
# TTC in CMS

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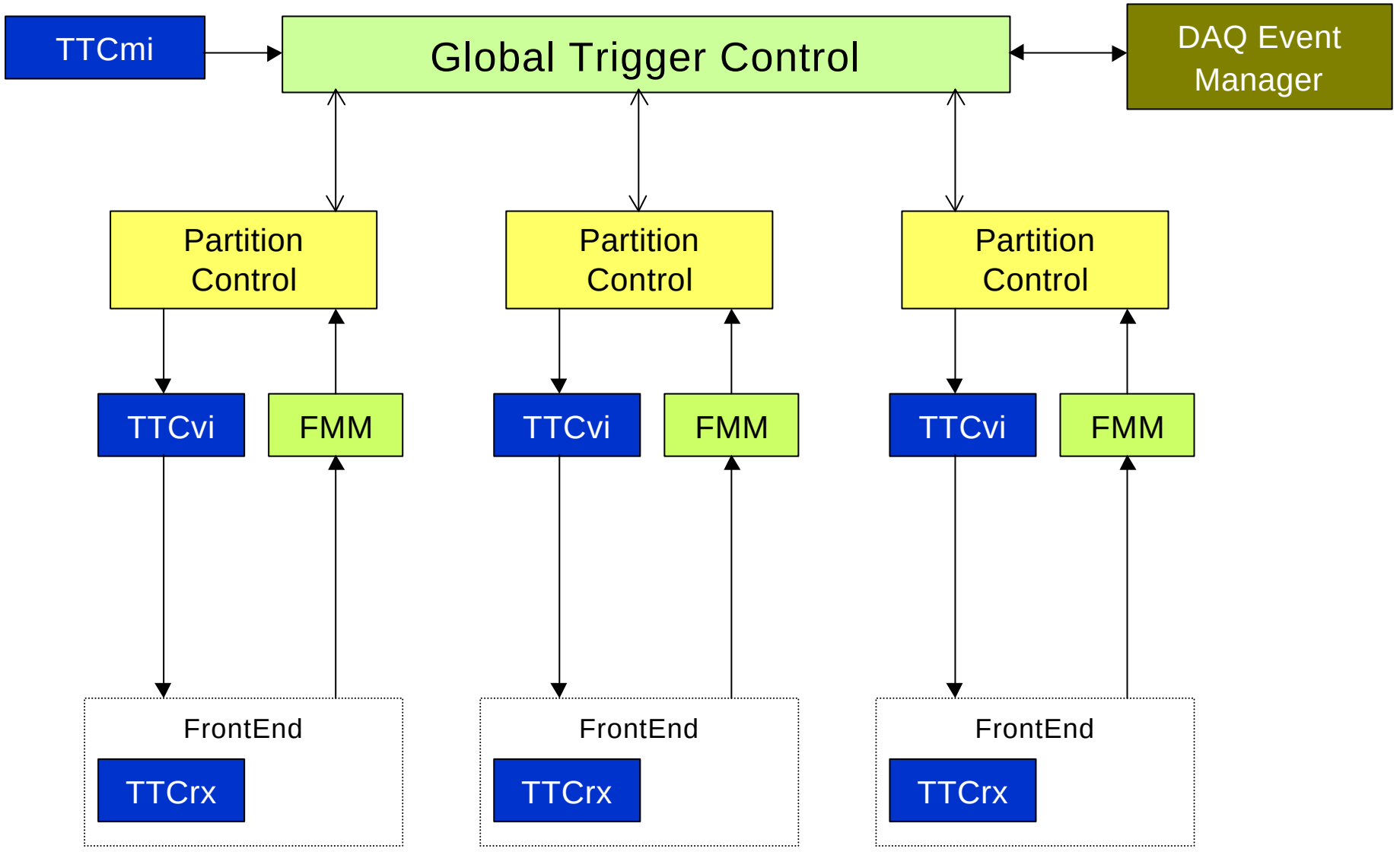
