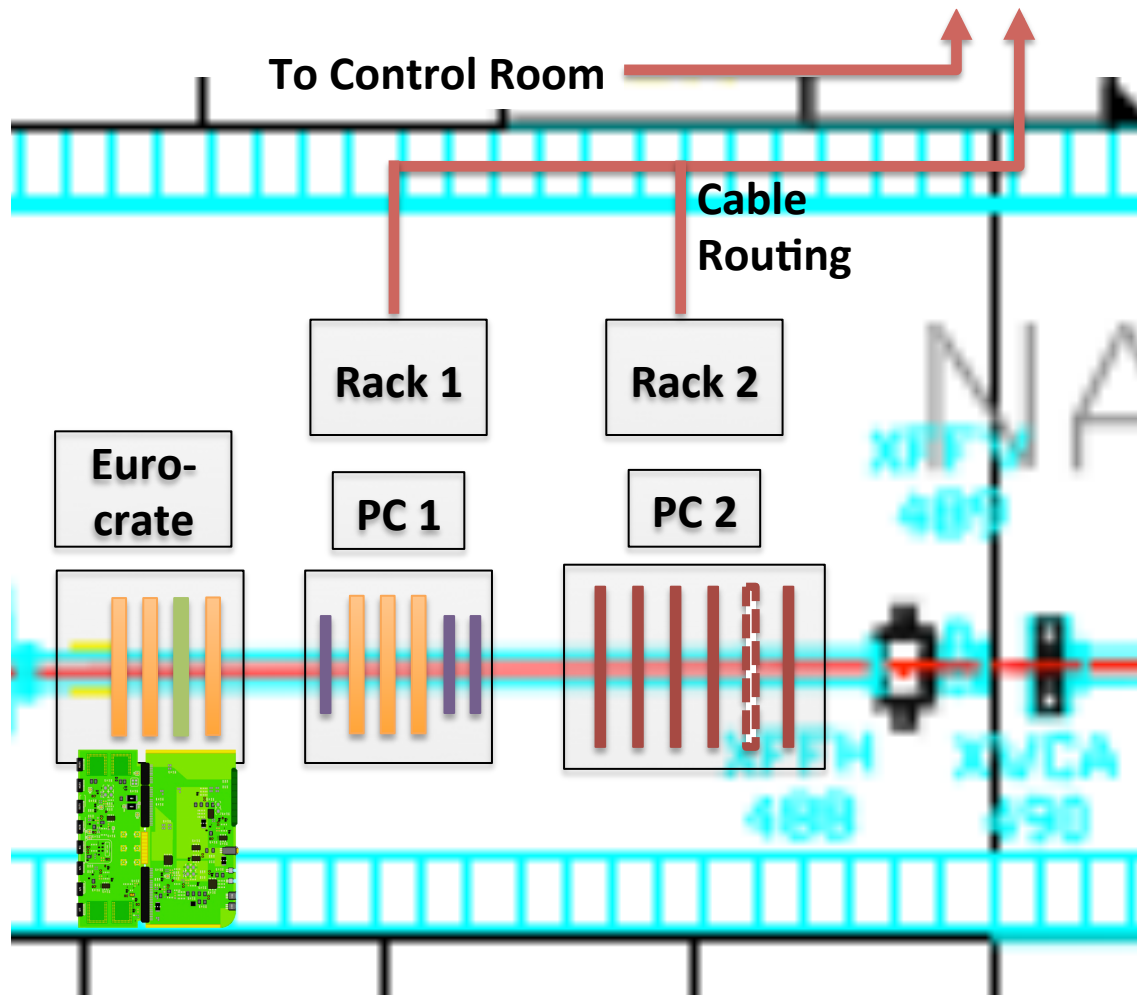 - **Can only see forwarded clock signal from slave boards**
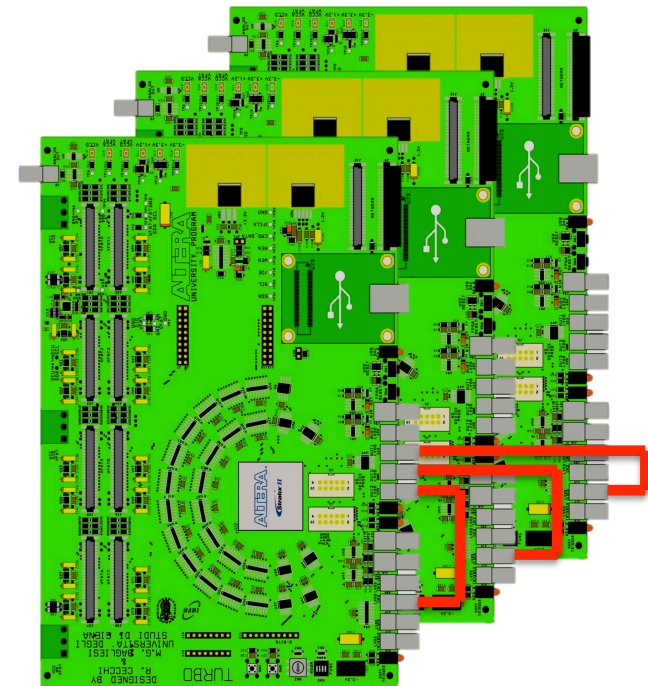
- **TURBOs allow performance measurements: Detection efficiency vs HV**
  - **Time resolution (time efficiency) vs HV**
  - **Spatial resolution vs HV**
  - **Performance of CMS GEM superchambers**

