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Trigger Efficiencies for the High E_T Central Electrons in the Gen6 data

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Abstract

We study the trigger efficiency of the high E_T central electrons associated with the ELECTRON_CENTRAL_18 trigger path. We select electrons using the "baseline cuts". We evaluate the tracking trigger efficiencies as a function of several variables. We find a dependence of the tracking trigger efficiency with η. We find the L1 tracking efficiency to be about 0.9831(3), the L2 tracking efficiency to be about 0.9993(1) and the L3 tracking efficiency to be about 0.9974(1), all compatible with the last running period of Gen5 data. We measure the parametrization of the L2 calorimeter trigger efficiency, which reaches 100% at $E_T \cong 30GeV$. We also measure the L1 and L3 calorimeter trigger efficiency, which are essentially 100%. Finally we include results for the COT compromised data period.

1 Introduction

The path ELECTRON_CENTRAL_18 is the main path used to trigger on high E_T central electrons, which are key ingredients for several CDF analysis, including W and Z reconstruction as well as top quark analysis in the dilepton and lepton+jets channels. The offline requirements made to select high E_T electrons are tighter than the trigger requirements. This means that all central electron E_T of interest should pass the trigger, except for the fact that the offline cut variables are slightly different than the trigger variables. For example if such a variable is E_T since offline has access to the best calibration constants while the trigger has cruder calibration constants, there will be a slight difference between these two quantities. Typically, this will only affects events for which those variables are close to the cut threshold.

The general idea of how to get a trigger efficiency is to count the number of candidates of interest (number of W events or number of electrons for example) and define this as the denominator. For the numerator, we need to count the number of events that passed the denominator selection and also those that passed the trigger we are studying.

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Section 2 describes the triggers used for the central high E_T electrons. Section 3 contains the measurements of the tracking trigger efficiencies, while section 4 contains the measurements of the calorimeter trigger efficiencies. Section 5 contains the summary of the results as well as the total trigger efficiency applicable for the $t\bar{t}$ analysis.

The studies shown here follow very closely the studies that were done for the Gen4 processed data [1] and the Gen5 processed data [2].

2 Trigger Definitions

The following table summarizes the trigger requirements for the path ELECTRON_CENTRAL_18, taken from the trigger database:

Trigger Name	Requirements
L1_CEM8_PT8	$\geq$ 1 trigger tower ET_CENTRAL $\geq$ 8 GeV HAD_EM_CENTRAL $\leq$ 0.125 (this Had/EM cut has no effect for ET_CENTRAL > 14GeV) XFT_PT $\geq$ 8.34 GeV/c XFT_LAYERS $\geq$ 3 XFT hits per superlayer $\geq$ 11
L2_CEM16_PT8	$\geq$ 1 trigger tower L2_EM_T $\geq$ 16 GeV L2_HAD_EM_RATIO $\leq$ 0.125 DCAS_HIGH_EM_CENTRAL_SEED $\geq$ 8 GeV DCAS_HIGH_EM_CENTRAL_SHOULDER $\geq$ 7.5 GeV XFT_PT $\geq$ 8 GeV/c ABS_ETA_MAX = 1.317
L3_ELECTRON_CENTRAL_18	nEmObj $\geq$ 1 CalorRegion = 0 CenEt > 18 GeV cenHadEm $\leq$ 0.125 lshr $\leq$ 0.4 cenDeltaZ $\leq$ 8 cm ZVert = 2 nTowersHadEm = 3 cenTrackPt $\geq$ 9.0 GeV/c

Table 1: Description of the ELECTRON_CENTRAL_18 path

The time period covered by the Gen6 label is the data after the December 2004 shutdown until September 4^{th} 2005. All through this period the version of the ELECTRON_CENTRAL_18 path has been the same (_v-8) which means nothing was changed for the L1, L2 and L3 triggers for this path. As for the L3 executable it has also been stable during this period of time. We conclude that the trigger efficiencies can be computed using a single time period. The run range is from run 190697 to run 203799. Later we also show the trigger efficiencies if we were to have several time periods.

We also include results for the period covering the so-called "COT compromised" region. The run range is from 179099 to 182842.

The good run lists with and without good silicon requirements are taken from the Data Quality Monitoring good run list version 10.0 for electrons and muons with cmx ignored. For the COT compromised period we use the corresponding electron and muons good run list for that period.

The ntuples used for all these studies are the TopNtuples which were processed using offline release 6.1.2.

3 Tracking Trigger Efficiencies

3.1 Dataset used

To study the tracking trigger efficiencies we need a backup trigger which has the same (or tighter) calorimeter requirements as the CENTRAL_ELECTRON_18 path, but does not have any tracking requirement. Such a trigger is satisfied by the W_NOTRACK path described in table 2. Both the effect of XFT tracking as well as L3 tracking can be studied with this sample, which is included in the high p_T electron dataset (for Gen6: bhel0h). We first select events which pass this path and then we require that the run number and run section be part of the good run list and then we apply the offline $W \to e\nu$ selection. The selection of the offline W events are summarized in table 3. The baseline cuts for the electron selection is summarized in table 4. The number of candidates passing the W_NOTRACK trigger as well as the offline W selection is shown in table 5. The trigger efficiencies shown here are relative to the offline tracking efficiency for high E_T electrons. All the computed efficiency uncertainties are asymmetric bayesian errors.

3.2 L1 Tracking Trigger Efficiency

To get the L1 tracking trigger efficiency we look at the number of W candidates that also had the ELECTRON_CENTRAL_18 L1 bit set:

$$\epsilon(L1\_XFT\_PT8) = \frac{numW \ \& \ passedL1\_CEM8\_PT8}{numW} \quad (1)$$

Since the CEM8 part of the L1 trigger was satisfied for the events that passed the W_NOTRACK path, checking the L1_CEM8_PT8 bit checks the tracking requirement. The number of events passing the L1_CEM8_PT8 and the corresponding efficiency is shown in table 6.

Trigger Name	Requirements
L1_EM8_&_MET15	$\geq$ 1 trigger tower ET_CENTRAL (or PLUG) $\geq$ 8 GeV HAD_EM_CENTRAL (or PLUG) $\leq$ 0.125 MET $\geq$ 15 GeV SUMET_THRESH_CENTRAL (or PLUG) $\geq$ 1 GeV
L2_CEM16_L1_MET15	L2_EM_ET $\geq$ 16 (20) GeV L2_HAD_EM_RATIO $\leq$ 0.125 DCAS_HIGH_EM_CENTRAL_SEED $\geq$ 8 GeV DCAS_HIGH_EM_CENTRAL_SHOULDER $\geq$ 7.5 GeV ABS_ETA_MAX = 1.1 L1_MET $\geq$ 15 GeV
L3_W_NOTRACK_MET25	nEmObj $\geq$ 1 CalorRegion = 2 CenEt (or plug) > 25 GeV cenHadEm (or plug) $\leq$ 0.125 nTowersHadEm = 3 MET $\geq$ 25 GeV

Table 2: Description of the W_NOTRACK path. Note that the L2 threshold was raised to $E_T \geq 20GeV$ for this time period, compared to 16 GeV during the Gen5 period.

1 electron with $E_T > 25GeV$
$\not\!\!E_T > 25GeV$
reject cosmic events

Table 3: Offline W selection.

We also look at the efficiency dependency as a function of several variables: p_T, ϕ, η, z_0, calorimeter isolation with a cone of 0.4, track isolation with a cone of 0.4, number of jets with $E_T^{jet} > 10GeV$ and $|\eta_{jet}| < 1.2$ and $H_T = E_T^e + \not\!\!E_T + \sum E_T^{jet}$ where $E_T^{jet} > 10GeV$ and $|\eta_{jet}| < 2.5$. Table 7 and figures 1, 2 and 3, 4 show the dependency of the trigger efficiency for each of those variables. We conclude there is no strong dependency in trigger efficiency except as a function of η. Near $\eta \approx 0$ there is a significant inefficiency as a result of the COT space bars and also due to the charge collection inefficiency coming from the shorter particle path lenght. We fit this dependency with the following equation:

$$\epsilon(L1\_XFT\_PT8) = A - \frac{c}{2\pi\sigma} e^{-\frac{\eta^2}{2\sigma^2}} \tag{2}$$

The values found for A, C and σ are shown in table 9 and figures 5 and 6, 7 and 8. The fact that the trigger efficiency as a function of tracking isolation, calorimeter isolation and number of jets is relatively flat indicates that the fake electron background

Electron Variables	Current baseline cuts
E_T	> 20 GeV
p_T	> 10 GeV/c
N_{SL}^{axial} with 5 hits	≥ 3
N_{SL}^{stereo} with 5 hits	≥ 2
Fiducial	1
Had/Em	$< 0.055 + 0.00045$E
L_{shr}	< 0.2
E/p	< 2 (for p_T ¡ 50 GeV)
$\lvert Z_{vertex}\rvert$	< 60 cm
$\lvert\Delta X\rvert$	-3.0 $< Q_{trk}\Delta X <$ 1.5 cm
$\lvert\Delta Z\rvert$	< 3 cm
χ^2_{strip}	< 10
Conversion	$\neq 1$ (not)

Table 4: Offline baseline cuts for central electrons. Note that the W_NOTRACK path requires $E_T > 25$ GeV at L3.

	w/o silicon	w/ silicon
Period 9	214207	194550
Period 10	37109	26017

Table 5: Number of $W \to e\nu$ candidates passing the W_NOTRACK path. Period 9 refers to the Gen6 time period (1-8 is Gen5) and Period 10 to the COT compromised period.

	w/o silicon		w/ silicon	
Period 9	210587	0.9831(3)	191252	0.9830(3)
Period 10	35787	0.9644(10)	25023	0.9618(12)

Table 6: Number of $W \to e\nu$ candidates passing the L1_CEM8_PT8 trigger and corresponding efficiencies. Period 9 refers to the Gen6 time period (1-8 is Gen5).

is not a big concern for these studies. However we still see the effect of this background when one looks at the trigger efficiencies as shown in tables 7 and 8. The values found for the L1 tracking trigger efficiencies are compatible with the last period of Gen5 running. Finally, in figures 9, 10, 11, 12, 13, 14 we show the L1 tracking trigger efficiency as a function of run number, luminosity and number of vertices. We conclude that there is no strong dependence over time or as the luminosity increases.

