Upgrade of the CMS muon trigger in the barrel region

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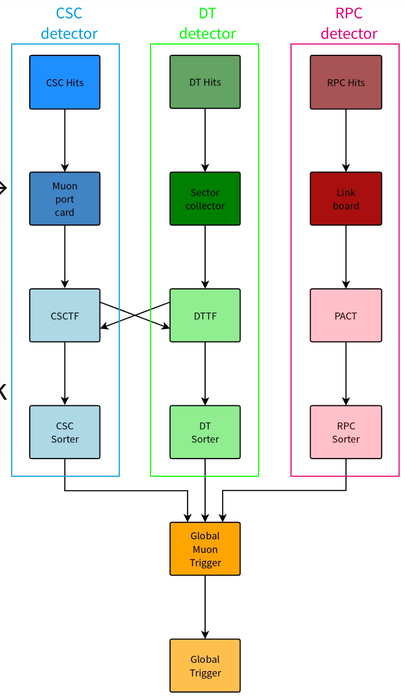
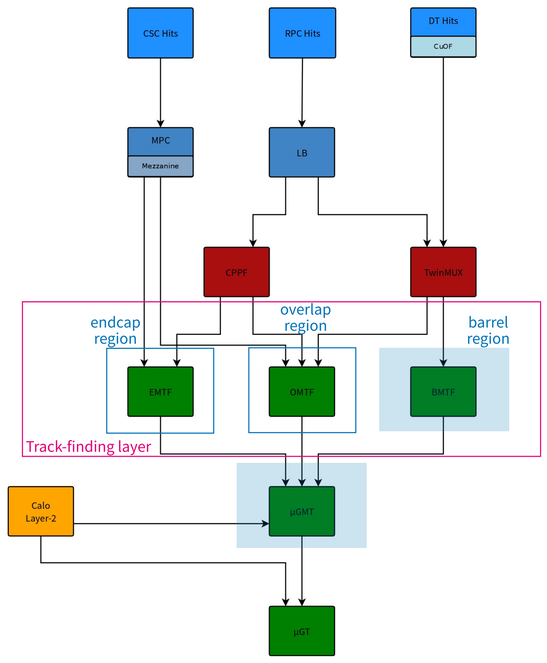
Context

Legacy system

- Track stubs combined in track finders (TF). 4+4 best tracks from drift-tube (DT) and cathode-strip chamber (CSC) TFs → Global Muon Trigger (GMT)
- Pattern matching in resistive-plate chamber (RPC) system. 4+4 best tracks from barrel and endcap → GMT
- GMT compares & combines tracks found by TFs + RPC system. Also "ghost busting" on muons found by both track finders in overlap. 4 best muons → Global Trigger (GT)
- GT combines muons from GMT with calorimeter trigger objects in 128 algorithms that can each trigger a readout decision



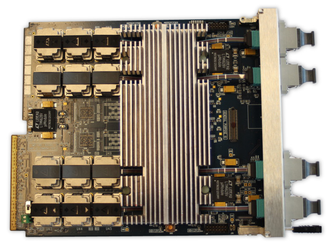


Upgrades to the muon trigger

- Increased precision in track finder algorithms
- Track finders move from detector- to region-centric model
  - Each track-finder covers assigned region
  - RPC information augments track-finding
  - Sorting and ghost busting integrated in Global Muon Trigger (µGMT)
- Dedicated track-finding system for overlap between barrel and endcap region
- 8 muons sent to Global Trigger (µGT)

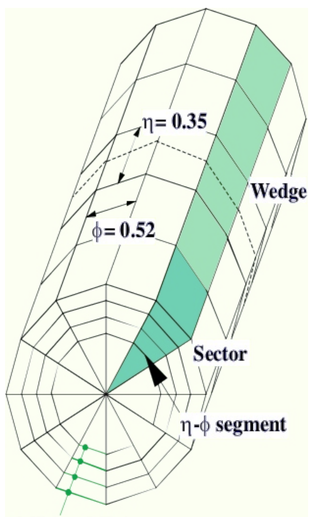
Common hardware

- Implemented in Virtex-7 690 field-programmable gate array
  - Significant increase in logic resources compared to currently used Virtex-II
  - Digital signal processors for fast integer addition and multiplication available
  - 800 Gb/s input and output bandwidth
- Carrier card: Imperial College MP7
  - High performance datastream processing board
  - Input/Output: (72+72)x 10 Gb/s
  - Using µTCA crate standard

