The algorithm of the CMS Level-1 Overlap Muon Track Finder trigger

Karol Buńkowski
Institute of Experimental Physics, Faculty of Physics, University of Warsaw

CMSShadow

Why did you need a new muon trigger? The previous CMS muon trigger was working pretty well.

LHC increased the luminosity, so we had to improve the muon trigger to reduce the output rate. In practice this denotes more accurate measurement of the muon transverse momentum. In the barrel-endcap overlap region we have up to 18 layers of the muon detectors (DT, CSC and RPC) that potentially assure precise and robust tracking. But the previous track finding algorithms were not able to use so many detector hits for the momentum measurement.

Overlap Muon Track Finder trigger was working pretty well.

Good point! That’s why for each layer we divide the muon’s momentum spectrum into 52 bins and we assumed that the likelihood that a muon has a hit in each layer is just a product of the likelihoods of the muon hit phi positions (in each layer):

\[ P(\phi_1, \phi_2, \ldots, \phi_n) = P(\phi_1) \times P(\phi_2) \times \cdots \times P(\phi_n) \]

And we assign to the muon the \( \phi_i \) of the "golden pattern" with the highest likelihood.

Overlap Muon Track Finder trigger was divided into three parts, processing data from the barrel, overlap and endcap regions of the detector, respectively.

Wait, but you can do like that only if the hits are not correlated, while the muon hit positions are highly correlated.

Hm, not stupid. But the muon chambers do have some inefficiency. If there are no hits in some layers, then what? The likelihood is 0.

True, that’s why we actually are not using the absolute hit position, but the distance \( \Delta \phi_{\text{mean}} \) between each hit and one chosen hit that we call reference hit (minus average bending \( \Delta \phi_{\text{mean}} \)). Then the correlation is much weaker.

Your algorithm is implemented in the FPGA devices. Calculation of likelihoods requires a lot of floating point multiplications - in FPGA this is slow and consumes a lot of resources.

Yes, therefore, instead of multiplication of likelihoods we use the sum of the discretized likelihoods logarithms.

But what if you have more than one hit in a given detector layer?

I see one more problem though: the hit you have chosen as a reference can be a fake. Or you can have more than one muon in an event. Then your algorithm fails.

Very good! It gives 25% smaller rate and 2% better efficiency than the legacy muon trigger in the overlap region.

For each layer of a golden pattern we select only one hit that is closest to the middle of the likelihood distribution.

And what is the performance of your algorithm?

Good point! That’s why for each event we run the algorithm for up to four reference hits. If this produces duplicated muon candidates, we select only the ones that seem to be unique.

Artwork: Klara (8y) & Kinga (5y) Buńkowska

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