Period 9	no jets in $\|\eta_{jet}\| < 1.2$	≥ 1 jets in $\|\eta_{jet}\| < 1.2$
w/o silicon	0.9828(3)	0.9849(7)
w/ silicon	0.9827(3)	0.9849(7)
	Cal. Isol. < 2 GeV	Cal. Iso. > 2 GeV
w/o silicon	0.9829(3)	0.9845(7)
w/ silicon	0.9829(3)	0.9841(8)
	Track Isol. < 1 GeV	Track Iso. > 1 GeV
w/o silicon	0.9829(3)	0.9839(6)
w/ silicon	0.9829(3)	0.9837(7)
	$H_T < 100GeV$	$H_T > 100GeV$
w/o silicon	0.9827(3)	0.9858 (7)
w/ silicon	0.9827(3)	0.9857(8)

Table 7: Dependencies of L1 tracking trigger efficiency vs various variables for Period 9 (Gen6).

Period 10	no jets in $\|\eta_{jet}\| < 1.2$	≥ 1 jets in $\|\eta_{jet}\| < 1.2$
w/o silicon	0.9629(11)	0.9731(22)
w/ silicon	0.9604(13)	0.9702(28)
	Cal. Isol. < 2 GeV	Cal. Iso. > 2 GeV
w/o silicon	0.9636(10)	0.9713(27)
w/ silicon	0.9608(13)	0.9702(33)
	Track Isol. < 1 GeV	Track Iso. > 1 GeV
w/o silicon	0.9633(11)	0.9701(22)
w/ silicon	0.9608(13)	0.9671(28)
	$H_T < 100GeV$	$H_T > 100GeV$
w/o silicon	0.9634(10)	0.9718(25)
w/ silicon	0.9607(13)	0.9701(31)

Table 8: Dependencies of L1 tracking trigger efficiency vs various variables for Period 10 (COT compromised).

w/o silicon	A	C	σ
Period 9	0.9965(2)	0.0699(15)	0.1857(39)
Period 10	0.9944(10)	0.1514(61)	0.2790 (100)
w/ silicon			
Period 9	0.9964(2)	0.0697(16)	0.1861(41)
Period 10	0.9946(12)	0.1679(76)	0.2858(114)

Table 9: Fit values for L1 efficiency vs η. Period 9 refers to the Gen6 time period (1-8 is Gen5) and Period 10 is the COT compromised region.

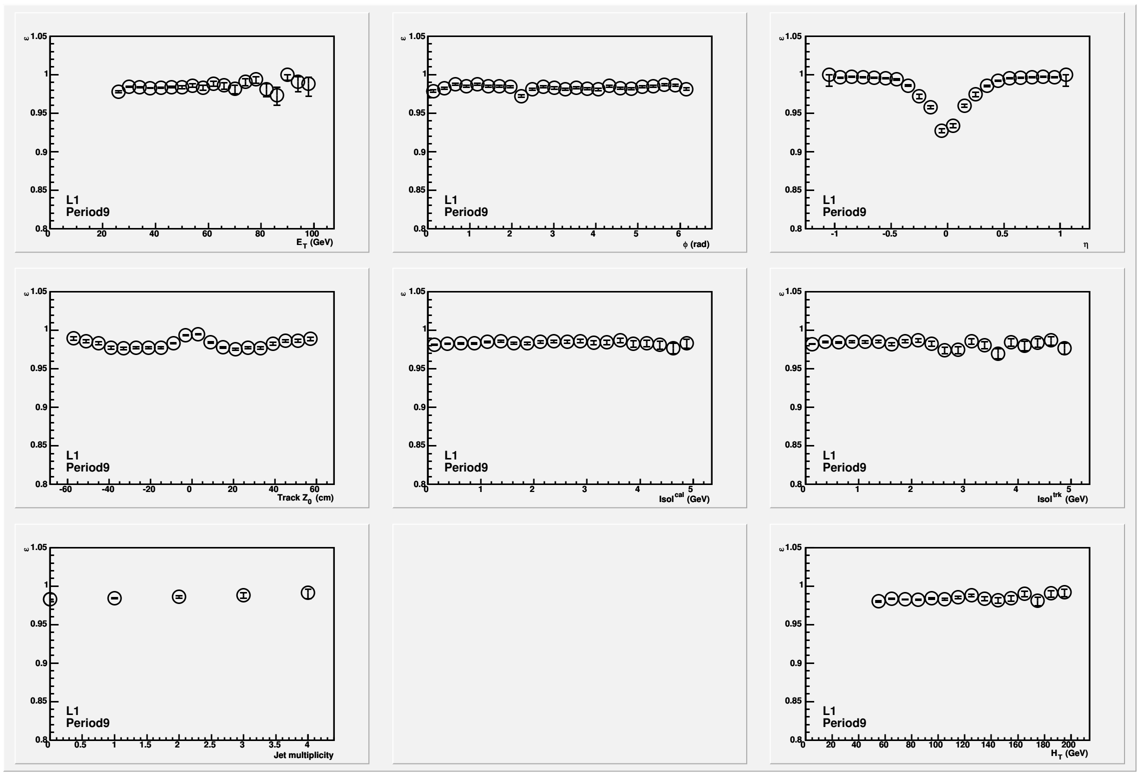

Figure 1: L1 tracking trigger efficiency dependences on various variables, without the silicon good run list for the Gen6 period.

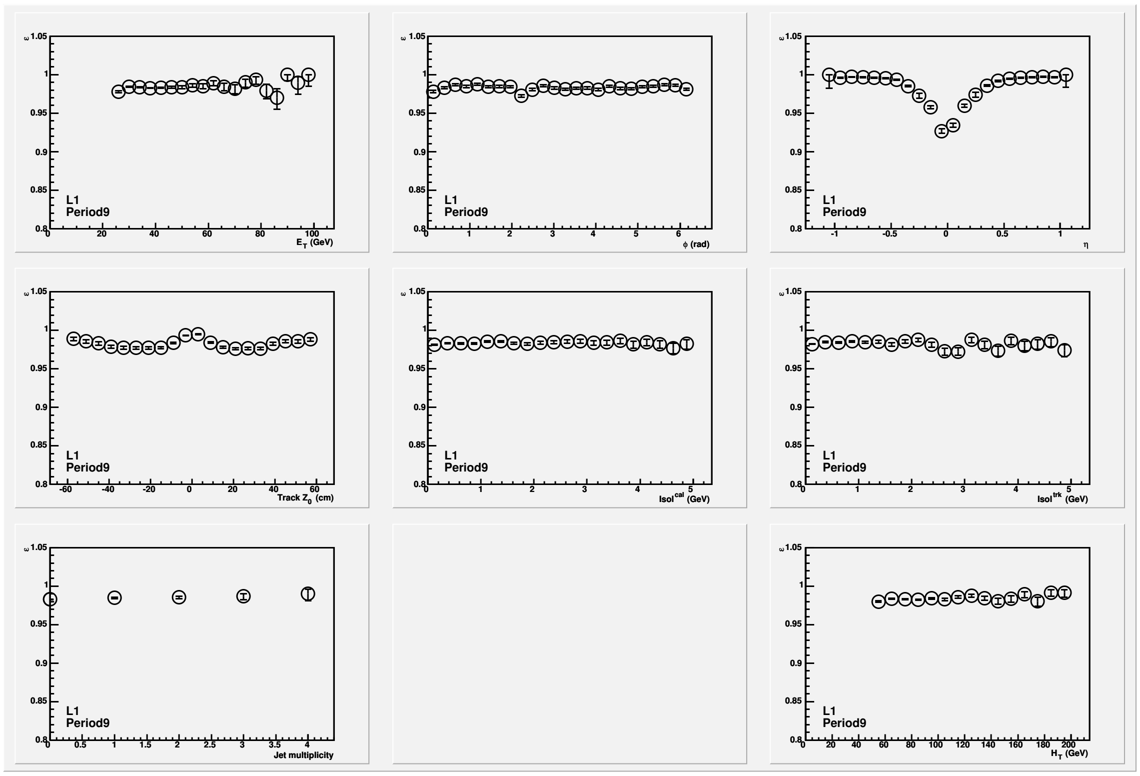

Figure 2: L1 tracking trigger efficiency dependences on various variables, with the silicon good run list for the Gen6 period.

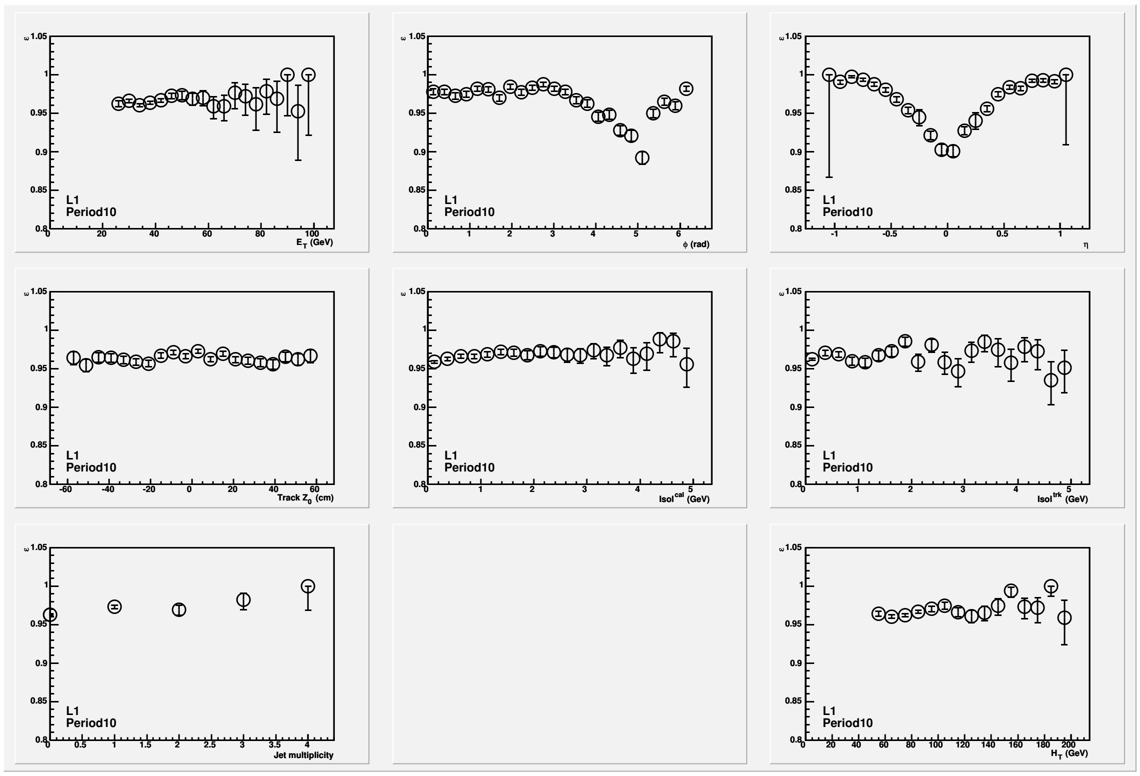

Figure 3: L1 tracking trigger efficiency dependences on various variables, without the silicon good run list for the COT compromised period.

