

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

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Abstract

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This is a thesis.

Declaration

There are many like it.

Author

Acknowledgements

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Thanks.

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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 $1 \times 10^{34} \text{cm}^{-2}\text{s}^{-1}$. However during 2011 the center of mass energy was 7 TeV and the maximum luminosity was $5 \times 10^{33} \text{cm}^{-2}\text{s}^{-1}$. 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

₁ Theory

Chapter 3

₁ The CMS detector

Chapter 4

Level One Calorimeter Trigger

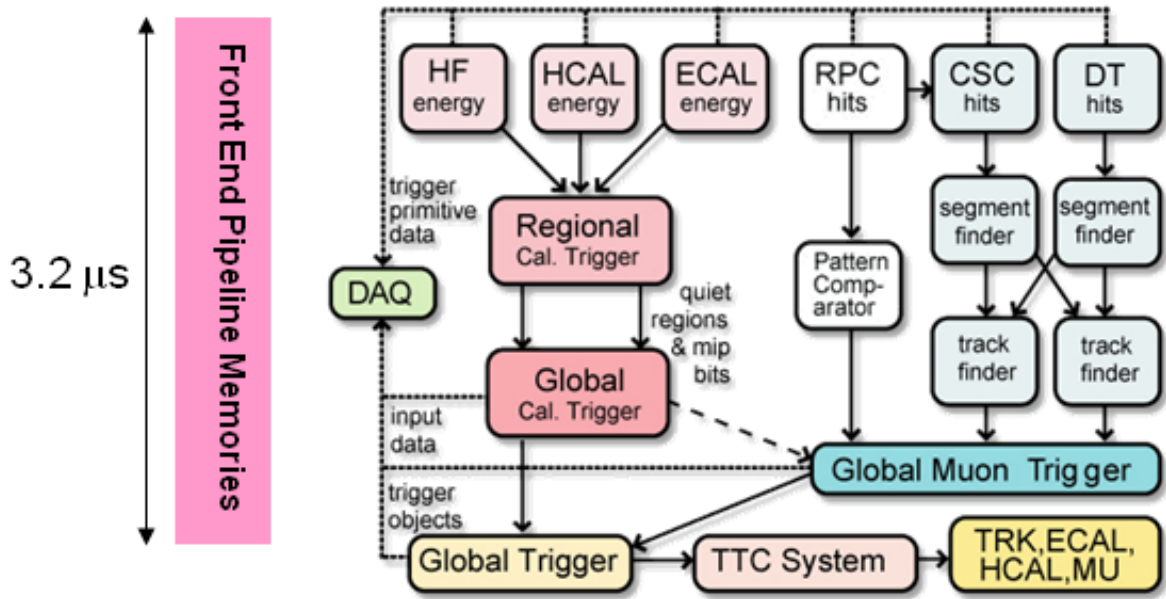


Figure 4.1: The CMS Level-1 Trigger system

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, which are interconnected as depicted in Figure 4.1.

Coarse grain information from the electro-magnetic, hadronic and forward calorimeters is processed by the Regional Calorimeter Trigger (RCT), this is then passed to the Global Calorimeter Trigger (GCT) where the coarse grain information is clustered into physics objects, these objects are then passed to the Global Trigger where the Level-1 accept decision is made. Due to the limited size of the pipe line this Level-1 accept must be issued within $4.0 \mu\text{s}$.

The objects passed from the GCT to the GT include electro-magnetic objects, both electrons and photons as due to the lack of tracking information at the Level-1 trigger these objects are indistinguishable, jets and energy sums.

The RCT generates up to 72 isolated and non-isolated electro-magnetic objects, these are sorted by rank, which is equivalent to transverse energy E_T . The four highest ranked electro-magnetic objects are then passed via the GCT to the GT at an equivalent data rate of 29 Gbs⁻¹ per type.

Hadronic objects under go two clustering steps. First the transverse energy sums of the ECAL and corresponding HCAL towers are calculated, the towers are then summed in to 4×4 trigger regions, these are passed to the GCT at a data rate of 172.8 Gbs⁻¹. These trigger regions are clustered in to jet candidates by the GCT and ranked. The jets are then sub-divided in the categories depending on their pseudo-rapidity and the result of τ identification.

Energy sums come in two forms, the total transverse energy E_T which is the scalar sum of all transverse energies and the total jet transverse energy H_T which is calculated as the scalar sum of all jets above some programable threshold.

