TTC for CMS CSC & RPC muon systems

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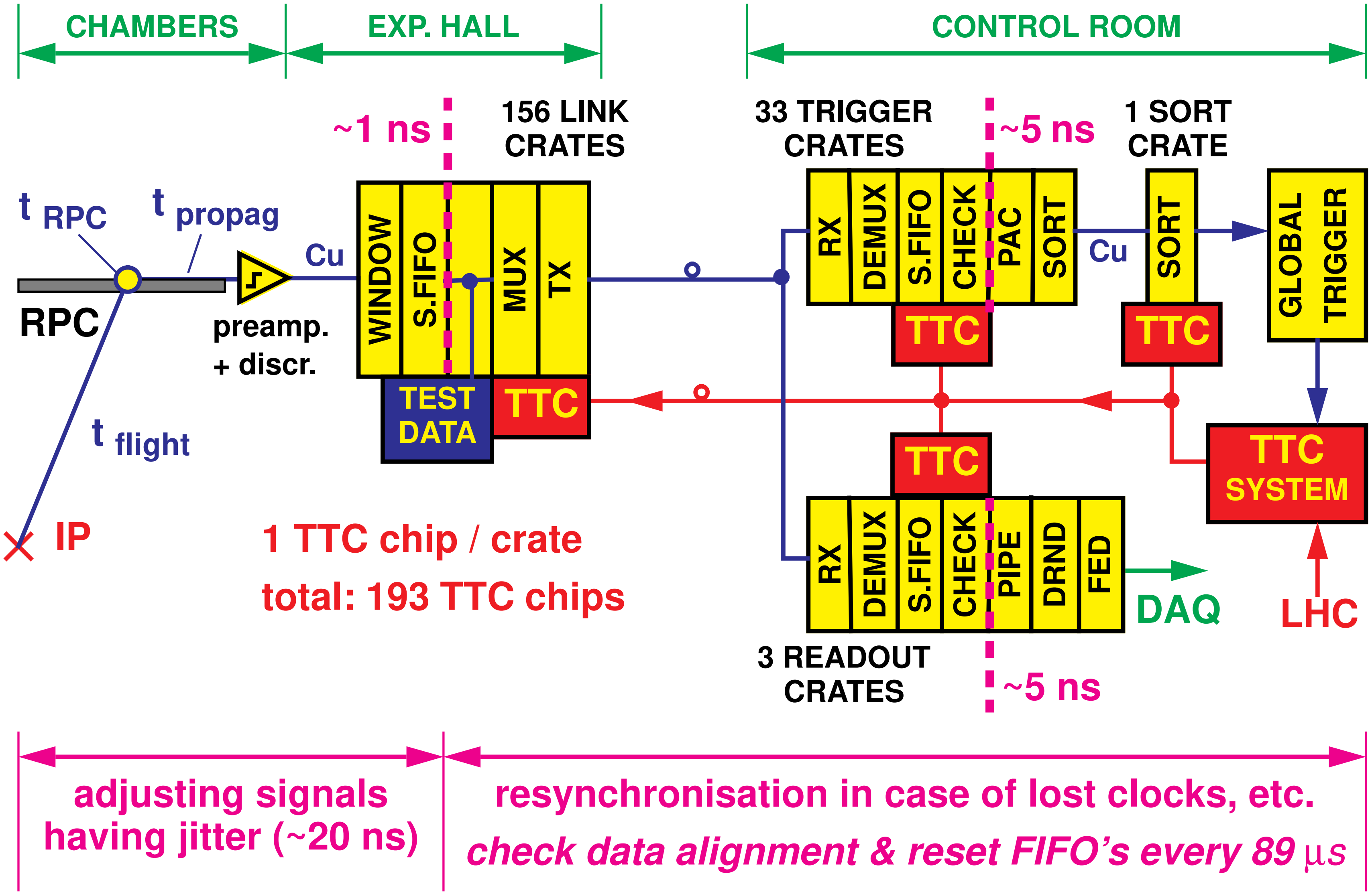
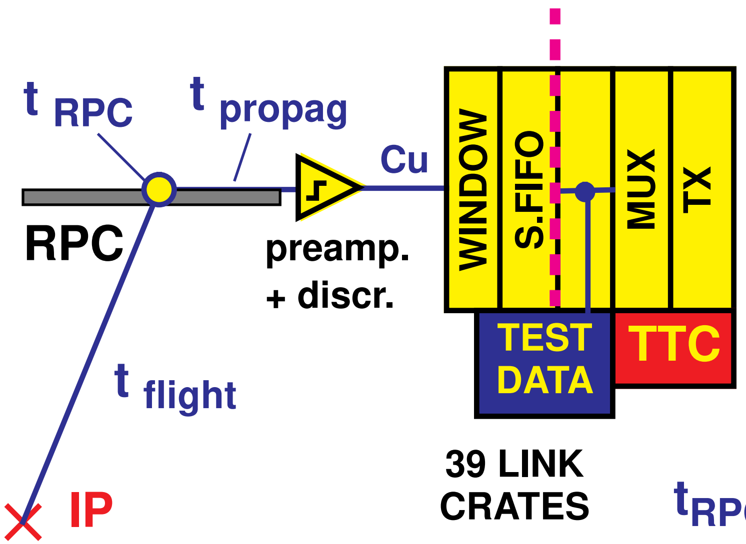
- **Description of the RPC PACT and DAQ system**
- **TTC network for the RPC system**
- **Synchronisation**
- **Description of the CSC trigger and DAQ system**
- **TTC network for the CSC system**