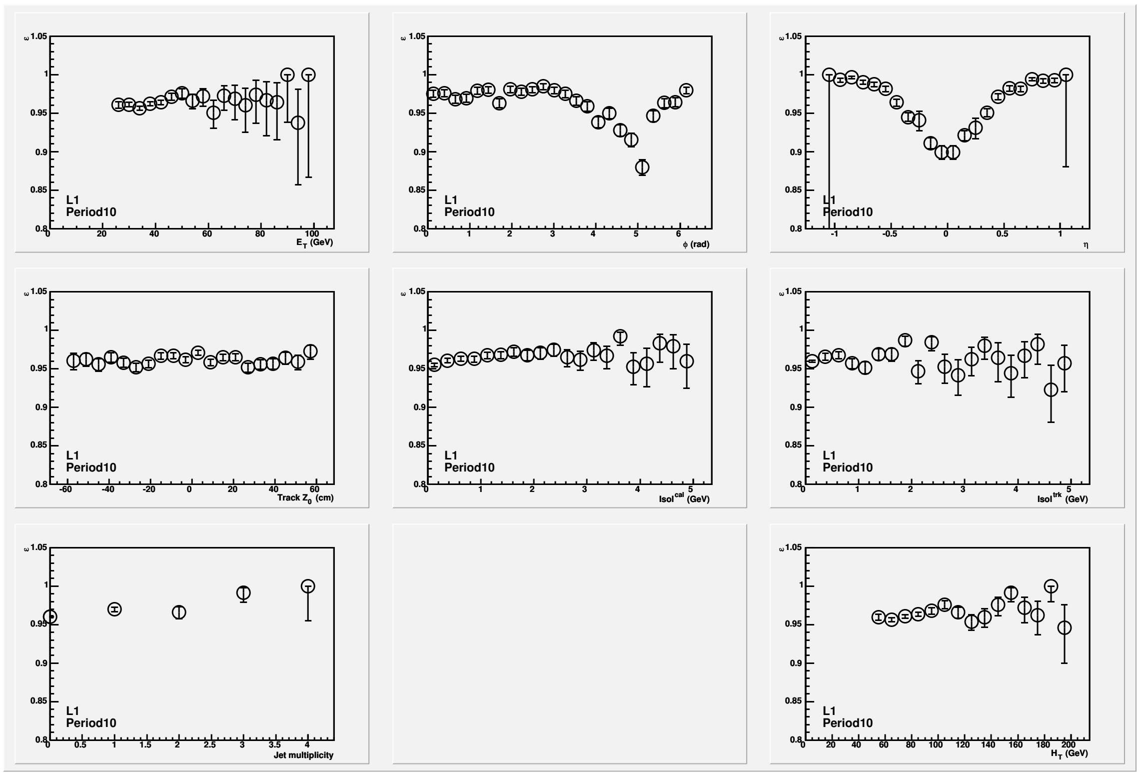

Figure 4: L1 tracking trigger efficiency dependences on various variables, with the silicon good run list for the COT compromised period.

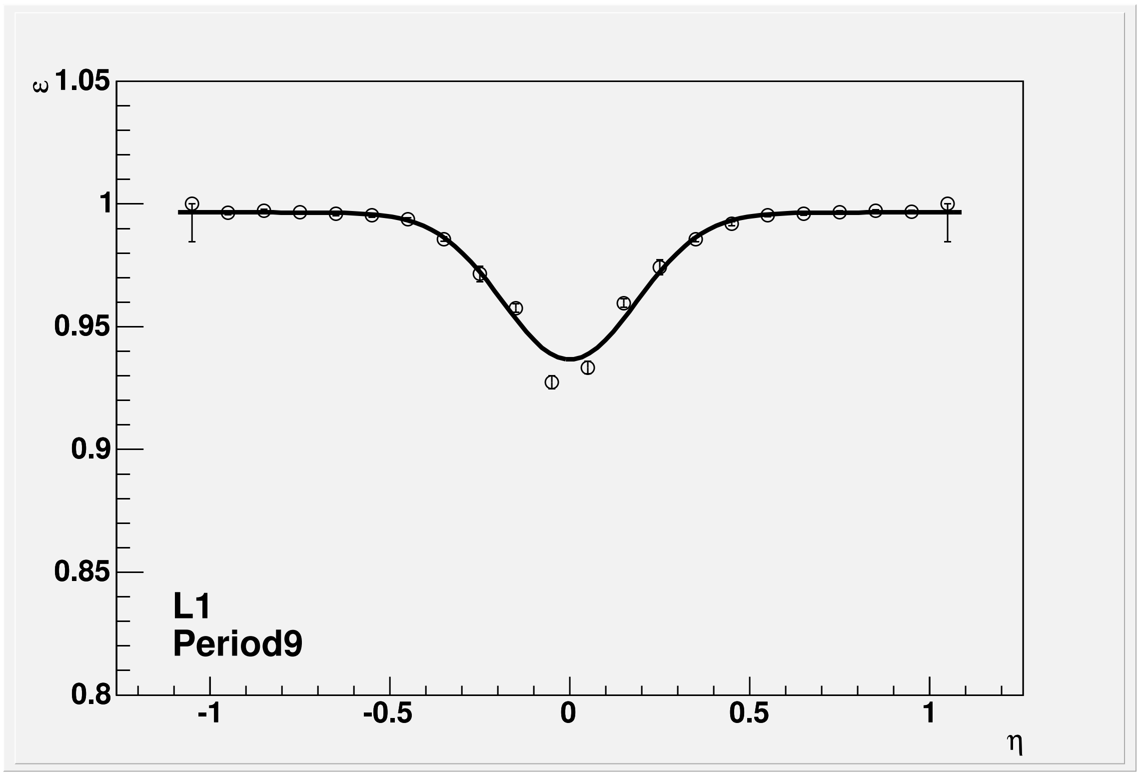

Figure 5: L1 tracking trigger efficiency as a function of detector η, without the silicon good run list.

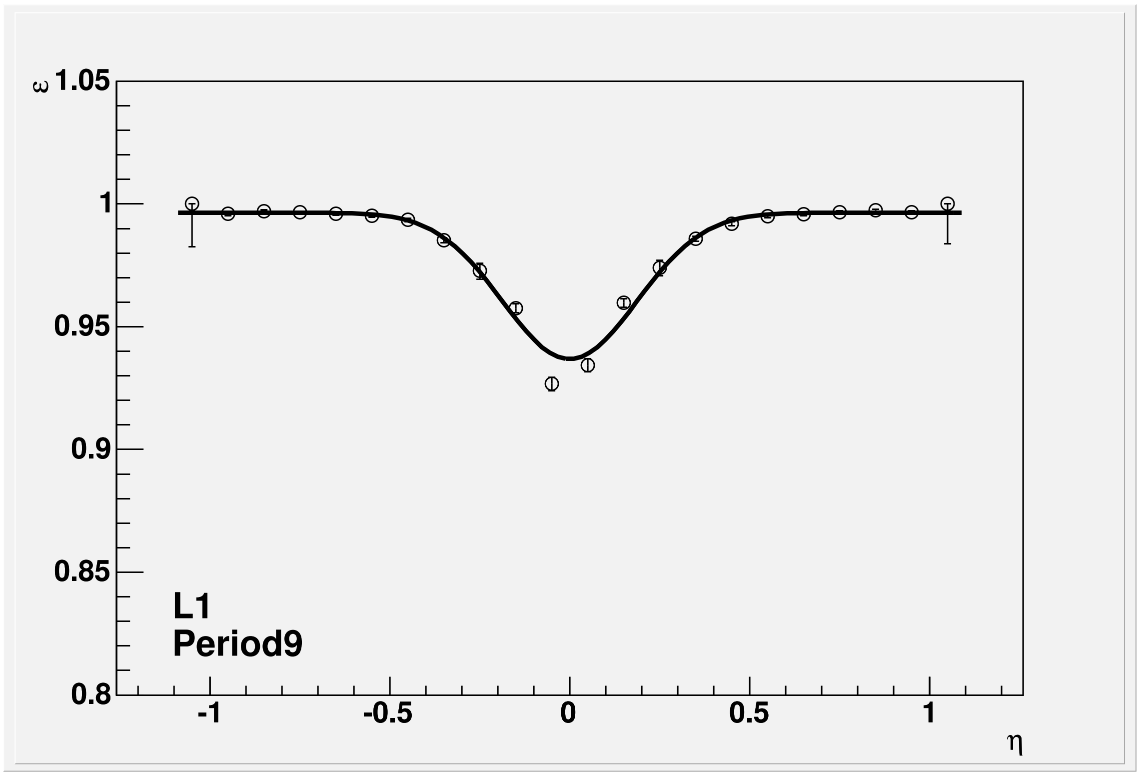

Figure 6: L1 tracking trigger efficiency as a function of detector η, with the silicon good run list.

