Global Trigger Algorithm Development

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Goal

Design prototype trigger algorithms optimized to meet Global Trigger System (GTS) Field Programmable Gate Array (FPGA) chip requirements

Motivation

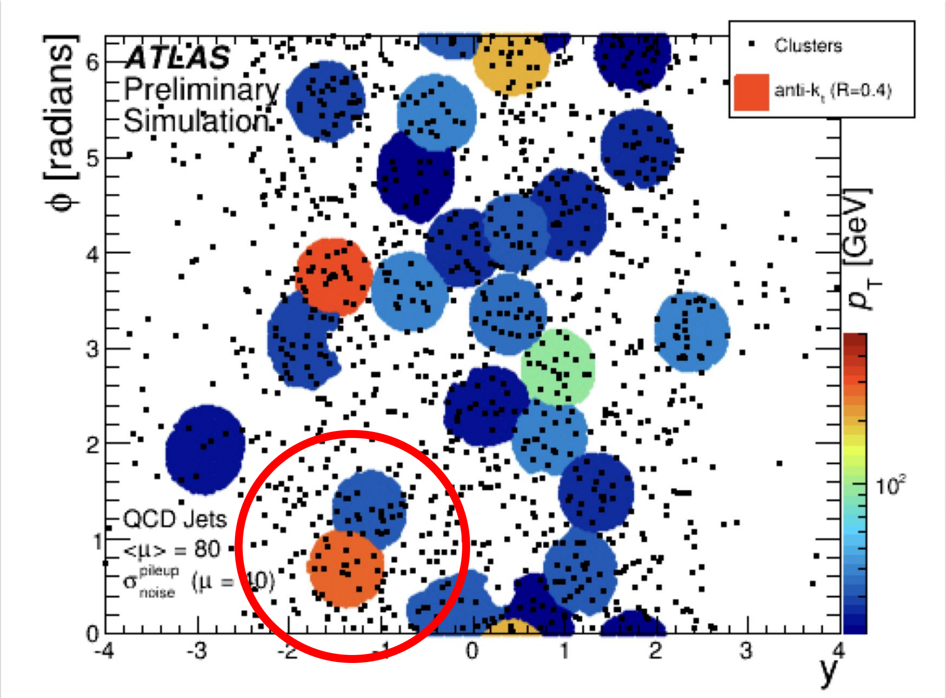
Simplified algorithms are needed to meet bandwidth requirements necessitated by collision frequency and calorimeter granularity.

Background rejection needs optimization to allow lower energy signal events to be recorded for study.

Jet Finding at High Luminosity

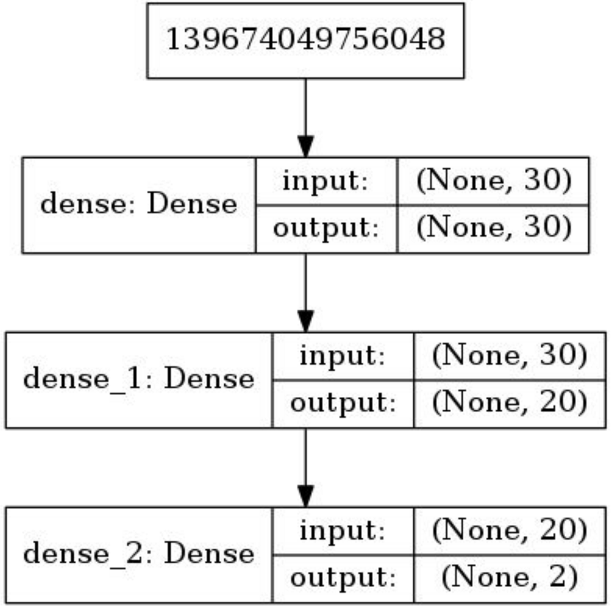
My studies are intended to differentiate interesting jets from uninteresting jets with simple algorithms.

Orange should be triggered on, whereas blue should be ignored.



DNN Structure

This neural network iteratively trains and tests, eventually calculating a score between pure QCD and pure top for each jet based on weights and variable values.



MC Sample Definitions

“Pileup” refers to the event dominating, soft, uninteresting jets.