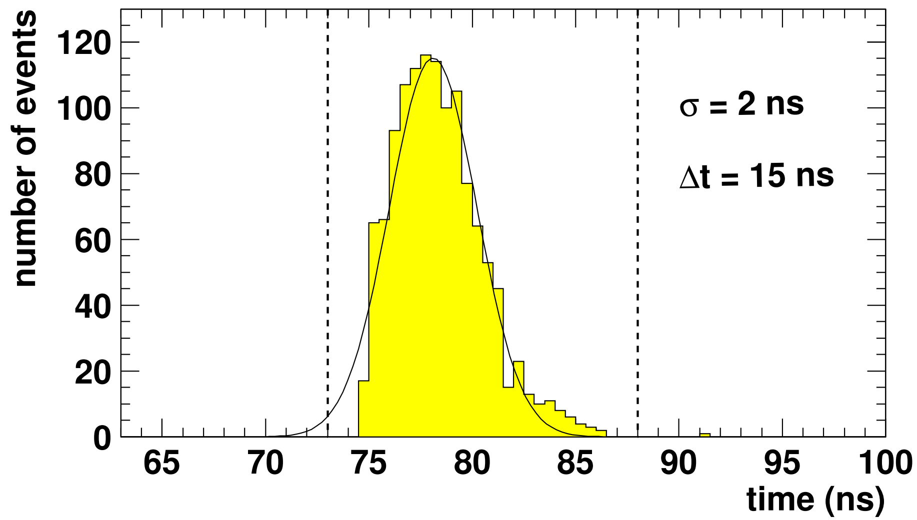
TTC for RPC PACT & DAQ



Alignment of RPC signals

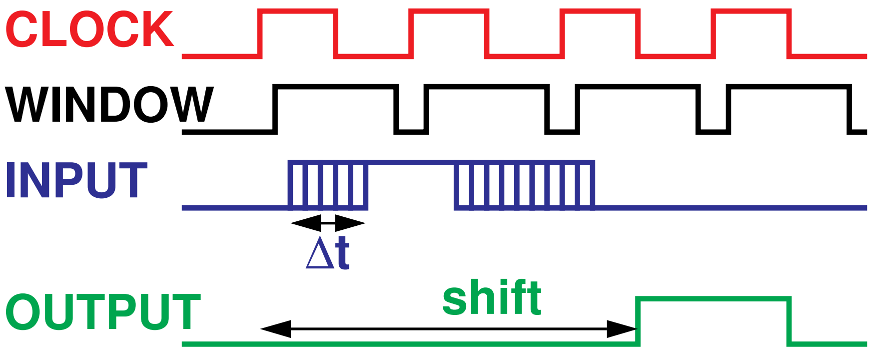
required precision: ~1 ns





t_{RPC}: ~Gauss distr., $\sigma \approx 2$ ns, i.e. $\Delta t_1 \approx 15$ ns

$t_{flight} + t_{propag}$: ~flat distr., $\Delta t_2 \approx 5$ ns



40 MHz, provided by TTC

adjustable width & position ($\times$1ns)

Δt = jitter of $t_{flight} + t_{propag} + t_{RPC}$

shift adjustable by S.FIFO ($\times$ 25ns)

With beam or not with beam?