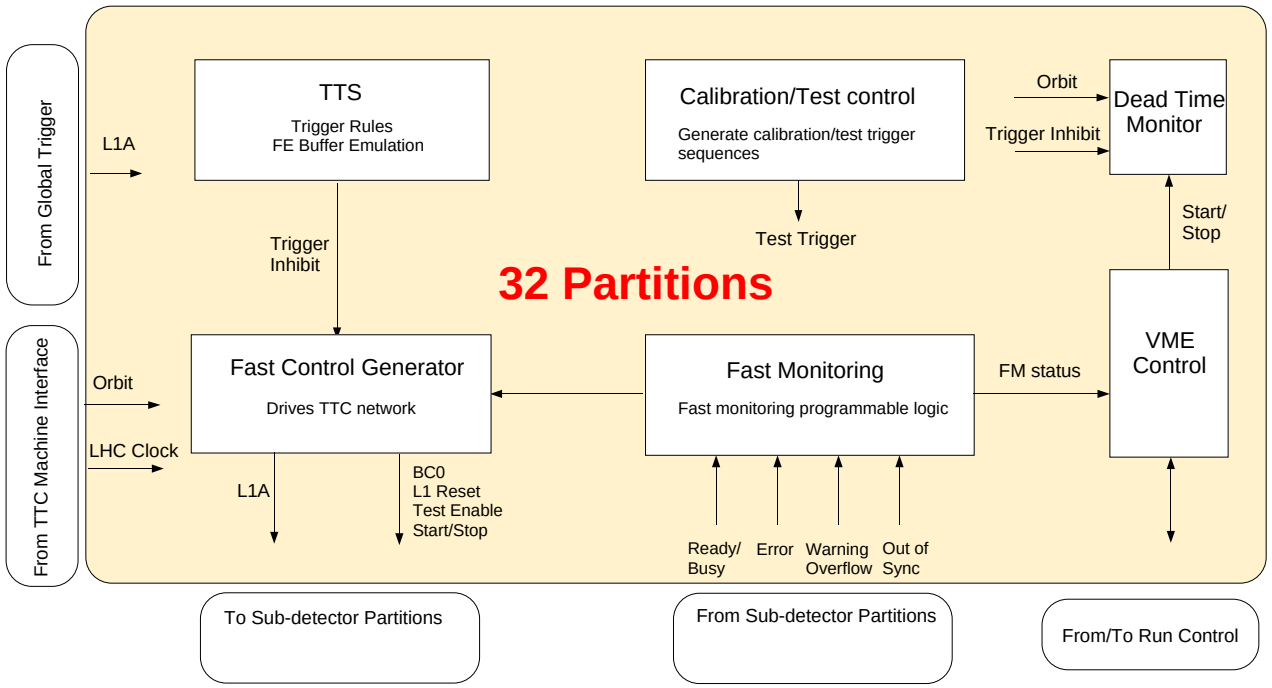
# Trigger Control Architecture