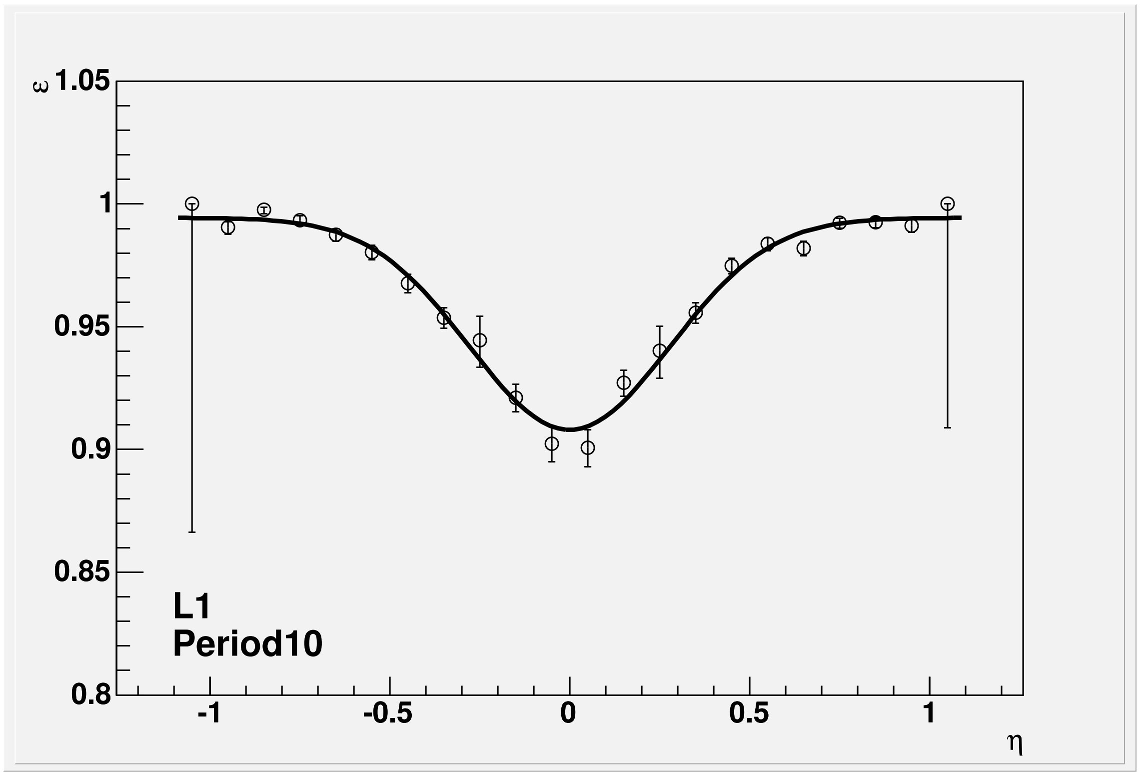

Figure 7: L1 tracking trigger efficiency as a function of detector η, without the silicon good run list for the COT compromised period.

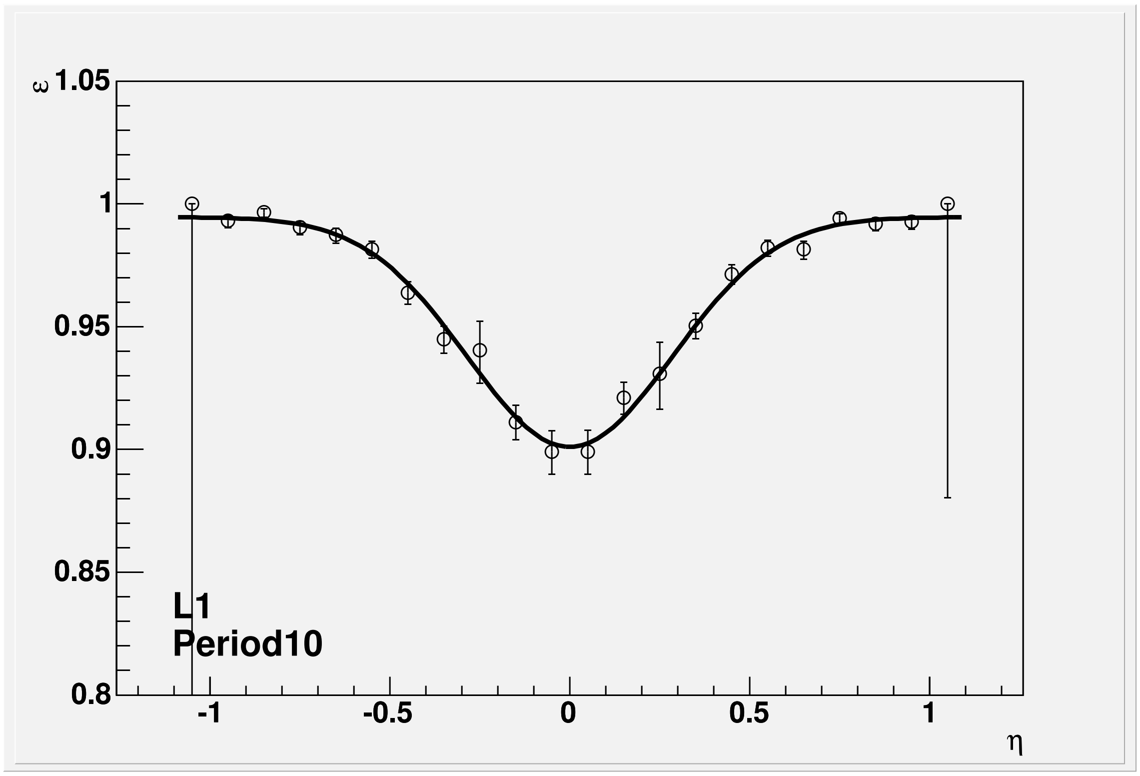

Figure 8: L1 tracking trigger efficiency as a function of detector η, with the silicon good run list for the COT compromised period.

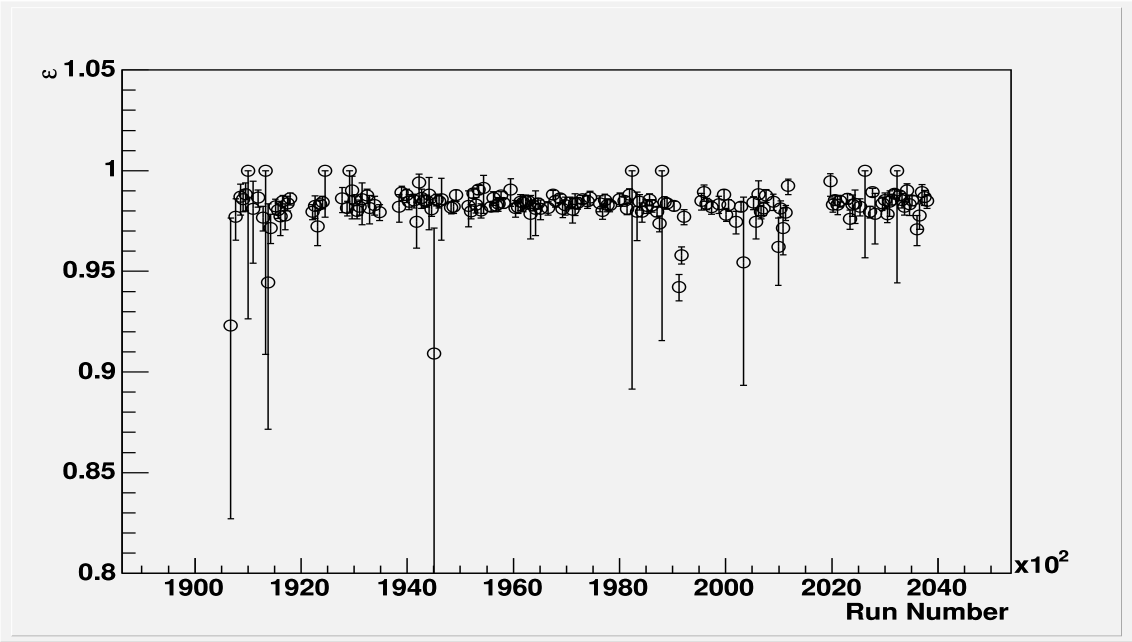

Figure 9: L1 tracking trigger efficiency as a function of run number for Gen6, without the silicon good run list.

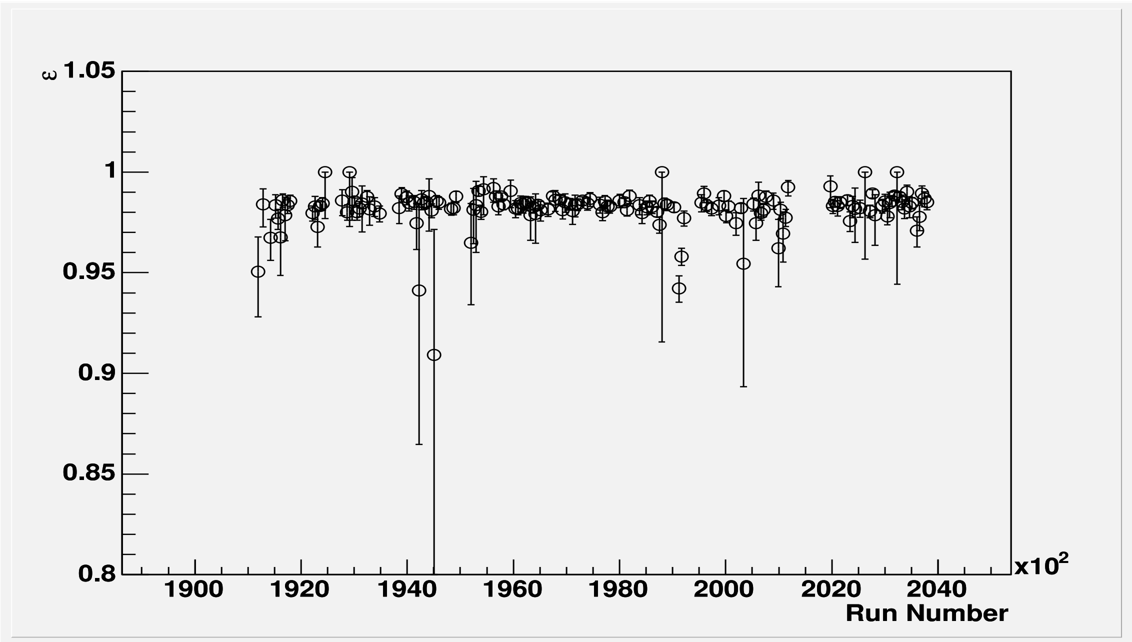

Figure 10: L1 tracking trigger efficiency as a function of run number for Gen6, with the silicon good run list.