***Muon rates* at $L=10^{33}$ cm^{-2}s^{-1}:**

- **The worst case: outermost barrel muon station MB4:**
  – chamber area = 1.28×3.75 m^2,
  – muon rate = 6 Hz/m^2 ≈ 30 Hz/chamber = 1800 events / minute / chamber
- **Channels of one chamber are in time by construction** (~1 ns)

Relative synchronisation *(station to station)*

- **Compare timing of hits from a given muon**
- **All muons can be used**
- **1 minute needed — can be done**

Absolute synchronisation *(b.x. assignment)*

- **Observed events must coincide with nonempty b.x.'s given by TTC**
- **Only first/last b.x. in each train can be used**
  – 35 trains / 3564 b.x.'s in each cycle ≈ 1%
  – effective rate ≈ 0.3 Hz / chamber ≈ 1000 events / hour / chamber
- **1 hour needed — not absolutely hopeless**

Alignment of RPC signals

Procedure without the beam *(first iteration)*

- **Calculate the time of flight and measure the cables as precisely as possible**
  - expected precision: < 5 ns
- **Adjust the "WINDOW" position and the "S. FIFO" shift accordingly**
- **Set the "WINDOW" width close to 25 ns to maximize the efficiency**
  - background is not a problem at low luminosity

Procedure with the beam — special run *(fine tuning)*

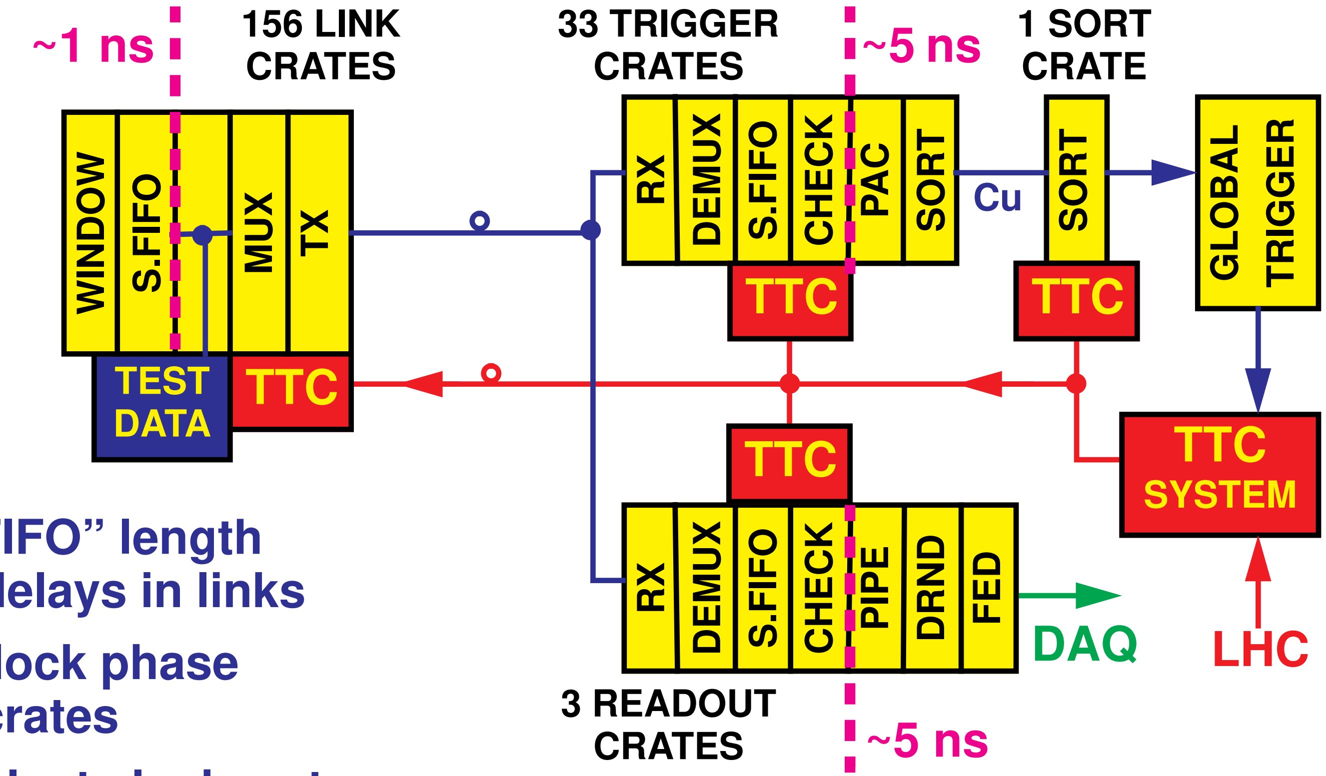
- **For each trigger collect data from several (e.g. $\pm$2) consecutive b.x.'s**
- **Observe how the data are distributed among b.x.'s**
- **Correct the "WINDOW" position and the "S. FIFO" shift accordingly**
- **Narrow the "WINDOW" width to the calculated jitter**