# Multi-Partition Trigger Control

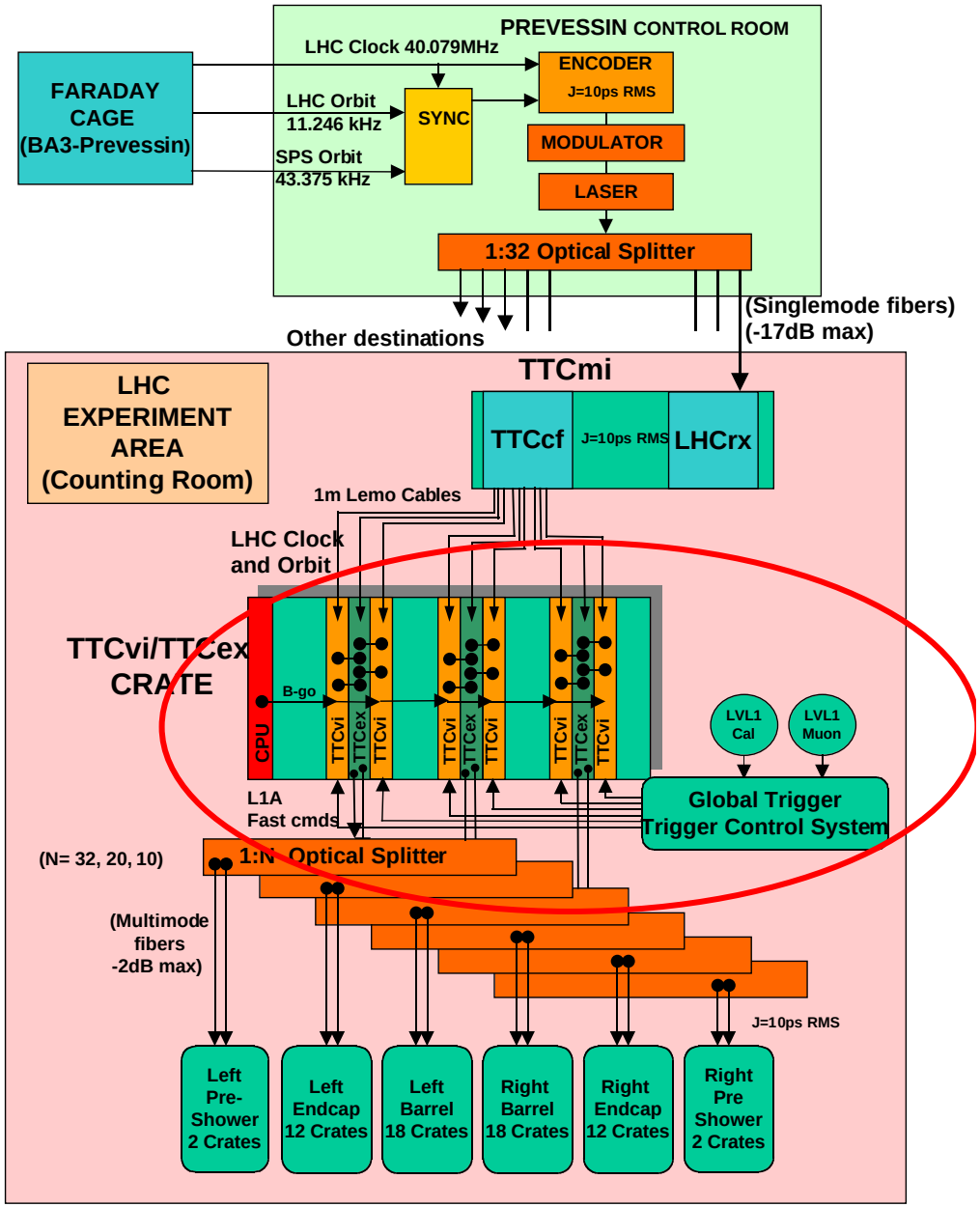



**Allows Subdetector Partitions or Partition-Groups to run independently with complete functionality**

**Provides independent calibration or physics triggers to different Partition-Groups**

**In normal data taking all subsystems are included in one group**

**Reconfiguration achieved by software programming**




# Subdetector TTC partitions

## TTC distribution system:

Two-time division multiplexed channels

Optical passive network

Channel A: L1A signal (40 Mbit/s)

Channel B: Fast commands (40 Mbit/s)

## Sub-detectors TTC master crate:

**TTCvi module:** gets L1A and B-Go signals;
VME interface (programming of cmds)

**TTCex module:** encoder and transmitter

# Fast Control Signals

## Level 1 Accept (L1A)

- Transmitted every trigger (TTC Channel A)
- Event Identifier: Event Number , Bunch Number, Orbit Number, Trigger Type

## Bunch Crossing Zero (BC0)

- Periodic command synchronous to LHC Orbit signal (~ 11 kHz)
- Synchronization of trigger data, Bunch Counter Reset

## Fast Reset

- L1 Reset: Re-synchronization of event ID and readout buffers
- Hard Reset: Partial reset of readout electronics