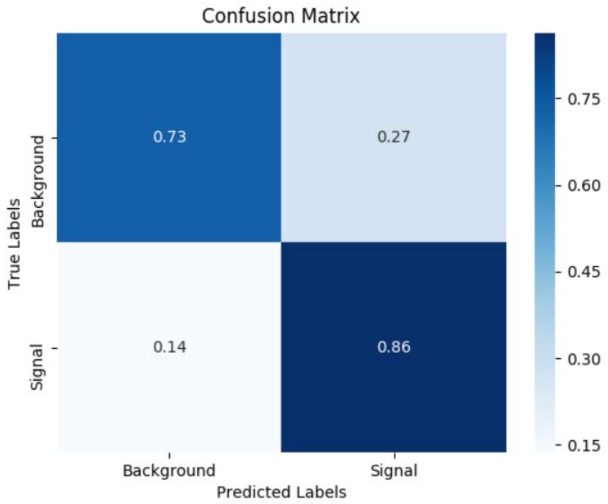
“Dijet” refers to QCD production of two hard partons, leading to two jets.

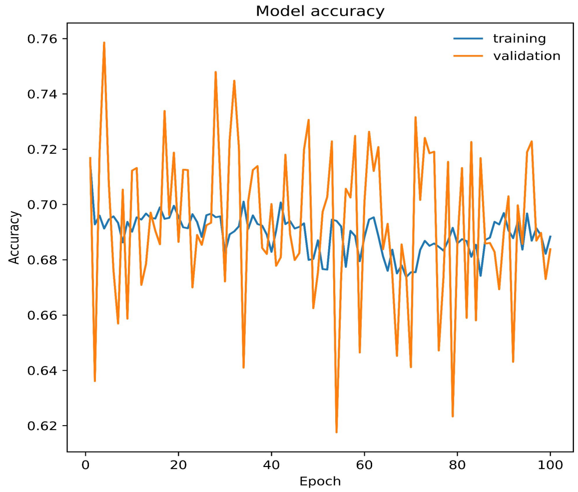
Z’->$t\bar{t}$ is a decay process used here to produce a sample top quark decay.

DNN Results

The neural network included 10 clusters of η, φ, and normalized transverse energy (E_T) of each jet.

The results were reasonably accurate, but very little learning occurred beyond the first few epochs.

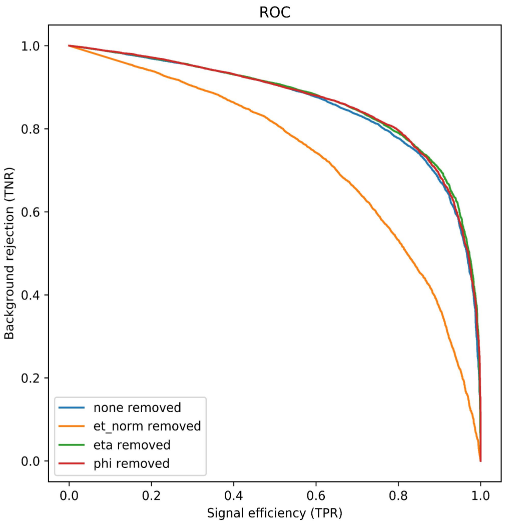


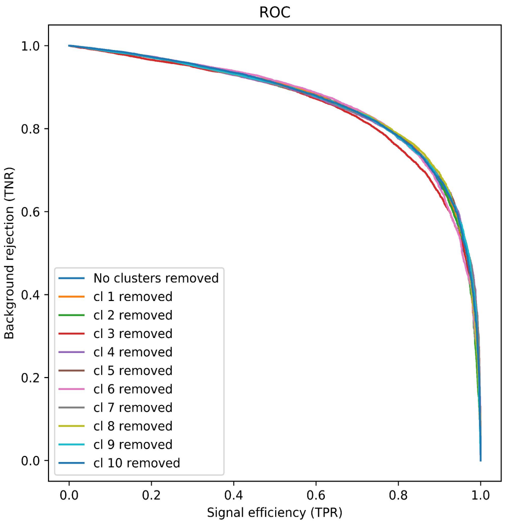


DNN Performance

Top figure: Removing cluster energy data has largest impact on DNN.