Procedure with the beam — "physics" run *(checking)*

- **Monitor efficiency map of the detector**
  - inefficiency in certain regions may be caused by wrong timing

“Downstream” synchronisation

1 TTC chip per crate



Tasks:

- Set the “S. FIFO” length to equalize delays in links
- Adjust the clock phase in different crates
- Take care of lost clocks, etc.: check data alignment & reset FIFO’s every LHC cycle (89 μs)

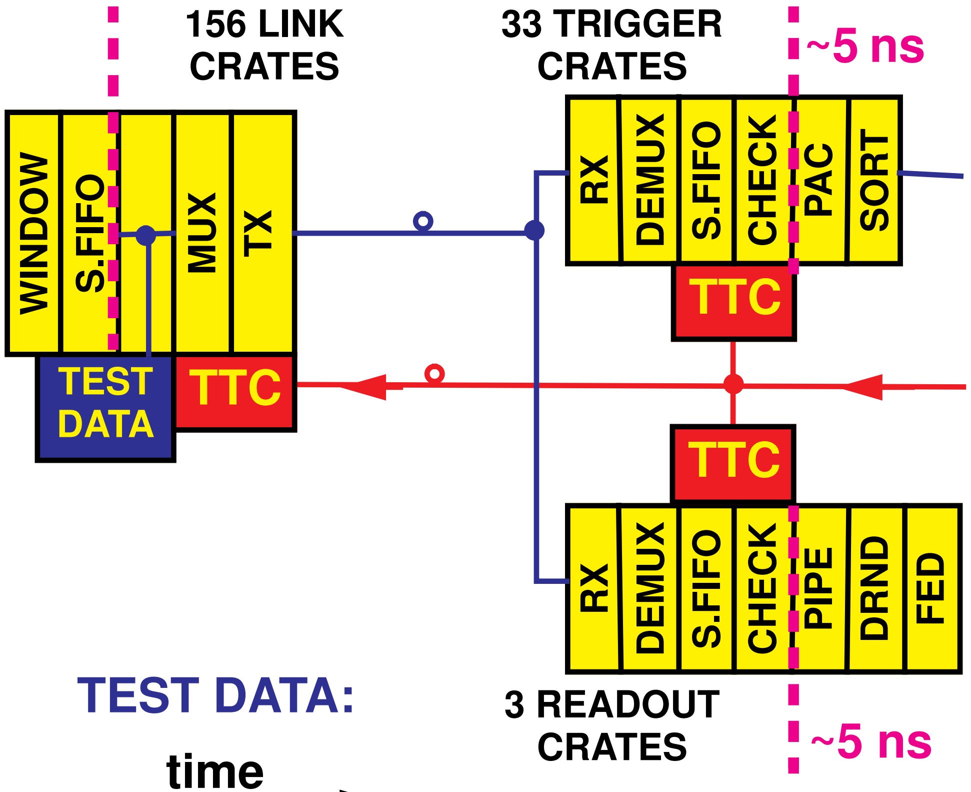
Methods:

- Alignment checking — injection of test data
- Resetting FIFO’s — “first bunch in the gap” method *(see J. Varela)*

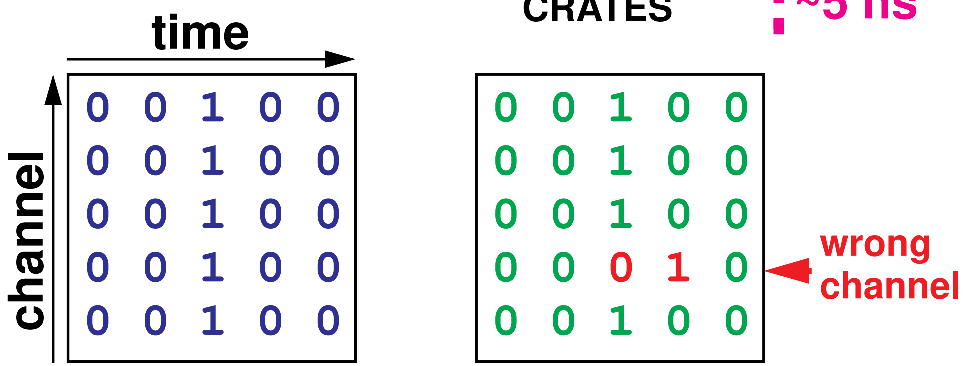
Injection of test data

Sequence of actions:

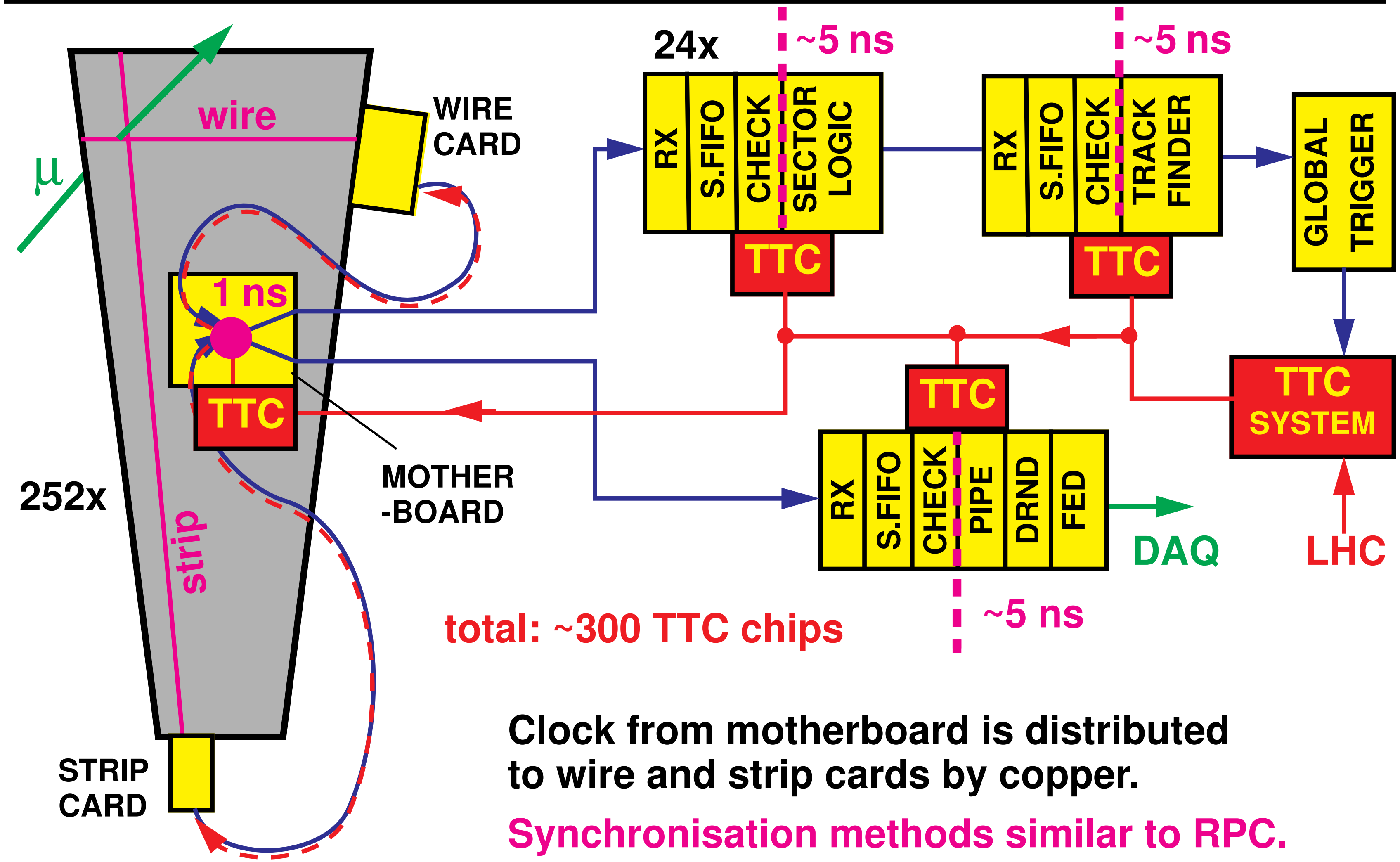
- **TTC broadcast:**
  - "test pretrigger"
- **"TEST DATA" module:**
  - prepare test data
- **TTC broadcast:**
  - "test trigger"
- **"TEST DATA" module:**
  - inject test data
- **"CHECK" module:**
  - check data alignment
  - if wrong: send message "corrupted trigger" or "corrupted data"
  - optionally it may inform which channel was shifted, how much and which way



TEST DATA:



TTC for CSC trigger & DAQ



Clock from motherboard is distributed to wire and strip cards by copper.

Synchronisation methods similar to RPC.

Crucial timing point: sampling of strip signal.