# Calibration and Test Modes

1) **Sub-detectors in standalone mode:**

   Test and calibration sequences are generated locally

   Data is captured with the sub-detector DAQ

2) **Sub-detectors in DAQ partition mode:**

   Trigger Control sends test and calibration triggers to a partition-group

   Data is collected by the central DAQ

3) **Periodic test and calibration triggers during a Physics Run:**

   Test triggers sequences are issued centrally and distributed to all partitions

   Calibration/test triggers are issued at pre-programmed cycles in the LHC orbit

   Data is collected by the central DAQ

4) **Local test and calibration triggers during a Physics Run:**

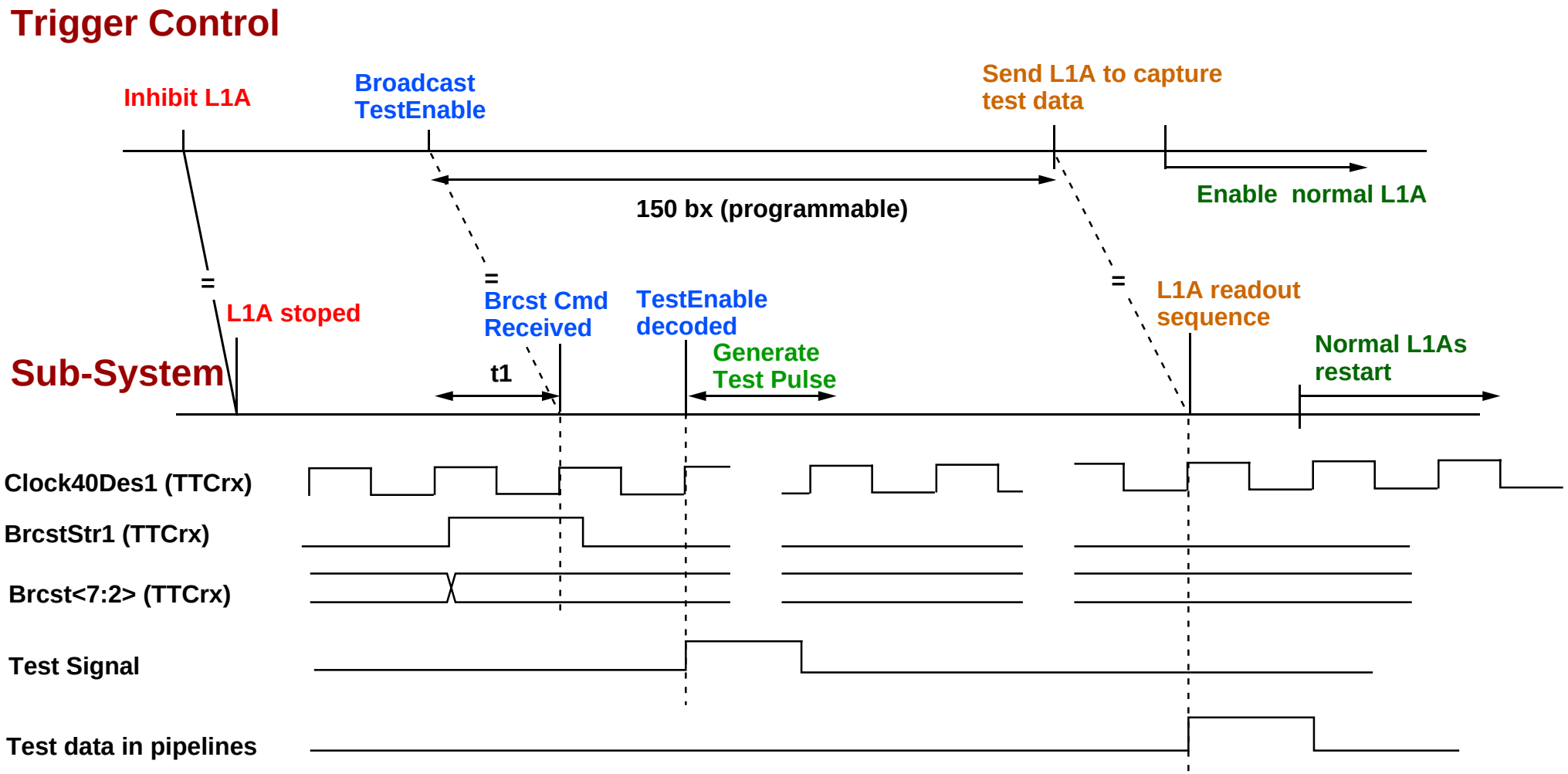
   The sub-systems perform test, calibration or monitoring activities during Private Gaps and Private Orbits

