TOTEM Trigger System

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Josef Kopal josef.kopal@cern.ch

UWB, TOTEM, CERN

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**Introduction - CERN, LHC and experiments**

**CERN - Conseil Européen pour la Recherche Nucléaire**

- European center for nuclear research
- 20 member countries, 7 observing

**LHC - Large Hadron Colider**
- The largest particle accelerator
- Two accelerating rings
- 4 interaction points

**LHC - 6 experiments**
- CMS, ATLAS, LHCb, MoEDAL
- TOTEM, LHC-forward a ALICE
Measurement principles

- **Elastic scattering**
- **Single diffraction**
- **Double pomeron exchange**
TOTEM experiment and forward physics

TOTEM Detectors

IP5 detail: T1 and T2 location inside the CMS

Interaction Point 5

Sensors after insertion

T1 and T2

Beam 1
Beam 2

Sector 45
Sector 56

9 m
13.5 m
220 m

Josef Kopal
josef.kopal@cern.ch

TOTEM Trigger System
What is trigger

**Trigger:**
- It is a mechanism to evaluate events and execute a data download and storage via a data-acquisition.
- It is a first step in data analysis.
- It significantly affects/reduces the transmitted volume of data.
- Its functionality is critical for a consecutive offline data analysis.

**Trigger hierarchy**
- The trigger uses a tree structure.
- The original information is significantly reduced and processed in each step to allow a continuous data transmission and events evaluation.

**Data transmission**
- Optical fiber - used for all detectors.
- Metallic wires - Used for Roman Pots 220m. Important for the TOTEM-CMS trigger integration.
Trigger structure

Detector side

- Particle incoming from a shower
- Particle incoming from the IP5
- Sensor planes perpendicular to the beam
- 16x5 bits CC 16 bits beam axis

Josef Kopal josef.kopal@cern.ch

TOTEM Trigger System
Counting-room side

- OptoRx
- Isolation Cards
- TOTFed
- LONEG
- Connector Mezzanine
Tracking data have to be stored into a detector buffer during an event evaluation.

In comparison to other experiments, our detectors are located up to 220m from IP. In this case, particle flight time and signal propagation delay caused by transmission line is significant.

TOTEM experiment had to take this into account in its design.

It was problematic to deliver a TOTEM trigger signal to CMS in time.

We replaced optical fibers with a parallel LVDS bus. What is important:

- We saved time needed to serialize and de-serialize data for an optical transmission.
- Used metallic cables have a propagation delay about 4.2 ns per meter (in comparison to optical fibers with a delay about 5 ns per meter.)
Conclusion

- Trigger system was used in a large number of measurements and is fully integrated into the whole system.
- Results of the measurements are already published.
- The first step in TOTEM-CMS integration has been done. In the moment the data from common runs are being analyzed and further trigger functionality is discussed.
Thanks a lot for your attention
Backup 1 - Repeater design
Backup 1 - repeater design 2
Backup 1 - repeater design 4 - Repeater output block

DRIVERt (LVDS driver stage)
Paulo Vareiro, 85/03/1999
IBM CMOS 6SF Technology
Backup 1 - repeater design 5 - Pulse response
Backup 1 - repeater design - 6 Final Repeater Measurements
Backup 2 - Electrical Trigger - signal sampling 1

- Broken Line
- Noisy Channel
- Different delay
- Aliasing due to the wrong sampling

High Rate | No Rate | Trigger Bit [-]

32 bit - One RP
Backup 2 - Electrical Trigger - signal sampling

Electrical Trigger Bit → Masking → Signal inversion → Signal sampling → Delay FIFO → Delay Select → Realligned Electrical Trigger Bit

LHC Clock → PLL → Phase 270, 180, 90, 0

Register → D Q → Register

Bunch/clock cycle

- Masked Channels
- All Channels are aligned
- Clear Bunch Train Structure is visible
- One noisy detector
- High Rate
- No Rate
- Trigger Bit [-]

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TOTEM Trigger System
Firmware - OptoRx and Main

Firmware tasks

- correct data reception
- synchronization of individual detectors
- implementation of trigger algorithm
- Provide human interface for configuration
Firmware - LONEG

CMS trigger part (Identical to the L1 Trigger block, without the CMS L1 signal)
Electrical trigger - installation