The missing energy equivalents of these E_T^{miss} and H_T^{miss} are formed from the negative vector sum of the objects considered for the transverse sums.

4.1 Leve-1 Trigger Jet Algorithm

FIXME:this is taken pretty much straight from [6] might want to steal less??

The CMS detector can be un-rolled in the ϕ direction to form a rectangular grid of the 396 calorimeter regions, connected along the ϕ edge. The rectangle 18 ϕ divisions (from $-180^\circ < \phi \leq 180^\circ$) by 22 η divisions (from $-5 < \eta < 5$). Each ϕ division corresponds to 20° . The η divisions correspond to $\Delta\eta = 0.5$ in the forward calorimeters and to $\Delta\eta \approx 0.348$ in the barrel. The schematic view of this can be seen in Figure 4.2

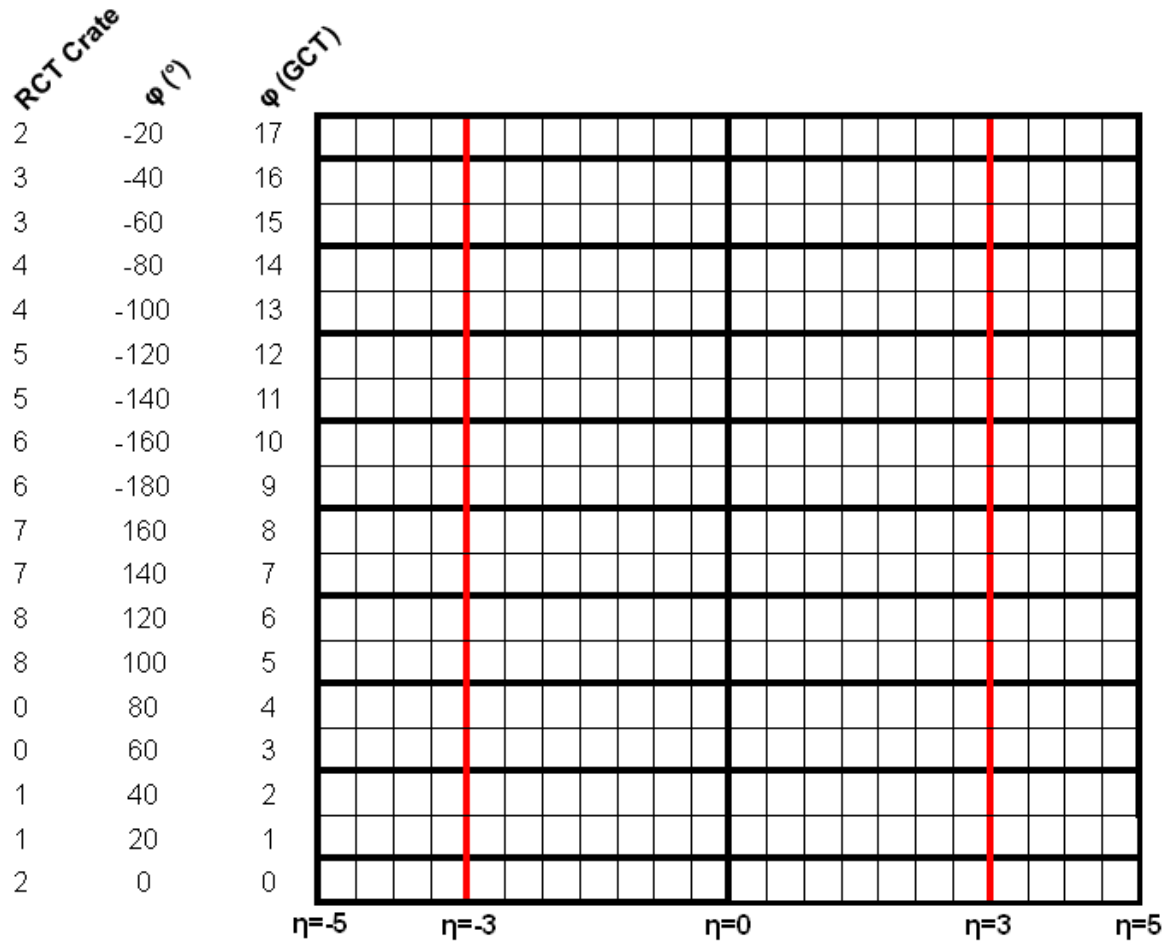


Figure 4.2: caption

4.2 Level-1 Trigger Performance

4.3 Level-1 Trigger Pile-up Mitigation

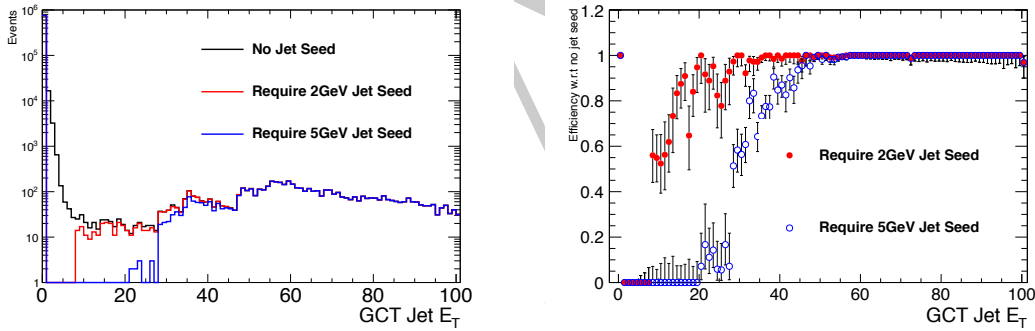
Due to the lack of a requirement of a jet seed threshold, soft non-collimated jets, such as those expected in a high pile up environment are found. Trigger decisions are then made using these pile up jets.

This is less of a problem for the single jet triggers which have a high P_T threshold. However the H_T triggers, where $H_T = \sum_{jets} E_T^{jet}$ and the requirement of $E_T^{jet} \geq 10$ 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 ?? 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.



(a) GCT jet E_T distributions for the same events with a 0, 2 or 5 GeV seed requirement. (b) Efficiency of applying a requirement of 2 or 5 GeV with respect to no requirement.

Figure 4.3: Effect of requiring a jet seed threshold on GCT internal jets.

Figure 4.3 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 4.3(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.

