The upgrade of the CMS Global Trigger

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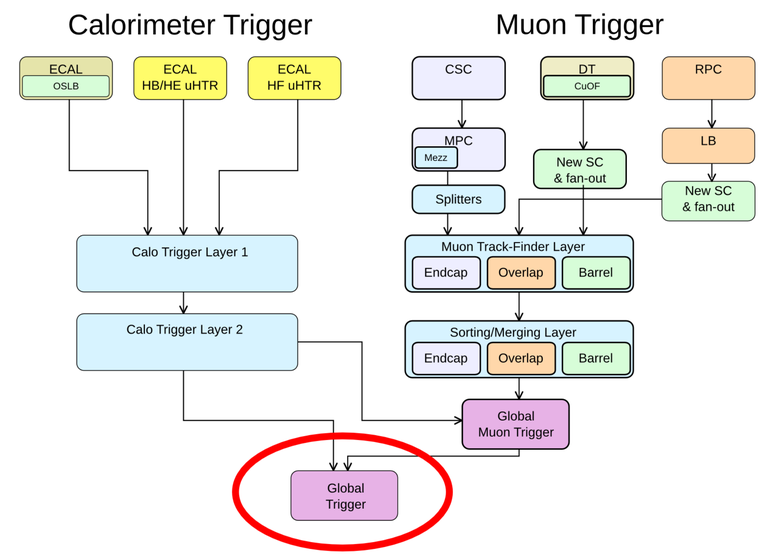
Johannes WITTMANN*, Bernhard ARNOLD, Herbert BERGAUER,
Takashi MATSUSHITA, Babak RAHBARAN
*corresponding author
Institute of High Energy Physics, Vienna | Austrian Academy of Sciences

HEPHY Institute of High Energy Physics

CMS Level-1 Trigger Upgrade

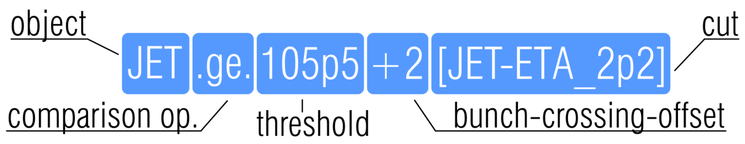
- Scalable re-implementation using modern FPGAs on Advanced Mezzanine Cards in MicroTCA crates.
- LHC increased its collision energy from 8 TeV to 13 TeV and its luminosity is expected to rise from $0.75 \times 10^{34} cm^{-2} s^{-1}$ to $2 \times 10^{34} cm^{-2} s^{-1}$.
- The upgraded system (μGT) is capable of processing higher luminosities and has further efficiency improvements.
- Replacing the legacy Global Trigger to extend its capabilities for the 2016 LHC operation and beyond.
- Number of algorithms will be scalable and new functionalities will be implemented (such as invariant-mass calculation).



Level-1 Triger Upgrade System

The new Global Trigger system

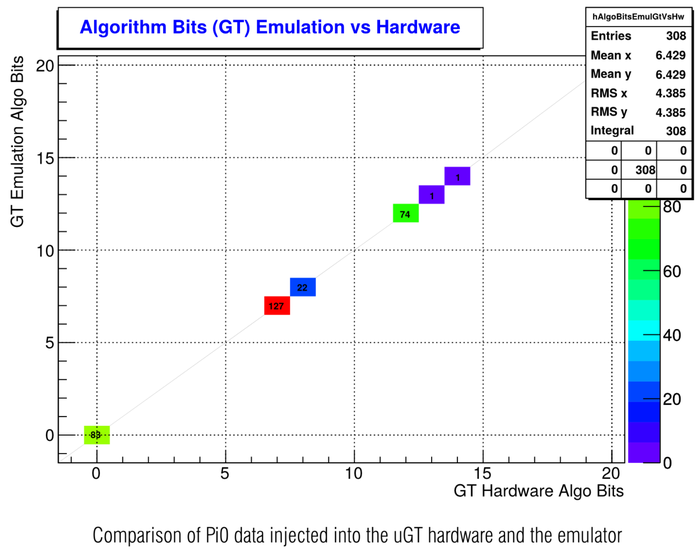
- Completely new development on XILINX Virtex-7 FPGAs using the collaboration solution MP7[1].
- Gives the possibility to use at least 512 trigger algorithms (instead of 128 as for the legacy system).
- New software and grammar were developed to handle the increased complexity of the upgrade[2]:



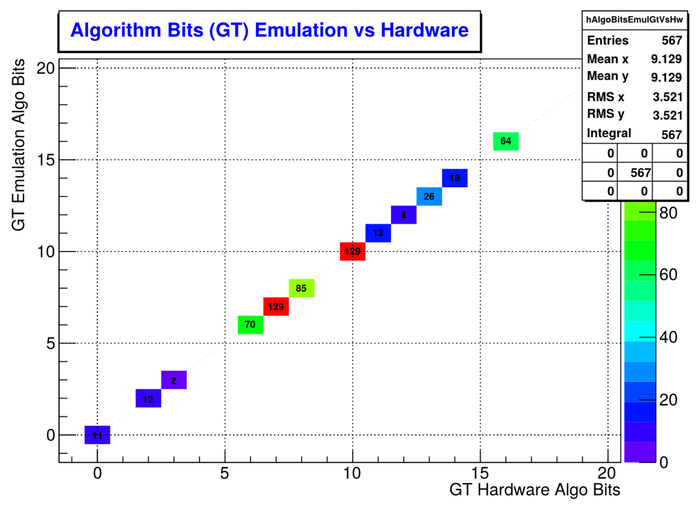
- 72 x 10 Gbps input links allow high data throughput.
- The system for handling basic binary input signals from external sources was completely re-designed using the new AMC502 from Vadatech[3].
- Highly modular and scalable system: If the resources of one MP7 board are insufficient for the complex algorithms, the global trigger logic can use up to 5 boards in parallel.
- A special AMC502 module collects the trigger signal from each μGT board and emits a final trigger.

Performance

- Many tests were performed injecting data from the muon and calorimeter trigger subsystems into the μGT.



Comparison of Pi0 data injected into the uGT hardware and the emulator



Comparison of Z->ee data injected into the uGT hardware and the emulator

- Parallel to the data flow through the hardware, the results were verified by the μGT emulator. The comparison of the muon data as well as the calorimeter data shows a perfect agreement between the trigger hardware and the emulator software. Shown are two plots from the calorimeter tests.

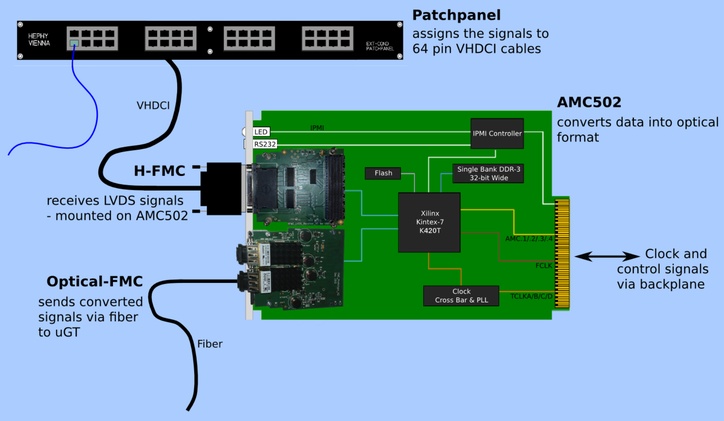
Parallel Run 2015

- The upgraded Global Trigger will be in parallel operation with the legacy trigger system in 2015.
- The hardware for this run is already installed at the CMS experiment site at the LHC accelerator.
- The upgrade of the CMS Global Trigger will take over the duty from the legacy system in 2016.

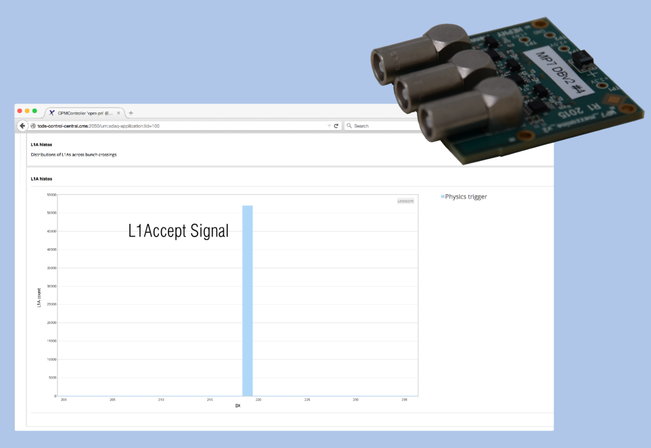
References: [1] A. Rose et al.: The MP7 and CTP-6: multi-hundred Gbps processing boards for calorimeter trigger upgrades at CMS, Journal of Instrumentation Volume 7, C12024, 2012;
[2] T. Matsushita: Software for implementing trigger algorithms on the upgraded CMS Global Trigger System, CMS Note (CMS-CR-2015-083), 2015;
[3] B. Rahbaran et al.: Global Trigger Upgrade firmware architecture for the level-1 Trigger of the CMS experiment, Journal of Instrumentation Volume 10, C02042, 2015;

The legacy Global Trigger crate of the CMS experiment at CERN

New microTCA-based Global Trigger of the CMS experiment at CERN



Completely new path for external trigger signals



Custom designed new mezzanine board sends trigger decisions

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presented by Johannes WITTMANN | mail: johannes.wittmann@oeaw.ac.at | web: globaltrigger.hephy.at

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