- **Data analysis on-going**

- **Full results comparison planned**
  - **Comparison with Ar/CO_2 data (H2, Oct '14)**
  - **Comparison between different (η, ϕ) sectors (H4, now)**

To Control Room

Cable Routing

Rack 1

Rack 2

Euro-crate

PC 1

PC 2
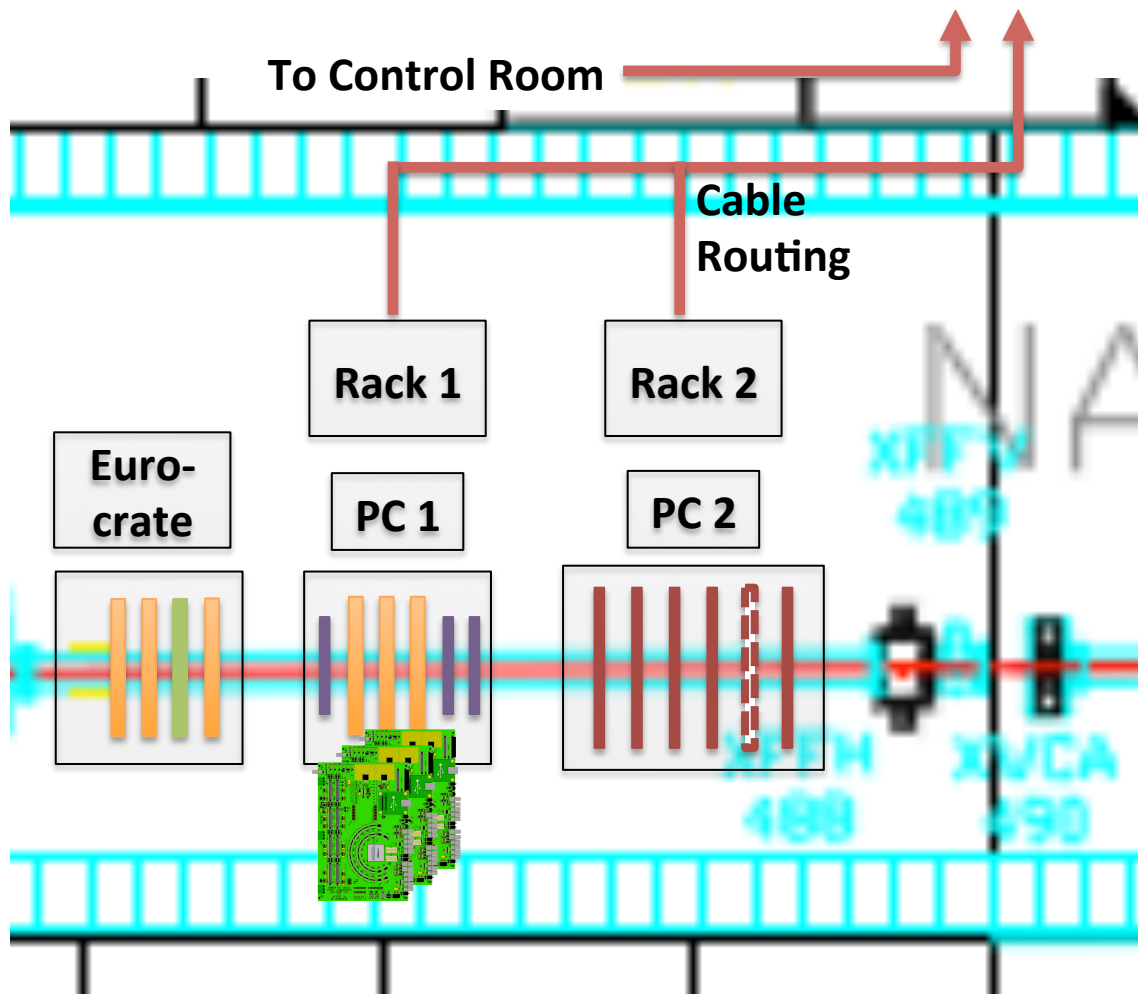
- **Multi-channel power supply potential HV system for CMS GEM LS2 installation**