# Calibration Control Signals

| Fast Control Signal | TTC Command Type | Comments |
|---|---|---|
| Test Enable | Channel-B Broadcast | Broadcast command sent a fixed time before a test or calibration trigger. |
| Private Gap | Channel-B Broadcast | Broadcast command marking the next Gap for private use by the sub-detectors |
| Private Orbit | Channel-B Broadcast | Broadcast command marking the next Orbit for private use by the sub-detectors |

**Calibration Request Signal:** sub-detectors may use the Fast Monitoring system to send Calibration Request signals.

# Test/Calibration Sequence




t1 = delay on TestEnable command; adjusted in subdetector TTCvi's

# Fast Monitoring Signals

**Signals received from Sub-detector Partitions and DAQ Event Manager**

- **Ready**
  The Partition is ready to receive triggers
  Allow L1As
- **Busy**
  The Partition is not ready to take data and can't accept L1A's
  Inhibit L1As
- **Warning Overflow**
  The Partition buffers are close to overflow and L1A rate should be reduced
  Reduce L1As
- **Out of Sync**
  Loss of synchronization in readout or trigger Partition
  L1 Reset
- **Error**
  The Partition is in error and needs a reset
  Hard Reset

HARDWARE SIGNALS

FAST MESSAGES

# Trigger Throttling

Front-end buffers may overflow due to statistic fluctuations in trigger rate and event size.

## Front-End Buffers Emulation

Front-end pipeline-derandomizers are emulated centrally
L1 trigger is inhibited if an overflow condition is detected

## Trigger Rules

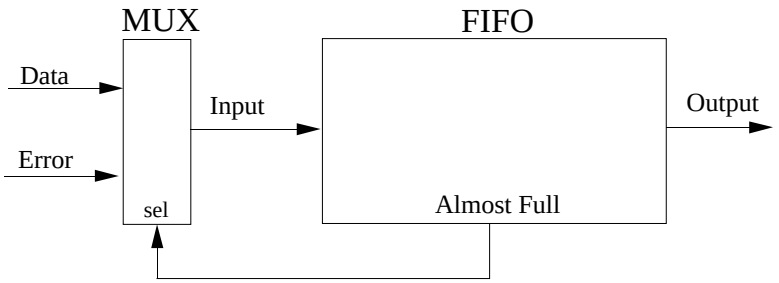
No more than n L1A per X ns (dead time less than 1%)

## Fast Monitoring

Fast feedback signal Warning Overflow

## Local Buffer Monitoring

Above buffer warning level store 'empty events'