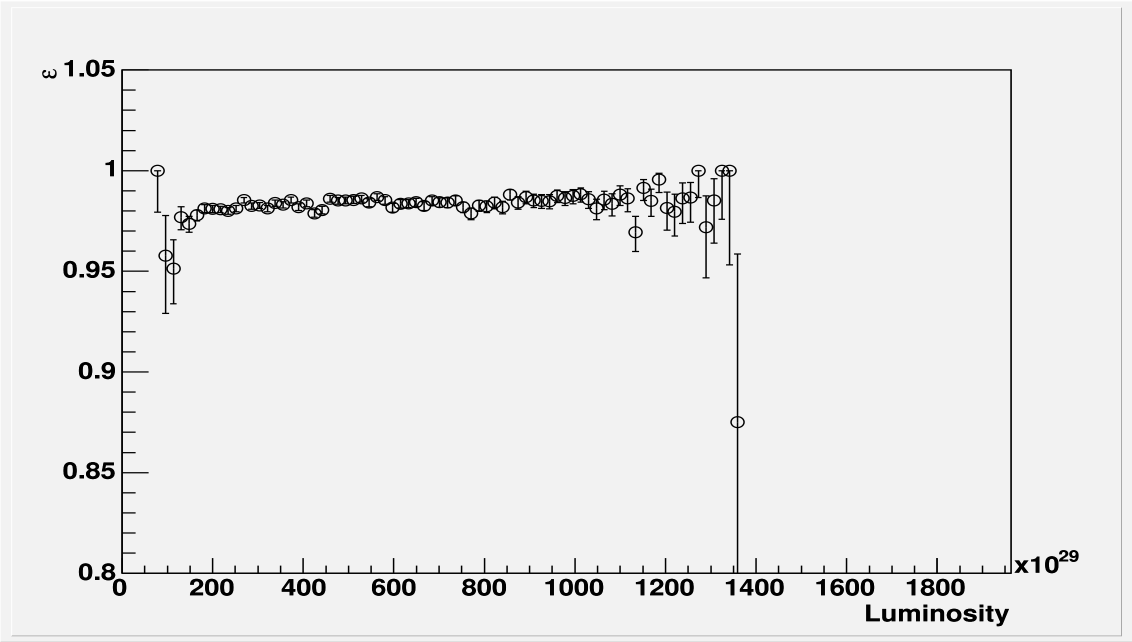

Figure 11: L1 tracking trigger efficiency as a function of luminosity for Gen6, without the silicon good run list.

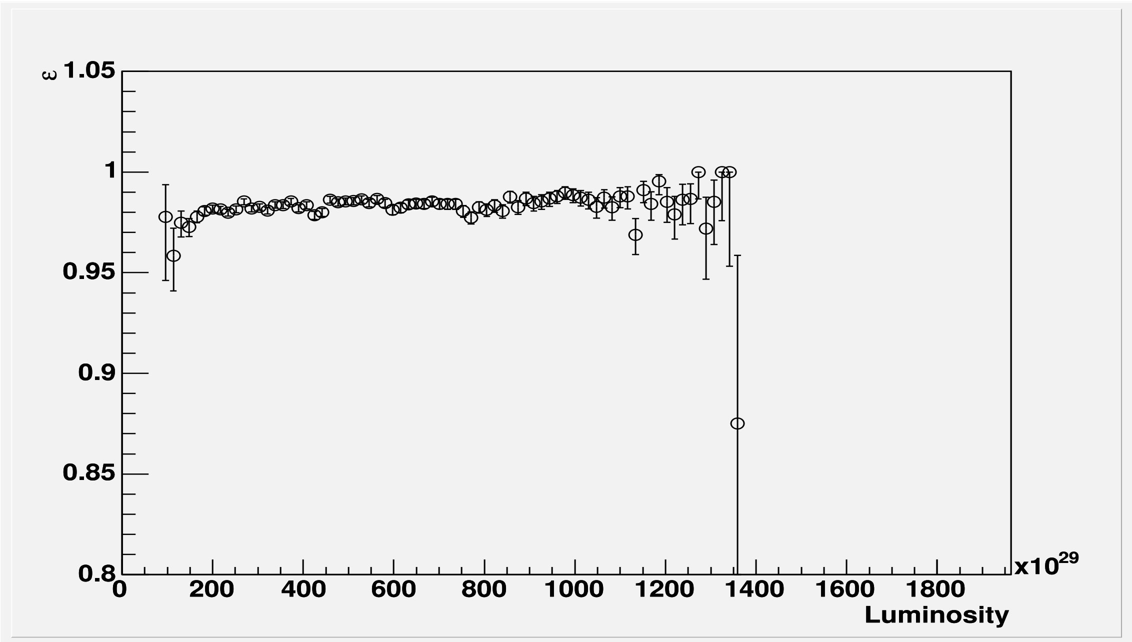

Figure 12: L1 tracking trigger efficiency as a function of luminosity for Gen6, with the silicon good run list.

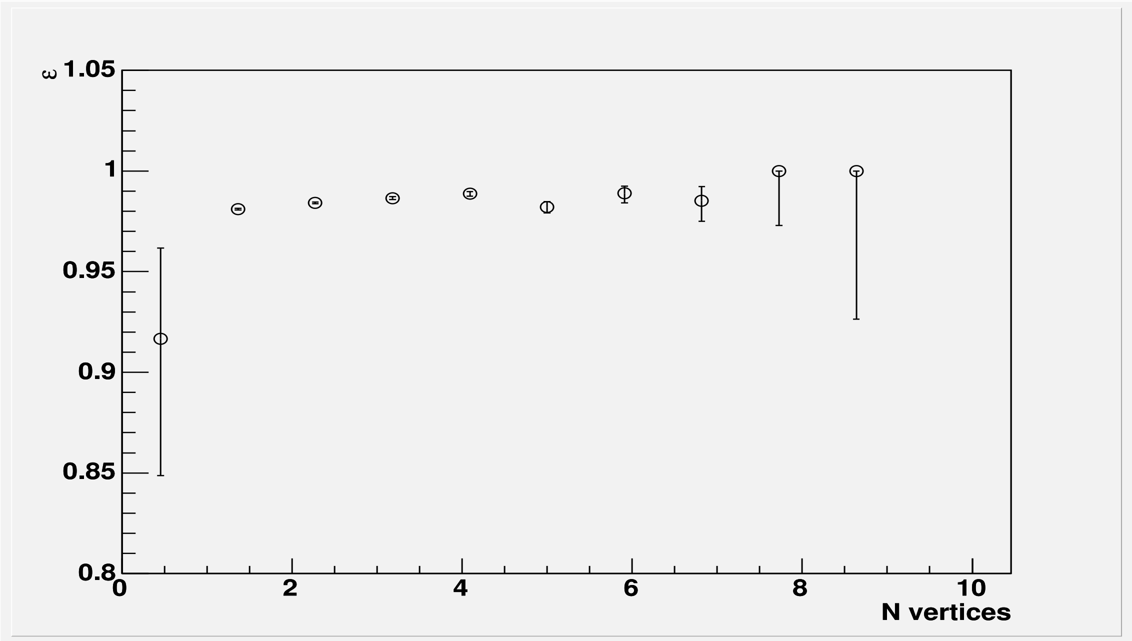

Figure 13: L1 tracking trigger efficiency as a function of number of vertices for Gen6, without the silicon good run list.

3.3 L2 Tracking Trigger Efficiency

At L2, there is no additional tracking done except for receiving the XFT information from L1. We just check that the L2 bit is set whenever the L1 bit is set, so we define the efficiency in the following way:

$$\epsilon(L2\_XFT\_PT8) = \frac{numW \ \& \ passedL1\_CEM8\_PT8 \ \& \ passedL2\_CEM16\_PT8}{numW \ \& \ passedL1\_CEM8\_PT8} \tag{3}$$

The results are shown in table 10 and are compatible with the Gen5 results. We looked at the run numbers where the errors happen and they distributed over several run ranges.

3.4 L3 Tracking Trigger Efficiency

We define the L3 tracking trigger efficiency in the following way:

$$\epsilon(L3\_PT9) = \frac{numW \ \& \ passedL1\_CEM8\_PT8 \ \& \ passedL2\_CEM16\_PT8 \ \& \ passedL3\_CEM18\_PT9}{numW \ \& \ passedL1\_CEM8\_PT8 \ \& \ passedL2\_CEM16\_PT8} \tag{4}$$

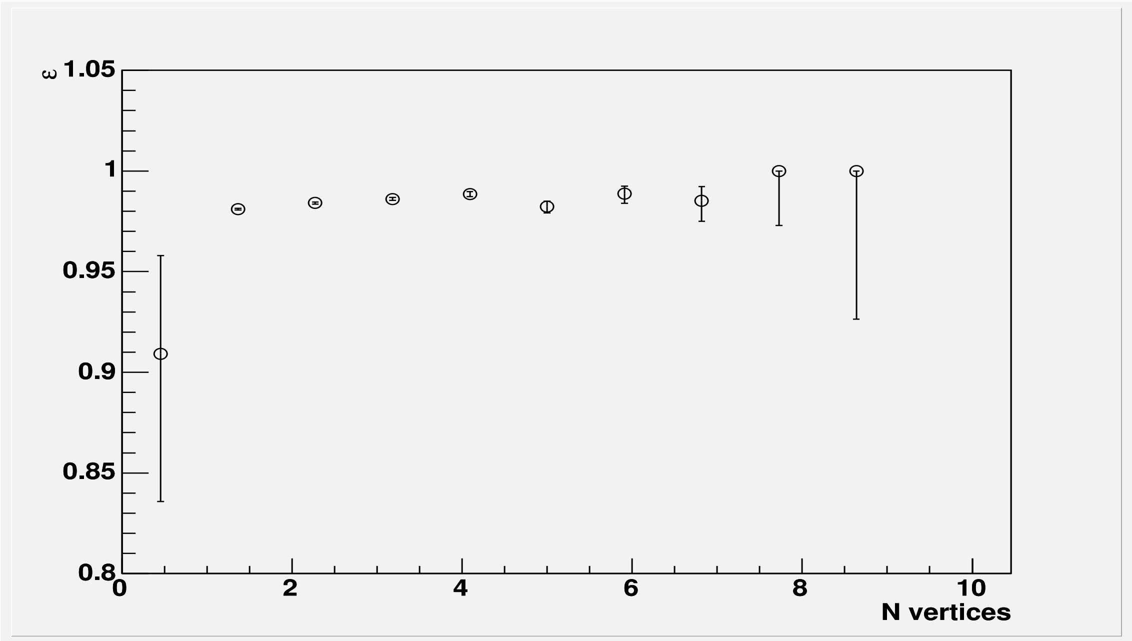

Figure 14: L1 tracking trigger efficiency as a function of number of vertices for Gen6, with the silicon good run list.

w/o silicon	Fail L2	Efficiency
Period 9	155	0.9993(1)
Period 10	37	0.9990 (2)
w/ silicon		
Period 9	145	0.9992(1)
Period 10	30	0.9988(2)

Table 10: L2 tracking trigger efficiencies. Period 9 refers to the Gen6 time period (1-8 is Gen5). Period 10 is the COT compromised period.