- **10x10cm2 triple-GEM chamber has been powered by two systems**
  - **Standard CAEN mainframe w/on-detector resistor divider**
  - **Multi-channel power supply**

- **Interested in studying any potential impact on detector performance by switching to multi-channel power supply**
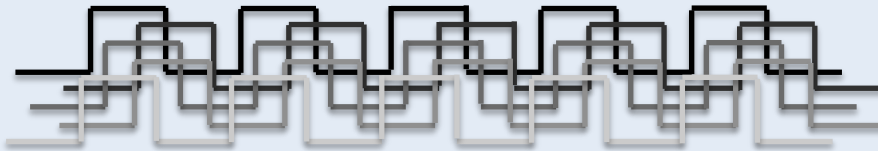

To Control Room

Cable Routing

Rack 1

Rack 2

Euro-crate

PC 1

PC 2

Time Measurement in Asynchronous Mode

Courtesy of J. Merlin

From **TURBO & SCINT**

TRIGG CLOCK SBIT

Data from TDC

trigger

SBIT

25 ns

random position of the trigger with respect to the clock

Delay

TDC

TDC Common Stop

TDC INPUT

TDC OUTPUT

Time Distribution

Stop

Few us window

Time

Time

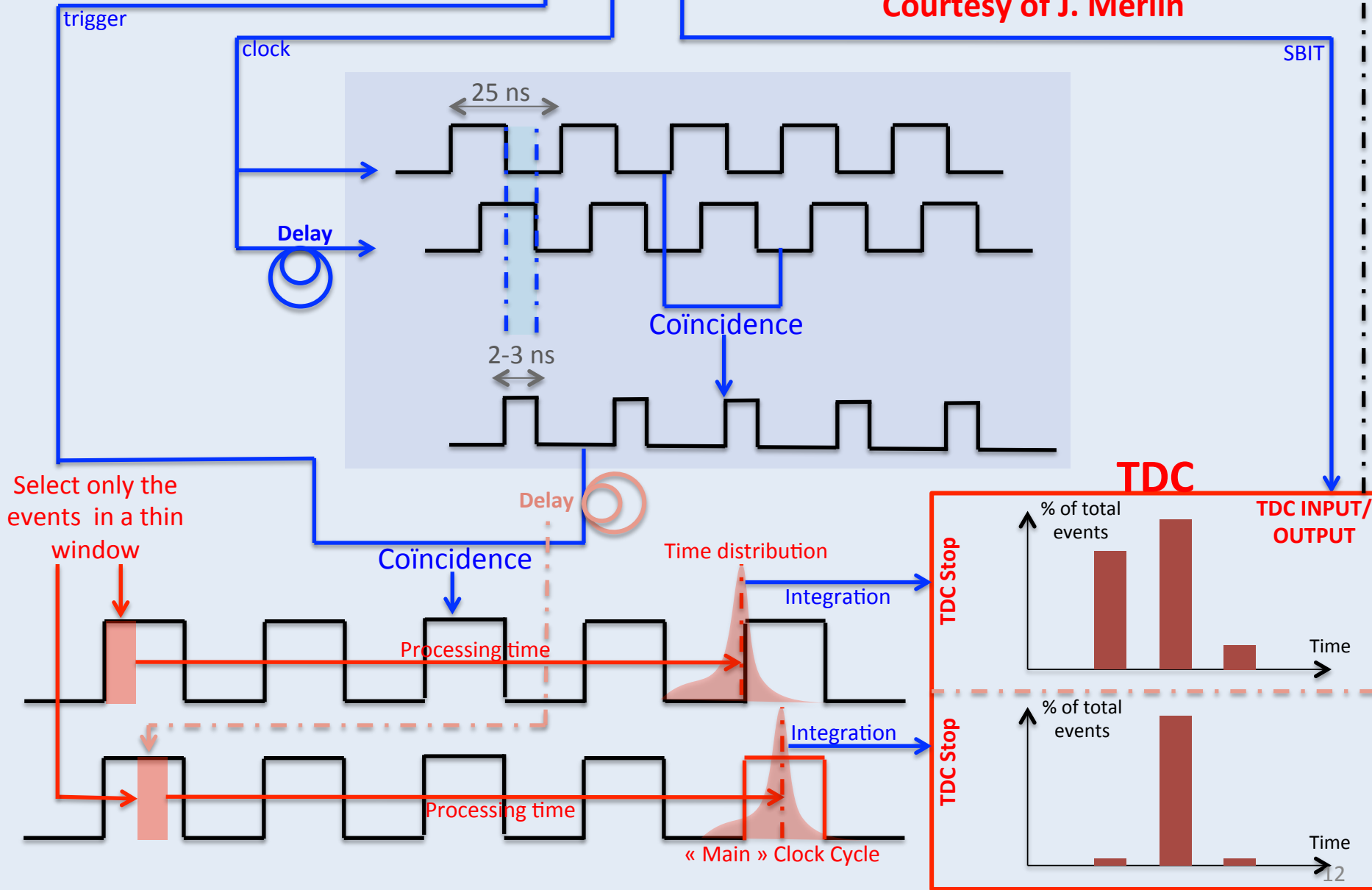Time

Time Measurement in Synchronous Mode

Courtesy of J. Merlin

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CMS GEM H4 Campaign: Summary

- **Five detectors under beam**