Bottom figure: Removing 3rd cluster data has largest impact on DNN.

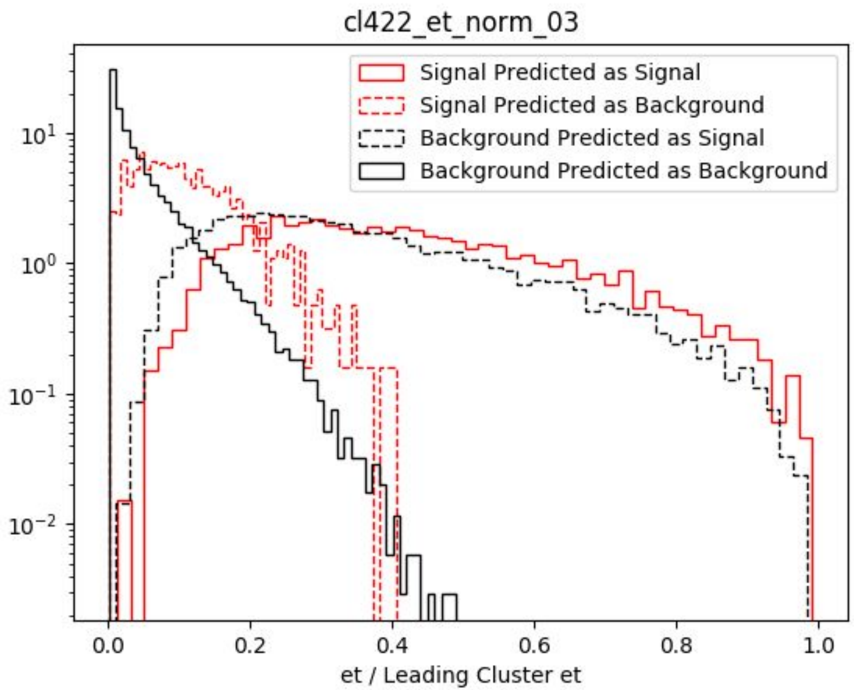




3rd Leading Cluster

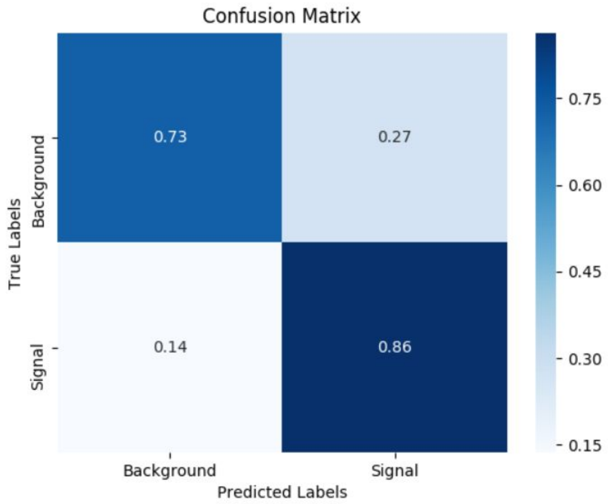
The 3rd cluster and normalized E_T were the most important based on the previous ROCs, leading to the study of the importance of their combined variable.

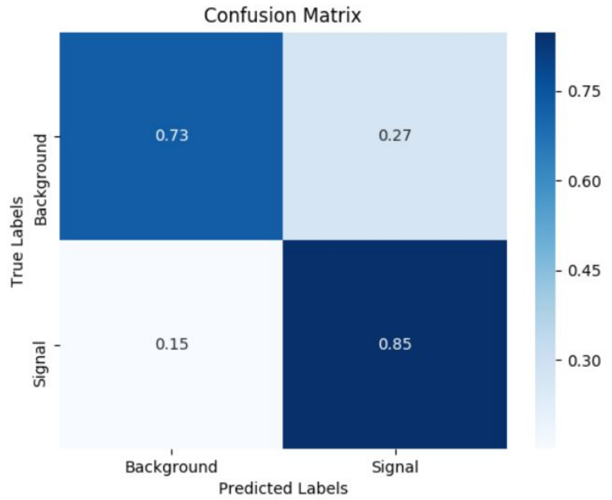
Top quark jets typically have 3 energetic constituents (coming from W boson and b quark). QCD jets typically have only 1-2 constituents.