# Synchronization Losses

**Identification of Sync Loss conditions that will require a L1 Reset:**

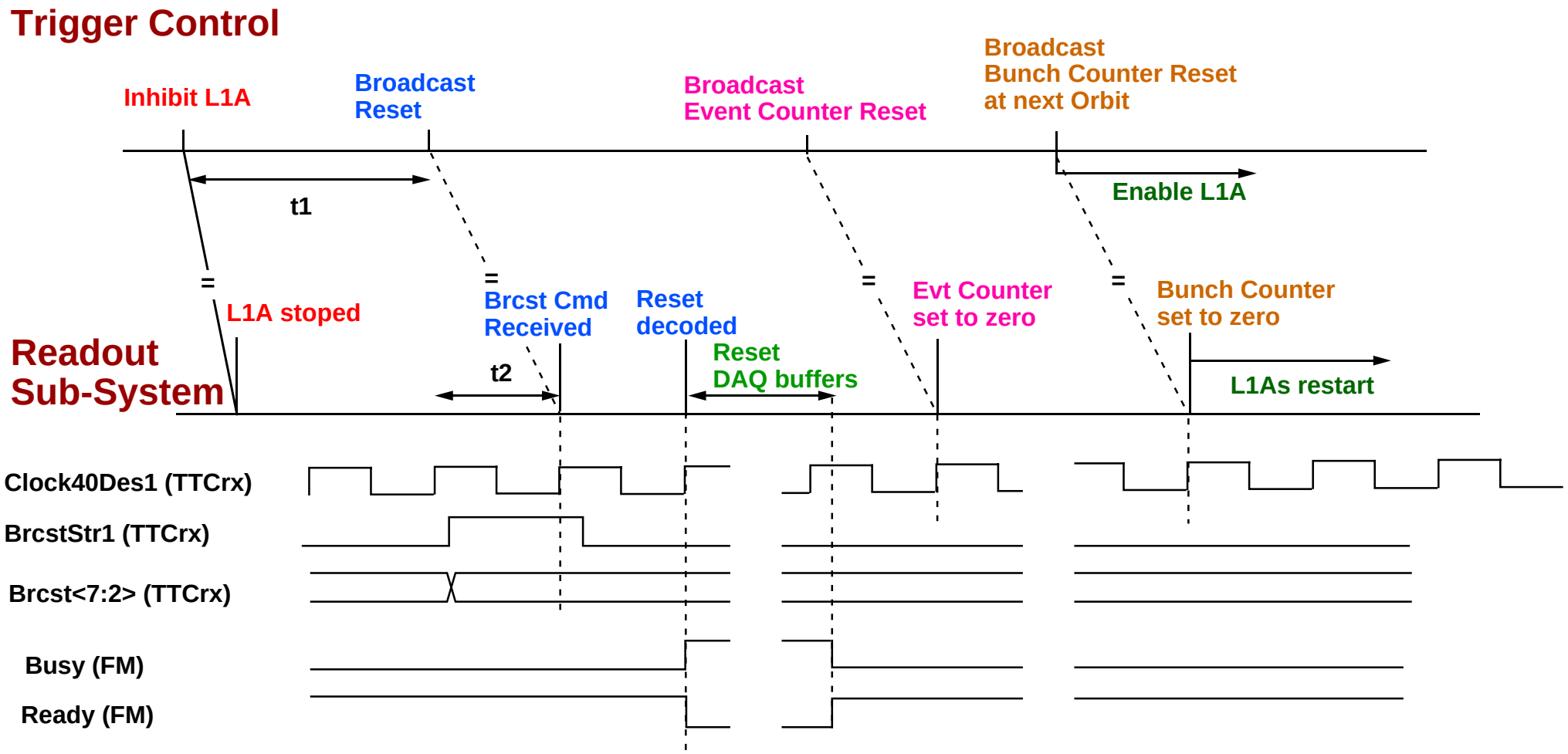
**in readout systems**

- buffer overflow
- mismatch between event ID's at any level of data concentration (FED, DCC, RU)
- mismatch between number of events received and number of L1A received
- mismatch between internal BC counter content and BC0 command
  (checked every orbit)

**in trigger systems**

mismatch between internal BC counter content and BC0 command
(checked every orbit)

# Fast Reset Sequence




t1 = time needed to empty DAQ buffers in subsystems

t2 = time needed to transmit a broadcast command to subsystems

# Project Status

- Conceptual design is being finalized

- Interfaces and functional specs of Trigger Control ready up to end 2001

- Detailed engineering design will start in 2002

# Functionality of TTCrx

- Functionality of TTCrx is well adapted to CMS architecture
- Clock jitter 150 ps p/p is a point of concern when used as master clock for high speed serial links
- CMS favors a re-design in submicron technology
- CMS prefers a TQFP packaging

# Functionality of TTCvi

## General comments

**Present TTCvi seems well adapted to small test systems**

**Functionality of final TTCvi should not be frozen now**

**CMS prefers to wait one year for a better understanding of the overall architecture and for more practical experience with test systems**

# Preliminary detailed comments on TTCvi

## B-Channel

- Addition of **12 external B-Go signals** to the present 4, allowing 16 different command types. Each new channel is associated to a single 8-bit register were a short-format broadcast command code can be stored.