The measured efficiencies are reported in table 11, they are compatible with the last period of the Gen5 studies. We also look at the dependence of the trigger efficiency as a function of the same variables described for the L1 tracking trigger efficiency as shown in table 13 and figures 15, 16 and 17, 18. We do not observe any strong dependence of the trigger efficiency with any of the variables. However, similarly as for the L1 tracking trigger efficiency, from table 13 we can conclude that we see some effect of the fakes background on the efficiency, although this time, the region where the fakes are expected shows a lower efficiency compared to the region where the background should be very minimal. Finally, in figures 19, 20, 21, 22, 23, 24 we show the L3 tracking trigger efficiency as a function of run number, luminosity and number of vertices. We conclude that there is no strong dependence over time or as a function of luminosity, but we see some dependence as a function of number of vertices. We also show in figure 25 the dependency but for the case where the cuts were tighten [2] to suppress the possible effects from backgrounds, which could produce additional fake vertices in the event. We see that the trend downward is amplified by doing this, leading us to believe this is a real effect. Since the uncertainties are large at high number of vertices, we decide to keep a single number for the trigger efficiency, but as more data gets collected at very high luminosity, the trigger efficiency might need to get parametrized as a function of number of vertices.

	w/o silicon	w/ silicon
Period 9	0.9974(1)	0.9973(1)
Period 10	0.9908(5)	0.9906(6)

Table 11: L3 tracking trigger efficiencies. Period 9 refers to the Gen6 time period (1-8 is Gen5). Period 10 is the COT compromised period.

Period 9	no jets in $\|\eta_{jet}\| < 1.2$	≥ 1 jets in $\|\eta_{jet}\| < 1.2$
w/o silicon	0.9974(1)	0.9970(3)
w/ silicon	0.9973(1)	0.9971(3)
	Cal. Isol. < 2 GeV	Cal. Iso. > 2 GeV
w/o silicon	0.9977(1)	0.9947(4)
w/ silicon	0.9977(1)	0.9947(5)
	Track Isol. < 1 GeV	Track Iso. > 1 GeV
w/o silicon	0.9976(1)	0.9962(3)
w/ silicon	0.9976(1)	0.9961(3)
	$H_T < 100GeV$	$H_T > 100GeV$
w/o silicon	0.9975(1)	0.9965(4)
w/ silicon	0.9974(1)	0.9966(4)

Table 12: Dependencies of L3 tracking trigger efficiency vs various variables. Period 9 refers to the Gen6 time period (1-8 is Gen5).

[2]require isolation ratio < 0.1 and $E_T > 25GeV$ for the electron and $\not{E}_T > 35GeV$

Period 10	no jets in $\vert\eta_{jet}\vert < 1.2$	≥ 1 jets in $\vert\eta_{jet}\vert < 1.2$
w/o silicon	0.9903(6)	0.9937(11)
w/ silicon	0.9901(7)	0.9937(13)
	Cal. Isol. < 2 GeV	Cal. Iso. > 2 GeV
w/o silicon	0.9905(5)	0.9937(13)
w/ silicon	0.9904(7)	0.9927(17)
	Track Isol. < 1 GeV	Track Iso. > 1 GeV
w/o silicon	0.9906(6)	0.9917(12)
w/ silicon	0.9903(7)	0.9920(14)
	$H_T < 100GeV$	$H_T > 100GeV$
w/o silicon	0.9906(5)	0.9926(13)
w/ silicon	0.9904(7)	0.9922(16)

Table 13: Dependencies of L3 tracking trigger efficiency vs various variables. Period 9 refers to the Gen6 time period (1-8 is Gen5). Period 10 is the COT compromised period.

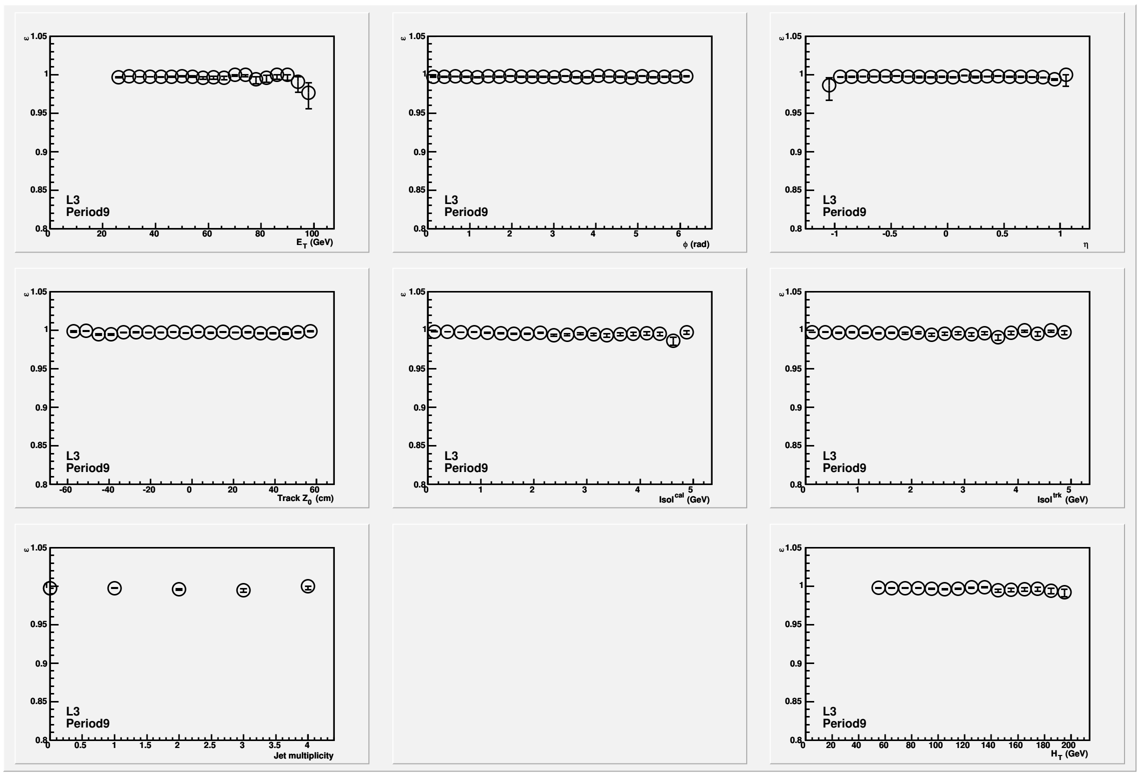

Figure 15: L3 tracking trigger efficiency dependences on various variables for Gen6, without the silicon good run list.

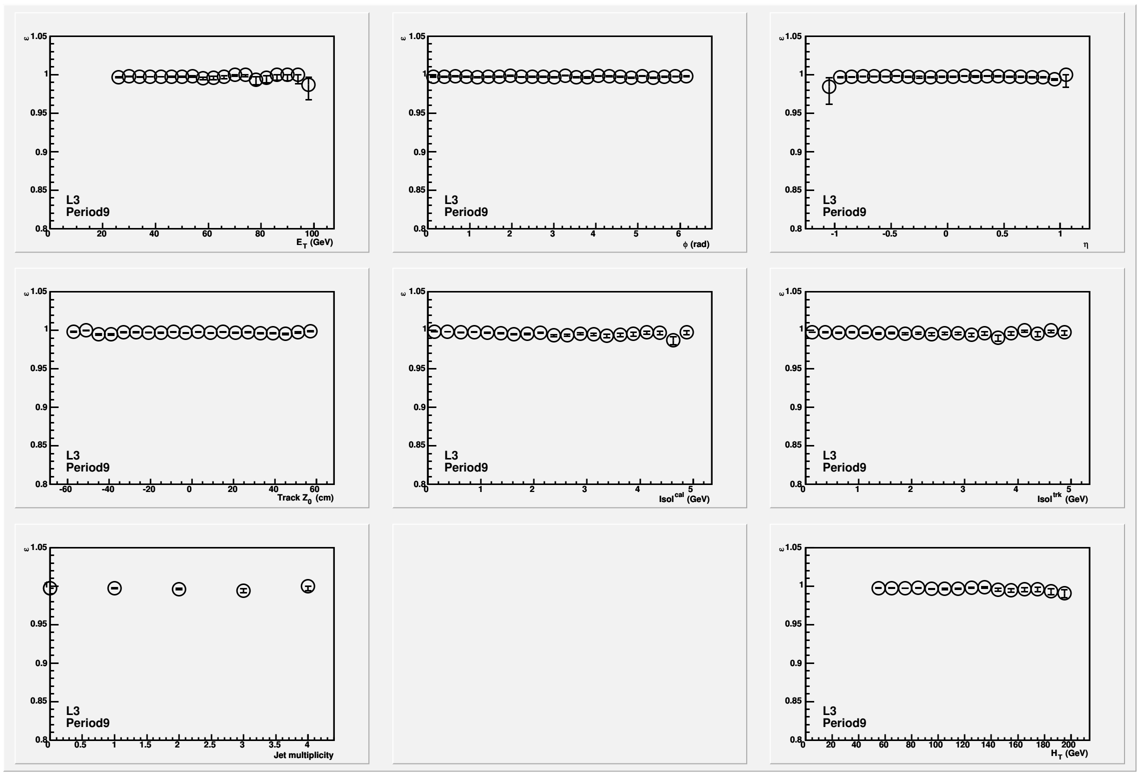

Figure 16: L3 tracking trigger efficiency dependences on various variables for Gen6, with the silicon good run list.