Can we classify using one variable?

At a fixed background rejection, the more complex DNN (top) showed just 1% higher signal efficiency than a 3rd cluster E_T normalized cut (bottom).

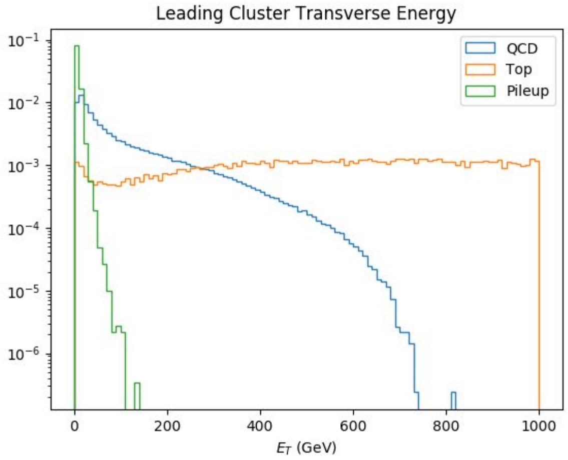


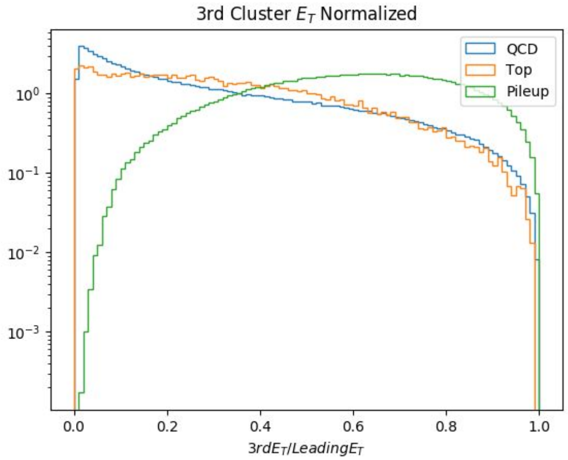


Trigger Optimization

Most(99.9%) of the “jets” that the trigger finds are pileup jets that are not interesting.

The 3rd leading cluster E_T normalized cut and a leading cluster cut are promising candidates for trigger variables.

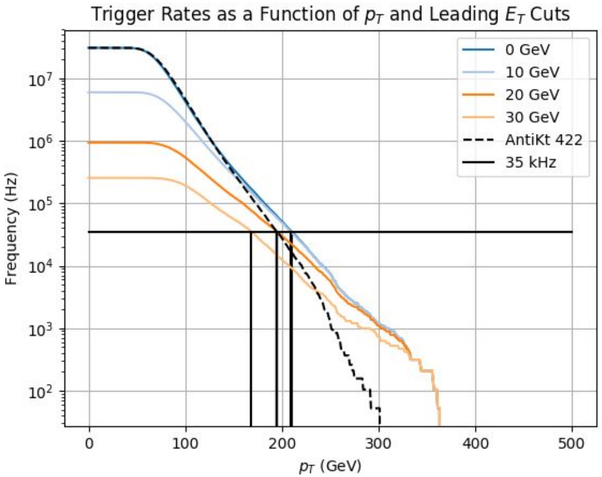


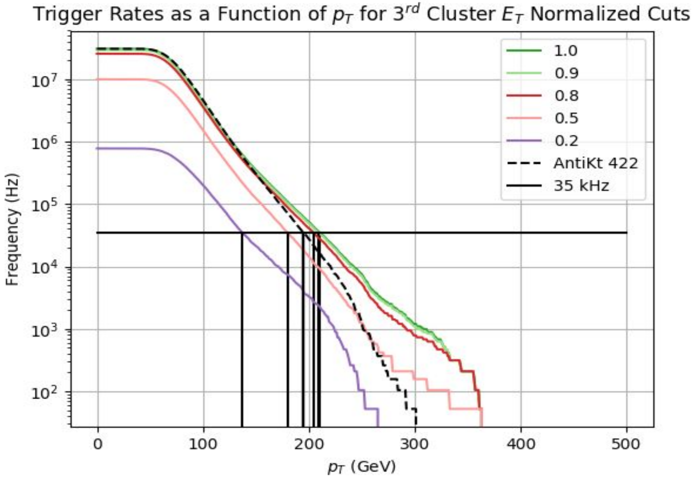


Trigger Optimization

Without rejecting pileup, the trigger would need to write data at roughly 40 MHz. This is far too high, so we seek trigger thresholds that limit to 35 kHz.