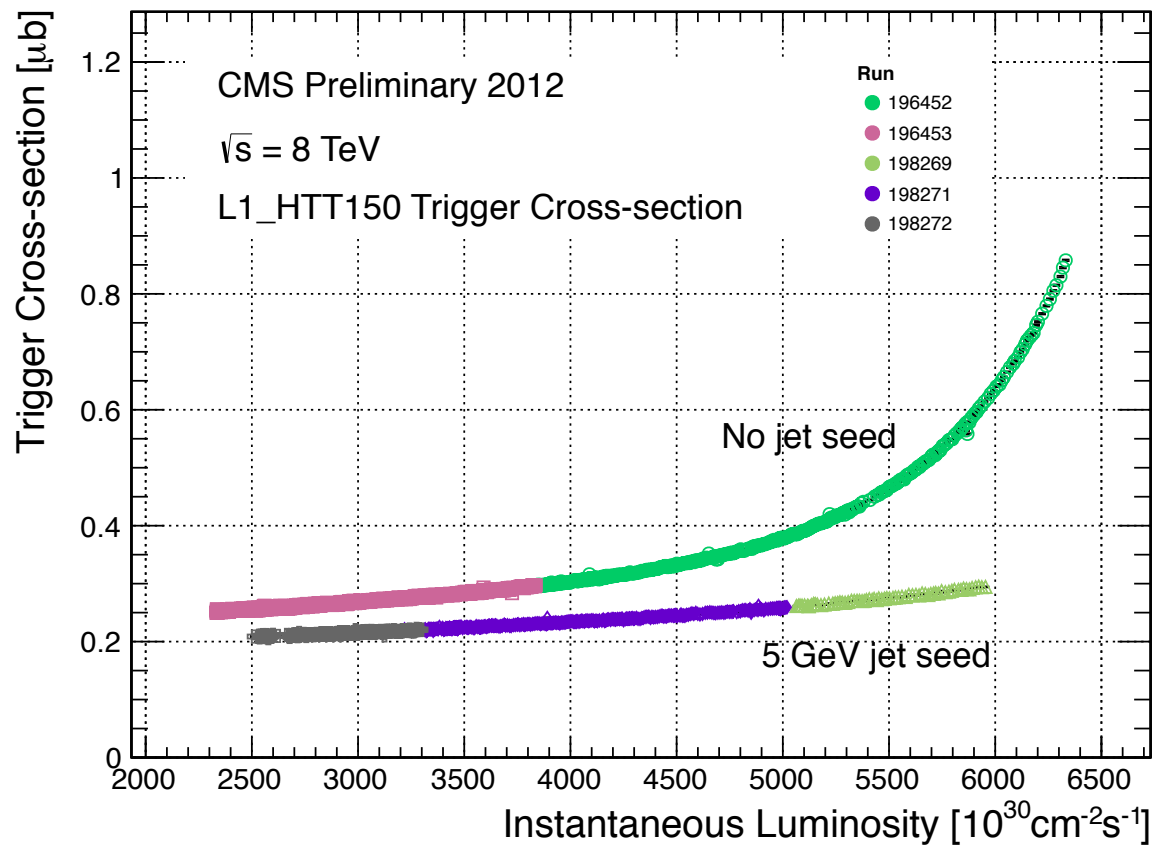


Figure 4.4: caption

Chapter 5

₁ Offline Object Definitions

Chapter 6

₁ The α_T analysis

Chapter 7

₁ Conclusion

DRAFT

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I Dumanoglu, N M Bakirci, C Dozen, M Zeyrek, M Yalvac, S Ozkorucuklu, K Sevim, Y Chang, W T Lin, S Bahinipati, K A Biery, E E Gottschalk, K Maeshima, T Kramer, S W L Kwan, S J Murray, L Taylor, N Mokhov, J M Marraffino, S Mrenna, V Yarba, B Banerjee, V D Elvira, D C Hare, B Holzman, F X Yumiceva del pozo, W Dagenhart, C L Dumitrescu, S C Ryu, B J Kilminster, J K Adelman-mc carthy, V E Bazterra, I Bucinskaite, P E Karchin, J R Incandela, M D'Alfonso, R Rossin, C A West, J L Gran, G Zilizi, P P Raics, A Bhardwaj, M Naimuddin, A Kumar, N Smiljkovic, C P De oliveira martins, M Petek, A Vercosa custodio, E J Tonelli manganote, M T Narjanen, P Graehling, F Blekman, J M Keaveney, S Blyweert, N van Remortel, X J Janssen, D Druzhkin, M Bansal, A Aleksandrov, M F Shopova, T R Fernandez perez tomei, C Krug, A A Shinoda, T V Rohe, P Arce, M Daniel, J J Navarrete marin, I Redondo fernandez, A Guirao elias, J Santaolalla camino, J Lottin, P Gras, F Kircher, B Levesy, A Payn, A K Nayak, V Bhatnagar, C Randieri, M Bruzzi, O Starodubtsev, A Tropiano, D