Level 1 trigger in the CMS barrel muon chambers during HL-LHC

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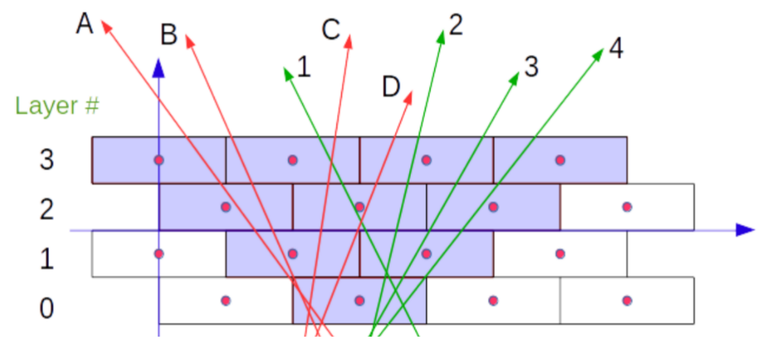
Context

The Compact Muon Solenoid (CMS) experiment is currently preparing the upgrades for the so-called **Phase-2** of the LHC. This new high luminosity era of the LHC operation (HL-LHC) will come with an enormous increase of detector occupancy, trigger latency and rates, that inevitable results in the need to replace the full electronics of the CMS Drift Tube (**DT**) chambers so that the great performance in muon identification perdures.

The Analytical Method

An algorithm that uses information from the hits received in the DTs to compute chamber segments.



The algorithm can be logically divided in three steps:

- **Grouping**: hits are clusterized into groups of 10 for each superlayer. From each cluster of hits, all possible combinations of muon candidates compatible with segments that contain 3 or 4 hits.

- **Fitting**: segments are analyzed using exact formulas, and the slope with respect to the chamber perpendicular axis (tan ψ), the horizontal position (x0), the BX and the muon primitive's time (t0) are extracted using exact formulas.

- **Correlation**: information of the two r-φ superlayers is combined in order to obtain better muon candidates. The correlation takes into account time compatibility between the two candidates that are to be correlated. If correlation is sucessful, all the parameters that define the trigger primitive are re-computed.

Conclusions

The Analytical Method algorithm has been presented in multiple ocassions due to the promising results in both simulation and cosmic data. From simulation results, **excellent performance** in terms of **efficiency** and **resolution**; furthermore, resolution is unaffected even in ageing scenarios (expected at the end of the HL-LHC era). From the slice-test, the preparation of one sector with all the required electronics to run simultaneously legacy and Phase-2 electronics has shown that the AM not only matches the segment reconstruction efficiency for legacy, but it also considerably improves time resolution.

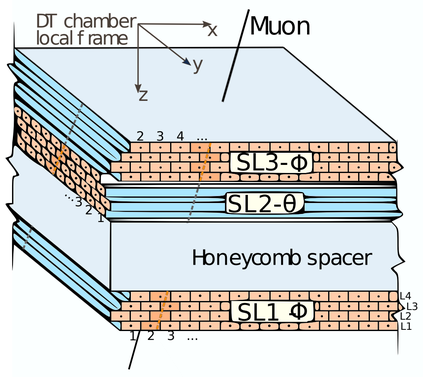
References

[1] The CMS Barrel Muon trigger upgrade, Andrea Triossi on behalf CMS collaboration, JINST 12 (2017), no. 01, C01095, doi:10.1088/1748-0221/12/01/C01095

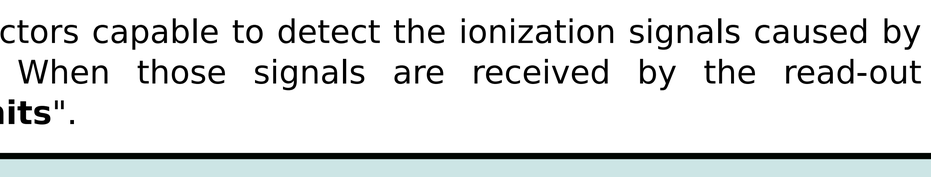
[2] The Drift Tube System of the CMS Experiment, G.Cerminara, JINST Vol. 172 (2007), pages 71-74, doi: 10.1016/j.nuclphysbps.2007.07.016

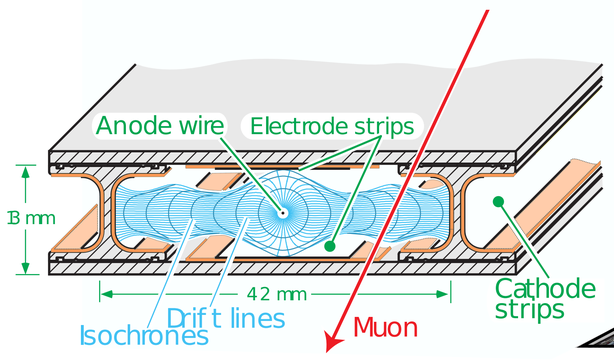
[3] Implementation in a sector of the CMS Drift Tube chambers of a muon tracking algorithm for Level 1 trigger during HL-LHC, C. F. Bedoya, IEEE-NSS 2020

The CMS barrel muon chambers



Muon identification in the central region of CMS (known as the barrel) relies on a system of **Drift Tubes (DTs)**. DTs are divided into 5 slices called wheels. The DT chambers are arranged in four muon stations (MB1, MB2, MB3, MB4) with increasing radius.





DT systems consist of gaseous detectors capable to detect the ionization signals caused by particles traveling through them. When those signals are received by the read-out electronics, they are digitized into "**hits**".

Performance evaluation and DT slice test

During Long Shutdown 2, one sector of the CMS muon system chambers was instrumented with the new front-end and back-end prototypes that, in principle, will be used for HL-LHC. Muon signals in the slice-test are splitted in two, so each of these signals can be simultaneously processed by the current electronics and the new boards that run the AM firmware for Phase 2. This methodology allows for computing efficiency and resolution comparisons between **Phase 1** and **Phase 2** triggering.