Searching for SUSY in all hadronic final states with the α_T variable

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Abstract

This is a thesis.

Declaration

There are many like it.

Author

Acknowledgements

Thanks.

Contents

Chapter 1

Introduction

The accelerator and detectors The Large Hadron Collider (LHC) [3] is a proton-proton collider which is situated in the Large Electron Positron (LEP) tunnel approximately 100 m under the franco-swiss border. Design center of mass energy is 14 TeV with an instantaneous luminosity of $1 \times 10\mathrm{e}^{34}\mathrm{cm}^{-2}\mathrm{s}^{-1}$. However during 2011 the center of mass energy was 7 TeV and the maximum luminosity was $5 \times 10\mathrm{e}^{33}$ $\mathrm{cm}^{-2}\mathrm{s}^{-1}$. To achieve this high energy and high beam current the LHC uses superconducting niobium-titanium magnets, cooled to a temperature of 1.8 Kelvin, that produce a maximum field strength of 8.36 Tesla.

TODO: we might well need some more stuff about the LHC its self in here!

Situated around the LHC ring are four detectors, two general detectors ATLAS [1] and CMS (see Chapter 3 for a detailed discussion of the CMS detector) [5][8] which are designed to measure the standard model to high precision and search for new physics. The LHC beauty experiment [7] is designed to study at previously unattainable precision the decays of heavy quark flavors, both to measure the standard model couplings and to search for beyond the standard model (BSM) physical processes. Finally the ALICE [2] experiment is designed to run when the LHC is running in it's secondary mode where rather than proton bunches, lead ions are collided, in an effort to study the quark-gluon plasma.

New physics Whilst the theory of the standard model and of new physics models will be discussed in chapter 2 it is prudent to discuss the observable features of these models with regard to design requirements for the general purpose detectors.

Chapter 2

Theory

Chapter 3

The CMS detector

Chapter 4

Level One Trigger

The CMS Level-1 trigger system[4] is a pipelined dead-timeless system based on custom-built electronics. The Level-1 trigger is a combination of several sub systems.

- Reginal Callorimeter (RCT).
- Global Muon Trigger (GMT).
- Global Callorimeter Trigger (GCT).
- Global Trigger (GT).

Some stuff about each of the sub systems

4.1 GCT Hadronic triggers

The global calorimeter trigger is responsible for forming hadronic jets in the central and forward sections of the hadronic calorimeters, there is a separate algorithm for forming hadronic τ jets. First 108 internal jets are formed and ordered, these jets are then used to calculate H_{T} and $H_{\mathrm{T}}^{\mathrm{miss}}$. The four highest energy jets then have their energy corrected, by passing though a look up table which is dependent on E_{T} and $|\eta|$, these jets are then passed to the Global Trigger so that the final trigger decision can be made.

4.1.1 Level-1 Trigger Jet Algorithm

The jet finding algorithm [6] at Level-1 finds local maxima from 3×3 blocks of trigger regions. The central trigger region is required to have $E_T^{cen} \geq E_T^{surrounding}$, however there is no direct requirement on the energy deposited in the central region.

generated/LoneTrigger/level1jetalgo.jpg

Figure 4.1: graphic of Level-1 jet algorithm

Due to the lack of a requirement of a jet seed threshold, soft non-collimated jets, such as those expected in a high pile up environment are found. Trigger decisions are then made using these pile up jets.

This is less of a problem for the single jet triggers which have a high P_T threshold. However the H_{T} triggers, where $H_{\mathrm{T}} = \sum_{jets} E_T^{jet}$ and the requirement of $E_{\mathrm{T}}{}^{jet} \geq 10$ GeV is made, see a large increase in rate due to pile-up, this is due to the low energy threshold required for a jet to be added to the H_{T} sum.

To counteract the effect of pile up on trigger rate we study the effects of requiring a jet seed threshold on the rate and efficiency of the individual jet and H_{T} triggers.

Figure 4.1 depicts 3×3 trigger regions, each of which are built from 4×4 trigger towers. In this case the central region is the jet seed. The proposed change would require there to be a threshold energy in the seed region.

The study of using jet seed thresholds of 2 and 5 GeV is presented. The maximum energy of effected jets is 18 GeV when requiring a seed of 2 GeV and 45 GeV when requiring a seed of 5 GeV for jets made from 3×3 trigger regions, however some jets can include more than 9 trigger regions. The jet clustering is performed before the Level-1 jets are corrected according to their E_{T} and η, hence the effects are manifested in trigger decisions for Level-1 jets above 18 or 45 GeV.

Figure 4.2 shows how the different threshold requirements effect the rank of the internal GCT jets. The effect is to remove all jets below 2(5) GeV and to cut out jets from the low end of the distribution. From Figure 4.2(b) it is possible to see the point beyond which the requirement of a jet seed has no effect. For a cut of 2 GeV jets above a rank of ≈ 35 are not effected, for a seed threshold of 5 GeV jets above a rank of 55 are not effected.

generated/LoneTrigger/GCT_Jet_Rank_highPU.pdf

(a) GCT jet E_T distributions for the same events with a 0, 2 or 5 GeV seed requirement.

generated/LoneTrigger/GCT_Jet_Rank_highPU_ratio.pdf

(b) Efficiency of applying a requirement of 2 or 5 GeV with respect to no requirement.

Figure 4.2: Effect of requiring a jet seed threshold on GCT internal jets.

Chapter 5

Offline Object Deffinitions

Chapter 6

The α_T analysis

Chapter 7

Conclusion

1

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