Leading E_T cuts and 3rd cluster E_T normalized cuts have a notable effect.

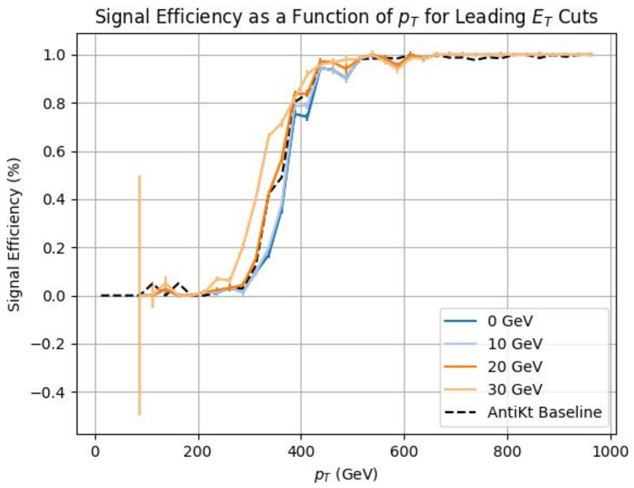


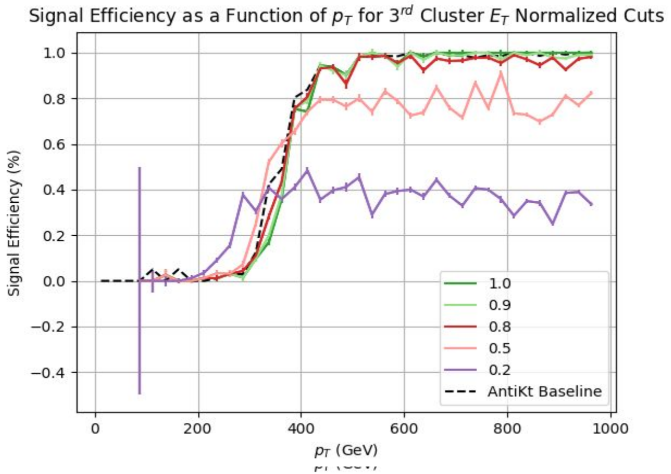


Trigger Optimization

The 30 GeV leading E_T cut accepts more lower p_T jets than AntiKt, but reaches 100% signal efficiency around the same p_T.

At the point where the E_T normalized cut has a notable reduction in minimum p_T, the signal efficiency is drastically reduced for all p_T.





Conclusions

ROC comparison of systematically removed variables to measure importance is a useful analysis tool that can be easily generalized to other analyses.

The comparison between topological cluster cuts and both the DNN and AntiKt algorithm shows that it is possible to replace complex algorithms with simpler algorithms at little to no cost in accuracy.

Run 4 topological clusters show immense potential for gathering interesting physics due to their pileup discriminating properties and the fine granularity of run 4 cells.