- **Priority scheme not needed.** Timing of B-commands is externally controlled (B-commands are not allowed to overlap) in order to guarantee synchronicity of B-channel.

- **Programmable B-Go delay** between external B-Go signal and actual command transmission is needed.

- **Prescaling factor on B-Go channels,** such that in synchronous repetitive mode a pre-loaded command is transmitted every N orbits.

## Internal Generation of L1A

Generation of **L1A synchronous with the Orbit** signal (at programmable bunch crossing number). Associated with this feature a Delay and a Prescaling factor should be defined.

## Transmission of Trigger Type

Addition of the possibility of transmitting after L1A, through B-channel, **the Trigger Type only** (The present TTCvi version has an option that allows to transmit after L1A the Trigger Type **and** the Event Number).

## Input Levels

TTL and LVDS levels are more suitable than the present NIM and ECL levels

# Preliminary CMS TTC Numbers

| SUB-SYSTEM | TTCrx | | Optical Couplers and fibers | | TTCvi/TTCex | |
|---|---|---|---|---|---|---|
| | Quantity | Schedule | Optical Splitting 1:N | Fiber length | Quantity | Schedule |
| **Pixels** | 100 | 2001 - 10 for R&D<br>2002 - 10 for R&D<br>2003 - 10 for R&D<br>2004 - 70 for production | 1 x 1:24<br>1 x 1:18 | 10-20 m | 5 | 2 in 2002<br>2 in 2004<br>1 in 2006 |
| **Tracker** | 610 | 2002 - 50<br>2003 - 50<br>2004 - 510 | 4 x 1:150 | 10-20 m | Not yet known | Not yet known |
| **ECAL** | 1450 | July 2001 5 pcs;<br>Jan. 2002 25 pcs;<br>Dec. 2002 50 pcs;<br>2003 1370 pcs. | 2 x 1:18 (EB)<br>2 x 1:12 (EE) | 10-20 m | 8 | 2001 1pc;<br>2002 1 pc;<br>2003 2 pcs;<br>2004 4 pcs |
| **Preshower** | 140 | 2001 few pieces;<br>2002 few 10s;<br>2003-2004 rest | | 10-20 m | 5 | 2001 1 pc;<br>2002 1 pc;<br>2003-2004 3 pcs. |
| **HCAL** | 1093 | 50 chips and 15 TTCRx test boards now<br>2Q 2002 - 1028 | 1:18 or 1:36 for 90 m fibers | ~90 m | | |
| **DT** | 400 | 2001 - 10<br>early 2002 - the rest | | ~90 m | 5 | 2001 - 2<br>2002 - 1 |
| **CSC** | 100 | 2001 - 15 pcs | 1:30 | ~90 m | 3 | |
| **RPC** | 2710 | 2001 - 20<br>2002 - 1000<br>2003 - 1000<br>2004 - 690 | 77 optical couplers | ~90 m | 2 TTCvi<br>2 TTCex<br>6 TTCtx | 2002 |
| **TRIGGER/DAQ** | 250 | 2002 - 100<br>2003 - 150 | 8 x 1:32 | 10-20 m | 11 | |
| TOTAL | 6850 | 2001 - 130<br>2002 - 2770<br>2003 - 2680<br>2004 - 1270 | | | >32 | |

# Experience with TTC System in CMS

| SUB-SYSTEM | Prototypes with TTCrx | TTC systems installed | TTC systems in test beam |
|---|---|---|---|
| **Pixels** | 1 | 0 | 0 |
| **Tracker** | 2 | 5 | 1 |
| **ECAL** | 2 | 1 | 0 |
| **Preshower** | 0 | 0 | 0 |
| **HCAL** | | | |
| **DT** | 0 | 1 | 0 |
| **CSC** | 1 | 1 | 0 |
| **RPC** | 3 | 1 | 1 |

# CONCLUSIONS

- **TTC system is extensively used by CMS**

- **Functionality of TTCrx is well adapted to CMS architecture**

- **CMS needs about 7000 TTCrx**

**- CMS prefers to wait one year to define the final specification of TTCvi**