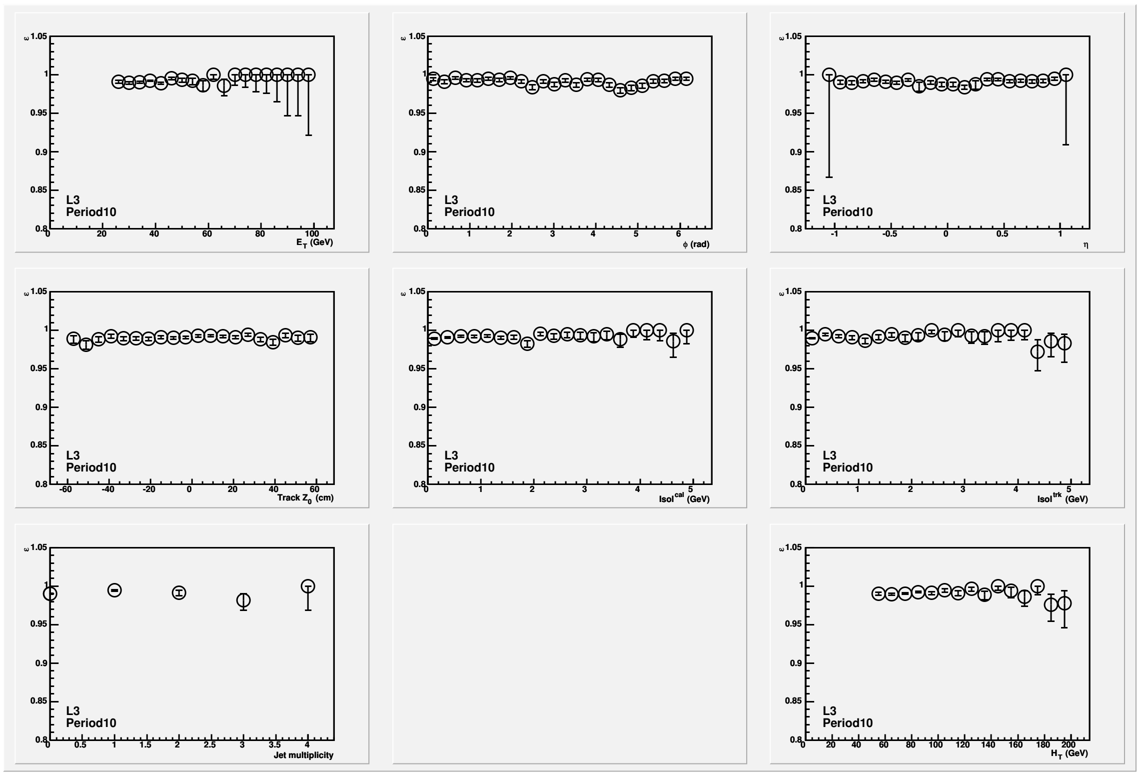

Figure 17: L3 tracking trigger efficiency dependences on various variables for the COT compromised period, without the silicon good run list.

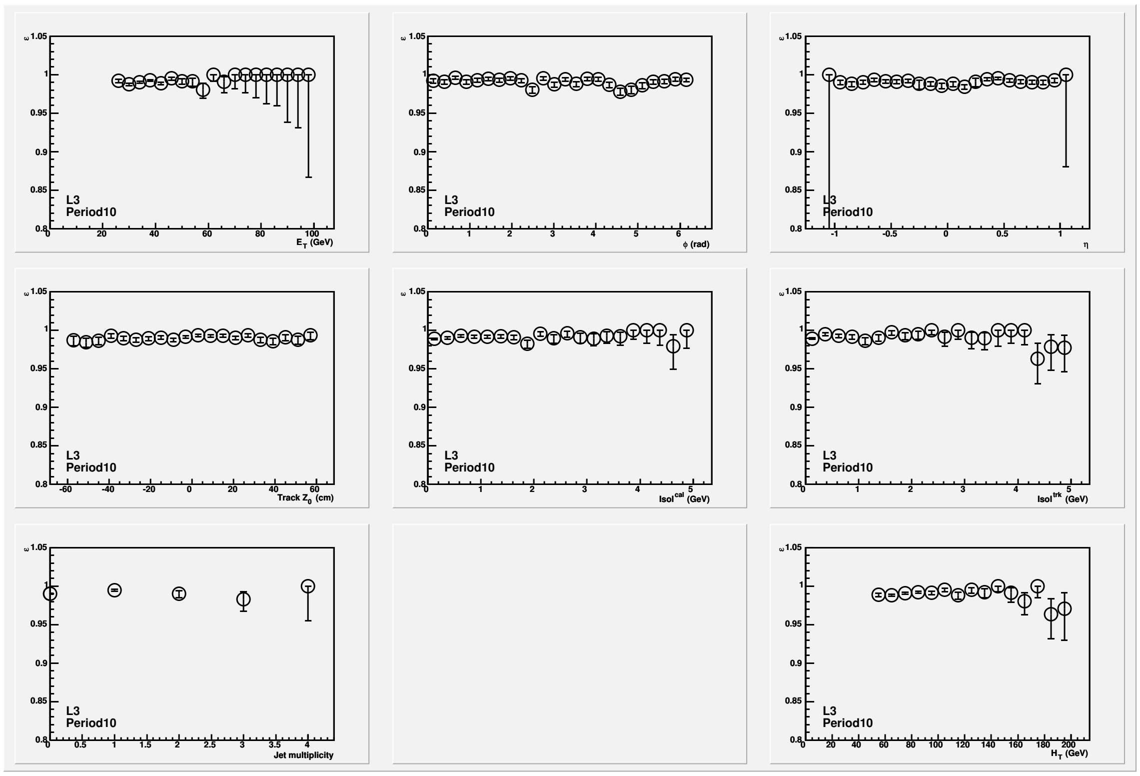

Figure 18: L3 tracking trigger efficiency dependences on various variables for the COT compromised period, with the silicon good run list.

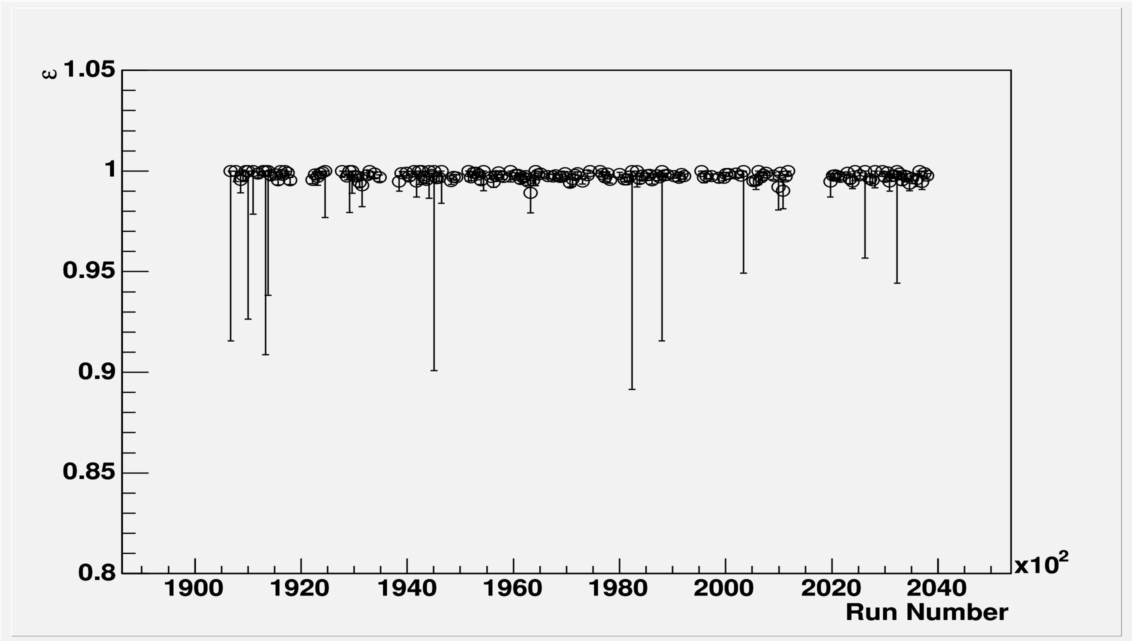

Figure 19: L3 tracking trigger efficiency vs run number for Gen6, without the silicon good run list.

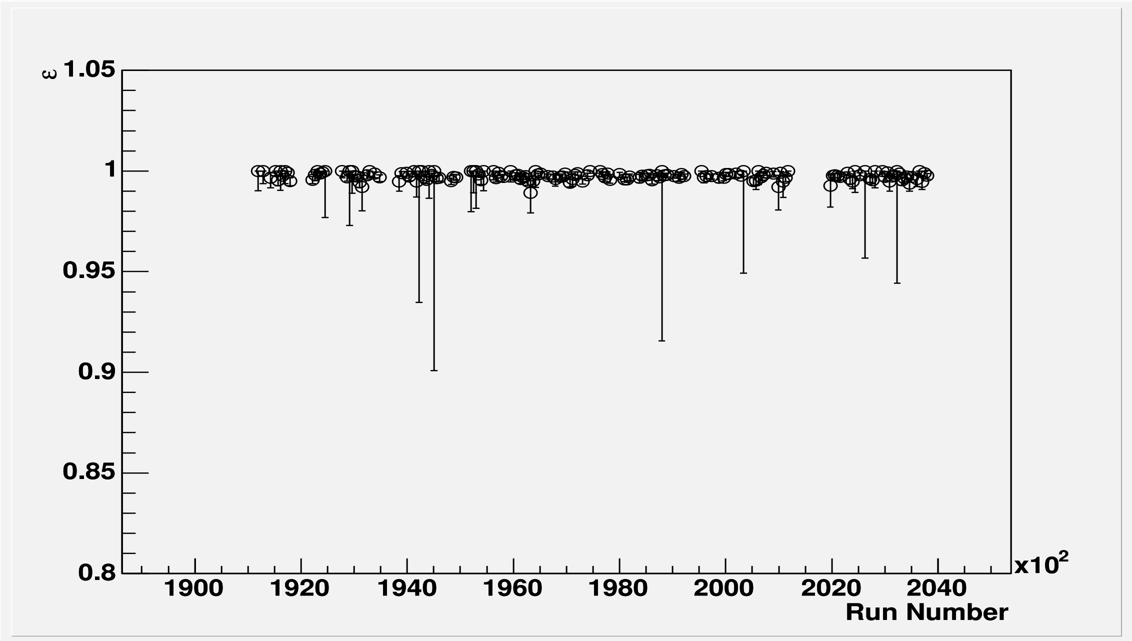

Figure 20: L3 tracking trigger efficiency vs run number for Gen6, with the silicon good run list.