- **Completed two-thirds of our measurement program**

- **Hope to install our GE1/1-V detector before beam is back on Wednesday evening**

- ***Data analysis on-going!***

- **Many thanks to Eraldo and the rest of RD51 Collaboration for all your help and support!**
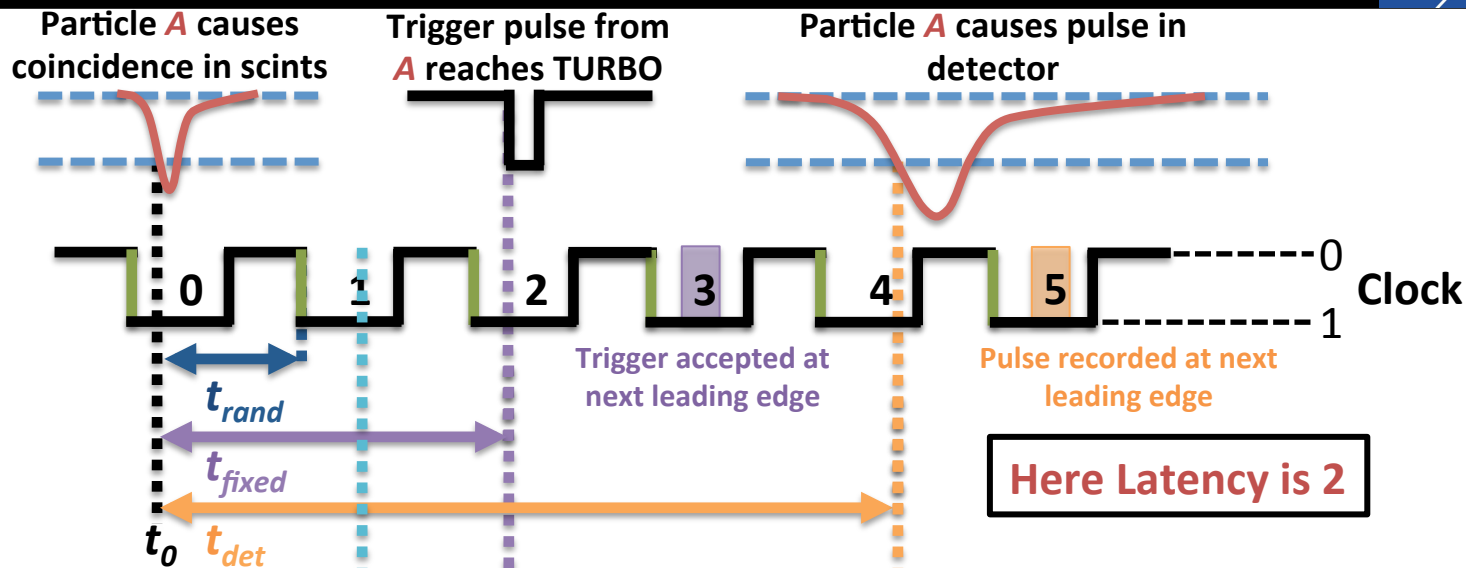
Back – Up

Case 1: t_{rand}

Particle *A* causes coincidence in scints

Trigger pulse from *A* reaches TURBO

Particle *A* causes pulse in detector

Clock

0
1

t_{rand}

Trigger accepted at next leading edge

Pulse recorded at next leading edge

t_{fixed}

t_0 t_{det}

Here Latency is 2

Case 2: $t_{rand} \neq t_{rand}'$

Particle *A* causes coincidence in scints

Trigger pulse from *A* reaches TURBO

Particle *A* causes pulse in detector

Clock

0
1

t_{rand}'

Trigger accepted at next leading edge

Pulse recorded at next leading edge

t_{fixed}

t_0 t_{det}

Here Latency is 3