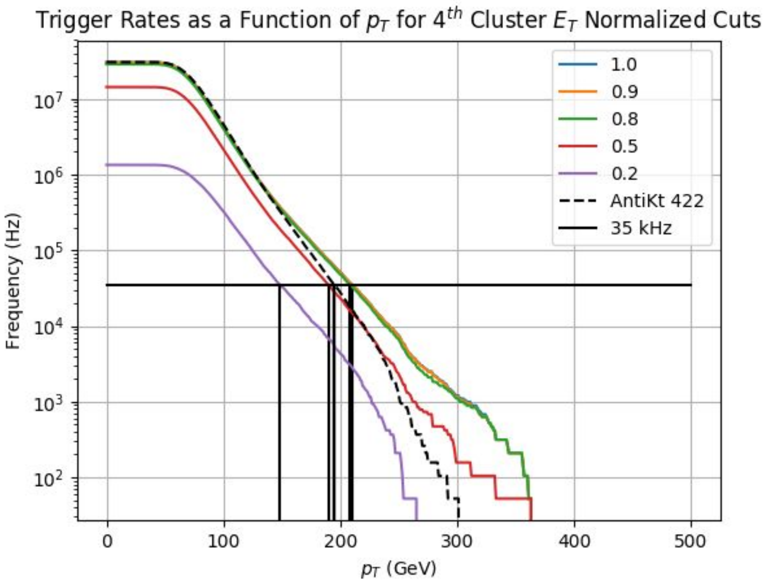
Next Steps

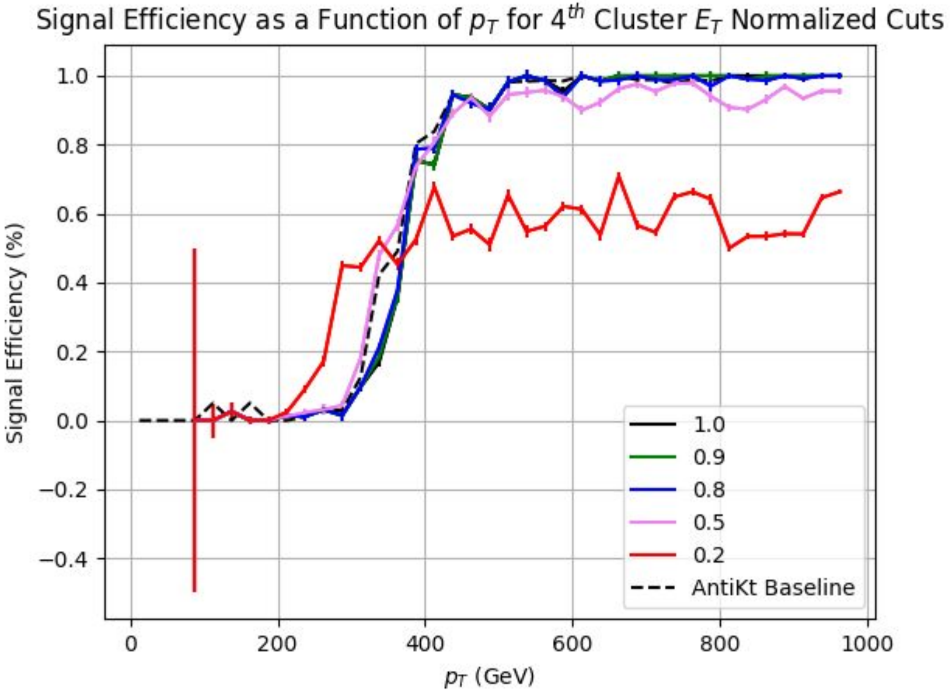
I will look at the effects of pileup suppression combined with E_T cuts on rates and signal efficiencies.

Thank you for your attention! I hope you learned something about the future of the LHC!

