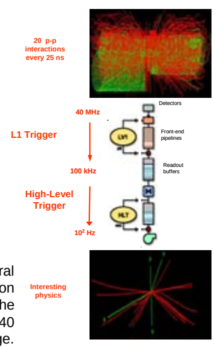
The Drift Tube Track Finder Muon Trigger at the CMS Experiment

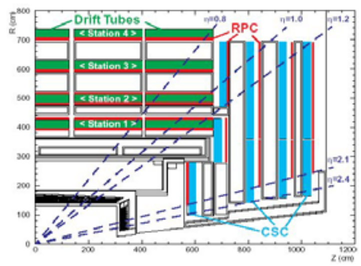
Ignacio Jiménez
Universidad Autónoma de Madrid
On behalf of the Bologna, HEPHY-Vienna and U. A. Madrid groups at CMS



H → ZZ → 4μ

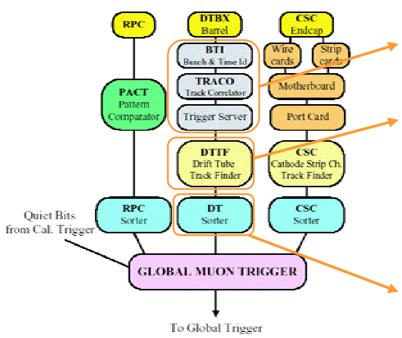
The **Compact Muon Solenoid (CMS)** is a general purpose experiment designed to study proton-proton collisions at the **Large Hadron Collider (LHC).** At the LHC proton beams will cross each other at a rate of 40 MHz, producing 20 proton-proton interactions in average. The CMS Level-1 Trigger must analyze all beam-crossings and select interesting ones at a maximal rate of 100 kHz.

Muons of large transverse momentum are expected to play a crucial role in the physics under study at LHC. CMS will combine three different technologies for efficient muon detection: Drift Tube (DT) chambers in the central region ($|\eta|<1.2$), cathode stripe cambers (CSC) in the forward region ($0.8<|\eta|<2.4$) and resistive plate chambers (RPC) in both regions ($|\eta|>2.1$). The information delivered from these detectors is analyzed by the corresponding L1 Muon Trigger Systems and output to the Global Muon Trigger.



- The DT Muon chambers are located in the barrel iron yoke.
- The barrel is divided in 12 30° wedges in ϕ, 5 wheels in η, and 4 stations in the radial direction (MB1,2,3,4).
- The DT Muon chambers contain 12 layers of drift cells organized in 2 r-ϕ superlayers and 1 r-z (θ) superlayer.

• The **CMS Level-1 Drift Tube Muon Trigger** is divided into a DT Local Trigger and a DT Regional Trigger.

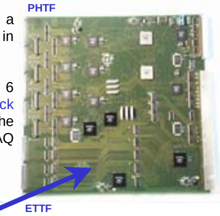


- Hits in the DT Muon detectors are organized in segments by the **DT Local Trigger.**
- The **DT Track Finder (DTTF)** links segments, forming tracks consistent with the trajectory of a muon originating from the interaction point and assigns a momentum, a charge, and a quality code.
- The **DT Sorter** outputs to the **Global Muon Trigger** the best four muons in the central detector.

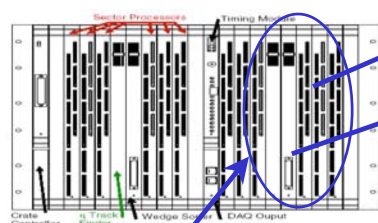
• The DT Track Finder Trigger is physically realized using a sophisticated electronic system. The system is organized in twelve modules stored in 6 crates.

• Modules correspond to a 30° wedge and are formed by 6 Phi Track Finder (PHTF) sector processors and 1 Eta Track Finder (ETTF). Two modules share the same crate, and the same Wedge Sorter, VME Controller, Timing, and DAQ Output cards.

PHTF



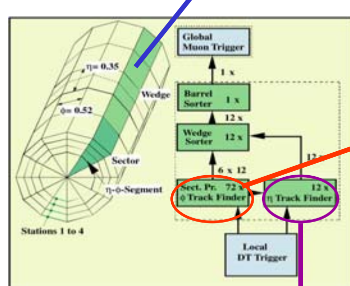
ETTF

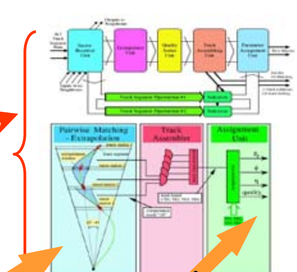


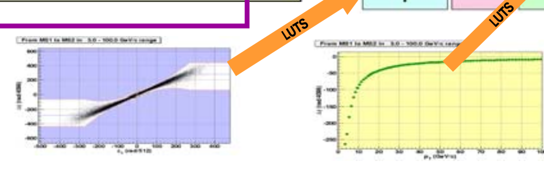
DTTF Module

The **Phi Track Finder (PHTF)** processors reconstruct muon tracks in the r-ϕ plane, and assign them physical parameters. This process is implemented in three logical steps:

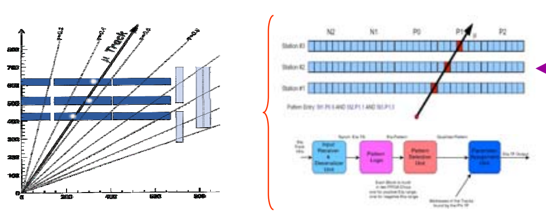
- **Extrapolation:** Pairs of segments are matched according to a extrapolation principle, i.e. the correlation between the change in the azimuthal coordinate ($\Delta\phi$) and the bending angle (ϕ_B). This correlation is conveniently quantified in terms of 99%-efficient extrapolation windows. Windows are downloaded to the hardware in the form of Look-Up-Tables (LUT).
- **Track Assembling:** Consistent extrapolations are assembled together to form tracks. A track quality parameter reflects the total number of segments linked.
- **Parameter Assignment:** Finally, the reconstructed tracks are assigned muon physical parameters: transverse momentum (p_T), direction (ϕ and η), and electric charge. The two inner muon stations with a valid extrapolation are used as a magnetic spectrometer: the value of p_T is estimated from the measured value of $\Delta\phi$ using a relation stored in the hardware LUTs.







• In every sector, the **Eta Track Finder (ETTF)** reconstructs the muon trajectory in the r-z projection. The ETTF organizes theta segments in MB1, 2 and 3 in "η-patterns", matches the patterns to PHTF tracks, and assigns a value of η.
• Even if no pattern can be matched, a rough η value can always be deduced from the position where the muon changed wheels.



• The DTTF selects the four highest rank muons in the detector barrel and forwards them to the Global Muon Trigger. This process is implemented in two steps: (i) the **Wedge Sorter** selects the two best muon tracks in a sector; (ii) the **Barrel Sorter** selects the four highest rank muons among the 24 delivered by the Wedge Sorters.

- The DTTF performance has been studied using simulated events. Next autumn the performance will be studied using real data at the CERN test beam.
- **Performance highlights:** momentum resolution: 15%; position resolution in η: 3% (fine), 8% (rough); single muon efficiency plateau limited by geometrical acceptance; dimuon resolution power.
- **Accumulated** inclusive muon DTTF **trigger rate** as a function of the transverse momentum cut: for a threshold of about 25 GeV the rate is 1.6 kHz.