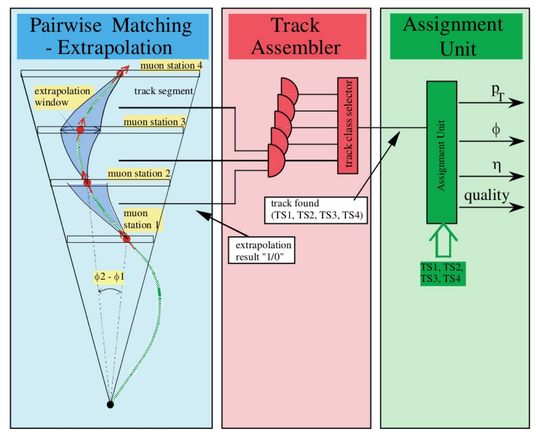


Barrel Muon Track-Finder

- Barrel region logically split into 12 30° “wedges”
  - Each wedge contains five sectors containing independent drift-tube (DT) and resistive-plate chamber (RPC) detectors
  - Data from each wedge treated by dedicated track-finder processor
- concentrator cards (“TwinMUX”) construct “super primitives” from DT and RPC hits for use by Barrel Muon Track-Finder
  - Super primitives describe track segments within a detector module.
  - Consist of spatial coordinates, bending angle, and quality bits indicating the confidence in the measurement



- Barrel Muon Track-Finder receives super primitives built from DT and RPC information in the barrel (|η|<0.83)
  - Tracks constructed separately for φ- and η-components
- Constructs tracks from super primitives within the given wedge and neighbours by extrapolating super primitives to neighbouring station.
- 3 best muons from each wedge sent to Global Muon Trigger



Upgraded Global Muon Trigger

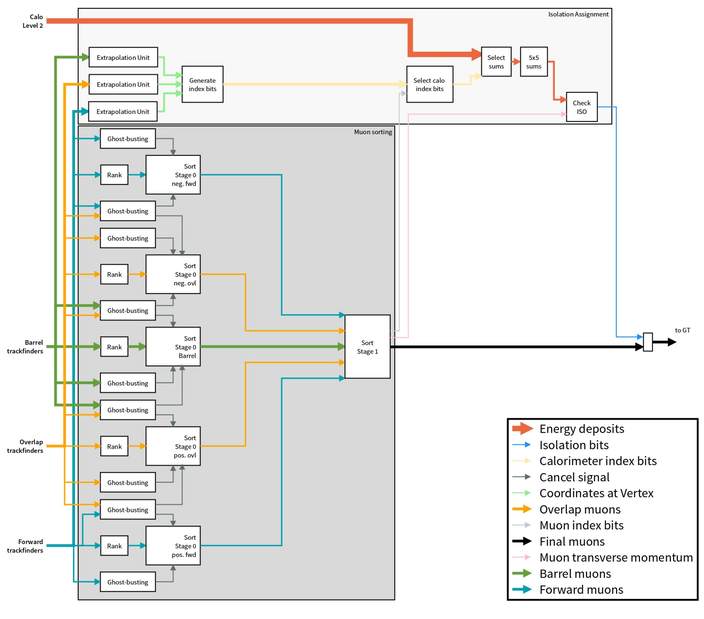
Features

Muon sorting

- 36 muons from each track finder @64 bit
- Sorting in two stages
  - for each region covered by track-finder seperately
  - global sorting for 24 pre-sorted muons from regional sorters

Cancel-out

- cancel-out possible between track finders during the regional sorting stage
- coordinate-based
  - works with matching window $\Delta R^2 = f_1 \cdot \Delta\eta^2 + f_2 \cdot \Delta\varphi^2$
- track address-based
  - requires dedicated track addresses that encode detector hits used to build track

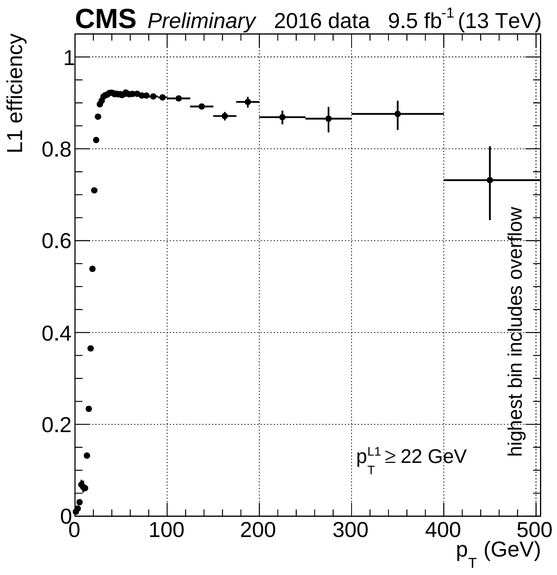


Muon isolation

allows to identify and tag muons created in jets

- receive energy sums around each 2x2 trigger tower from calorimeter trigger
- extrapolate muon tracks to vertex and select corresponding energy sum
- calculate absolute and relative isolation value for final muons

Performances



Method

Using tag and probe method on a dataset of events recorded using a single muon trigger

- Considering full detector coverage
- Level-1 trigger muons have p_T > 22 GeV
- The highest p_T bin contains any muon with p_T > 400 GeV

Results

- Algorithm optimisation ongoing to improve efficiency for high-p_T muons
- Rate for Level-1 Single Muon algorithm for luminosity of 6.7E33cm^{-2}s^{-1}:
  - ~5.3 kHz for 18 GeV threshold
  - ~3.5 kHz for 22 GeV threshold
  - ~2.9 kHz for 25 GeV threshold