Backup Slides

Trigger Optimization

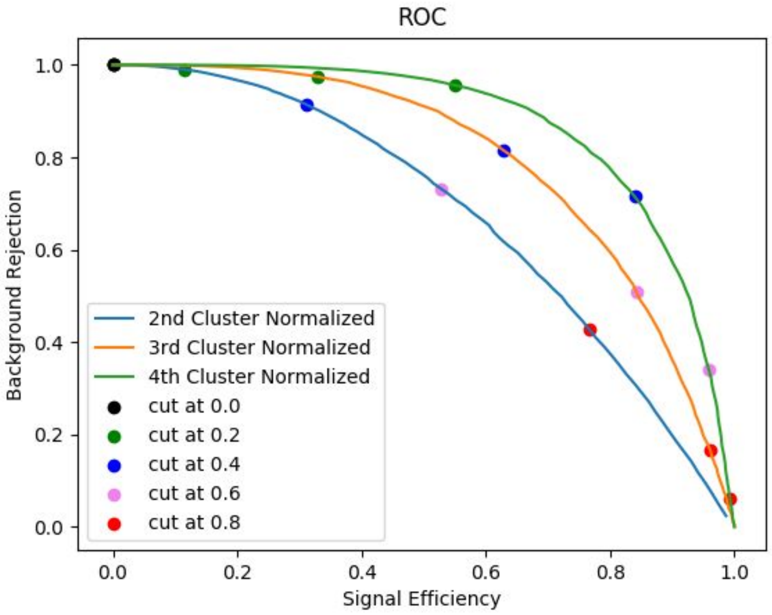




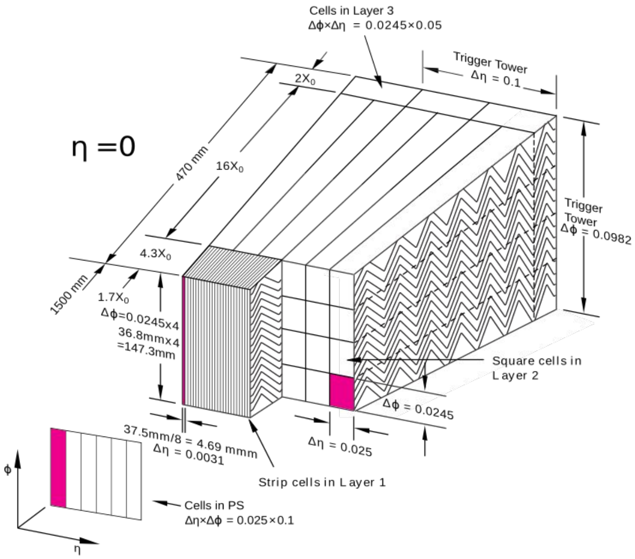
Trigger Optimization

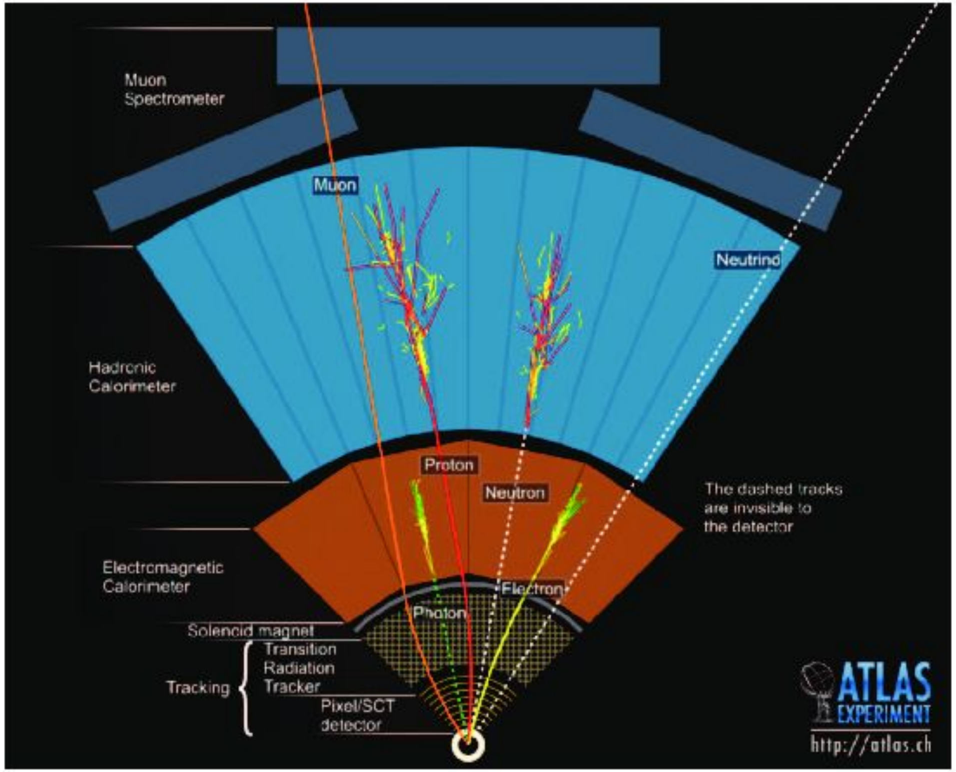
E_T Normalized Importance

ROCs to compare cuts on 2nd-4th clusters show the 4th cluster to be the most effective for top vs pileup



Calorimeter Structure





2^{nd} Cluster E_T Normalized Distribution