Piccolo, C Sciacca, S Meola, A Saccomanno, M Esposito, P Azzi, E Conti, S Lacaprara, M Margoni, M Sgaravatto, N Pozzobon, P Torre, B Checcucci, L Fanò, S Taroni, A Lucaroni, F Romeo, G Bagliesi, M A Ciocci, A Giassi, T Boccali, S Arezzini, A Rizzi, G Broccolo, D Dattola, C Mariotti, A Ballestrero, E Camacho-Pérez, R Magaña-Villalba, J Martínez-Ortega, M Górski, G Wrochna, M J Bluj, A Zarubin, M Nozdrin, V Ladygin, A Golunov, A Sotnikov, N Evdokimov, I Lokhtin, A Ershov, N Tyurin, S Akimenko, V Talov, N Belikov, A Ryazanov, G W Hou, Y Chao, J Alwall, X Shi, D R Wood, D C Baumgartel, J Zhang, P D Luckey, K C Sumorok, G Gomez ceballos retuerto, S H Jaditz, G S Stephans, T Ma, P J Lehtonen, M H Chan, I J Moul, R A Ofierzynski, A Pozdnyakov, B L Pollack, P B Padley, A H Adair, W J Clarida, E Tiras, G Cerizza, M Pieri, V A Sharma, M W Lebourgeois, M Norman, F Golf, M J Murray, J L S Bowen, K Buterbaugh, M Sharma, J Bunn, H Newman, M Gataullin, M Spiropulu, J Veverka, S D Thomas, K J Rose, S M Panwalkar, A Calamba, Z Xie, J S Werner, A M Zuranski, A Ferapontov, E M Laird, G Kukartsev, Z Mao, S J Wimpenny, S Gleyzer, M G Weinberg, V Veeraraghavan, and J... Bochenek. CMS - The Compact Muon Solenoid. January 1996.

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