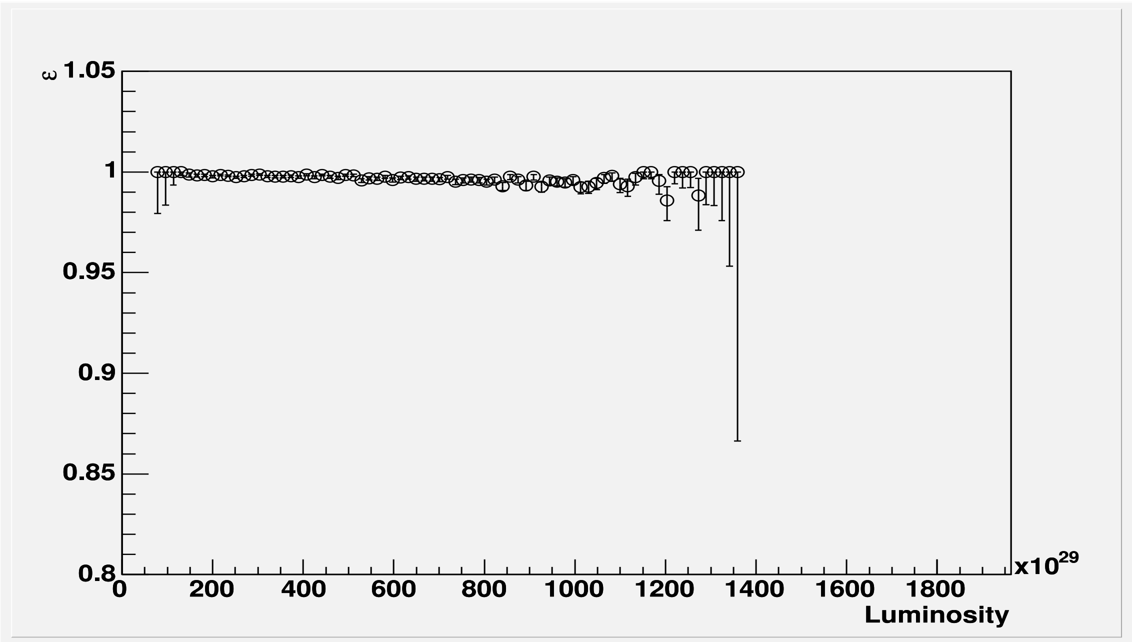

Figure 21: L3 tracking trigger efficiency vs luminosity for Gen6, without the silicon good run list.

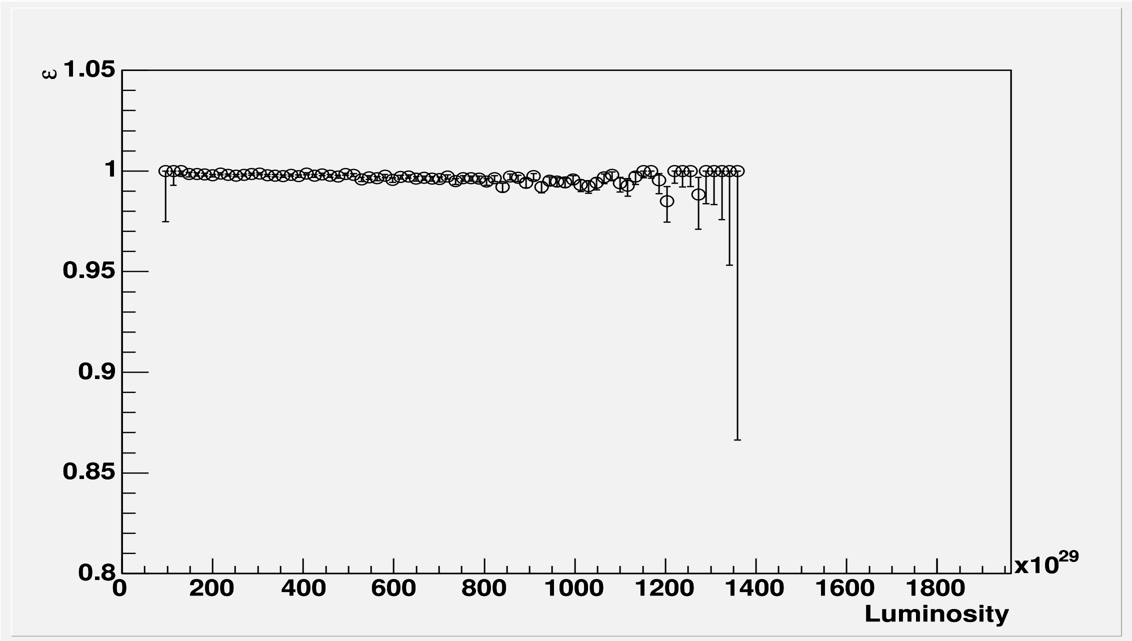

Figure 22: L3 tracking trigger efficiency vs luminosity for Gen6, with the silicon good run list.

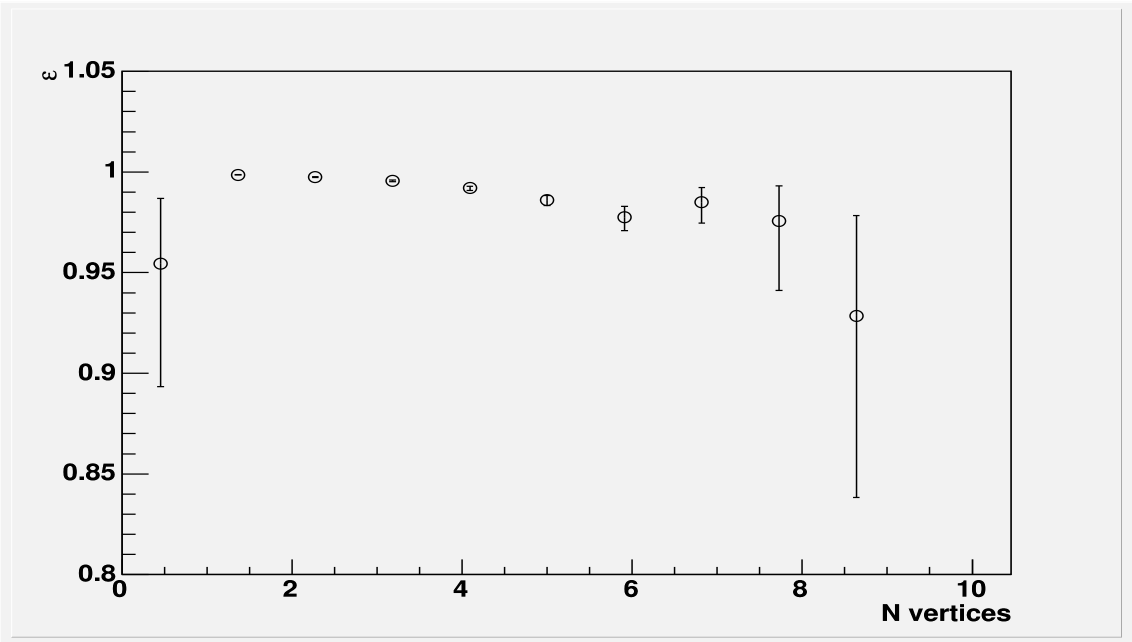

Figure 23: L3 tracking trigger efficiency vs number of vertices for Gen6, without the silicon good run list.

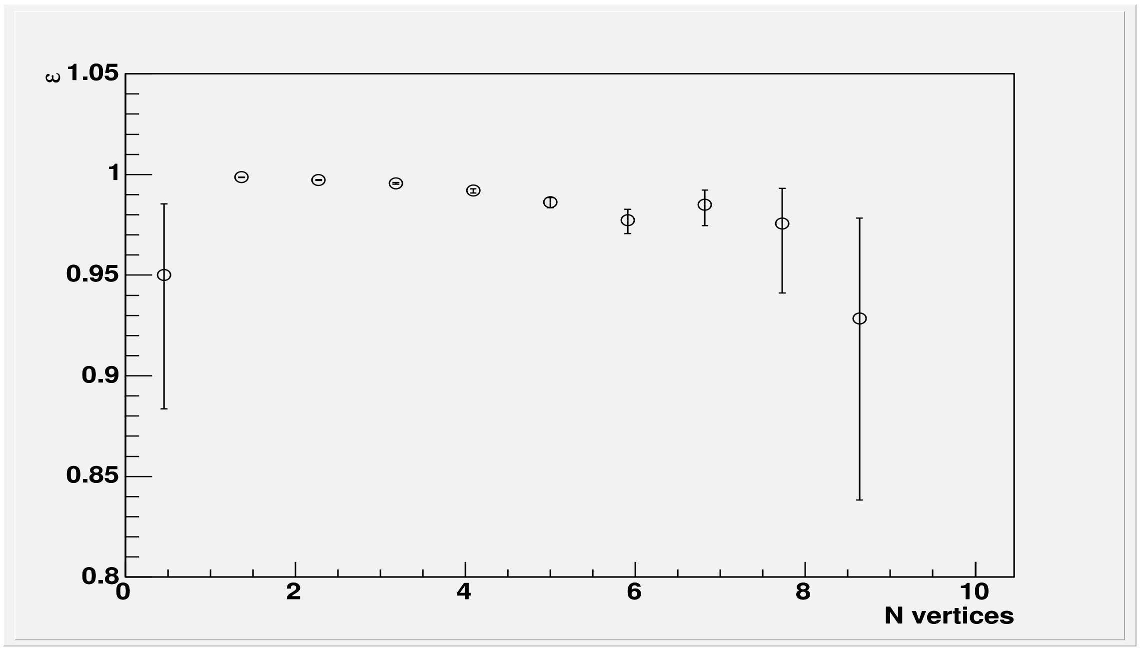

Figure 24: L3 tracking trigger efficiency vs number of vertices for Gen6, with the silicon good run list.

3.5 Summary of Tracking Trigger Efficiencies

We summarize the tracking trigger efficiencies and compute the total tracking trigger efficiency in table 14. The total tracking trigger efficiencies are compatible with the last period of the Gen5 data. In figures we show the L1 tracking trigger efficiency and L3 tracking trigger efficiency as a function of run number.

w/o silicon	L1	L2	L3	total
Period 9	0.9831(3)*	0.9993(1)	0.9974(1)	0.9798(3)
Period 10	0.9644(10)*	0.9990(2)	0.9908(5)	0.9545(11)
w/ silicon				
Period 9	0.9830(3)*	0.9992(1)	0.9973(1)	0.9796(3)
Period 10	0.9618(12)*	0.9988(2)	0.9906(6)	0.9516(13)

Table 14: Summary of tracking trigger efficiencies. Period 9 refers to the Gen6 time period (1-8 is Gen5). Period 10 is the COT compromised period. *) L1 total tracking trigger efficiency, use η parametrization shown in table 9

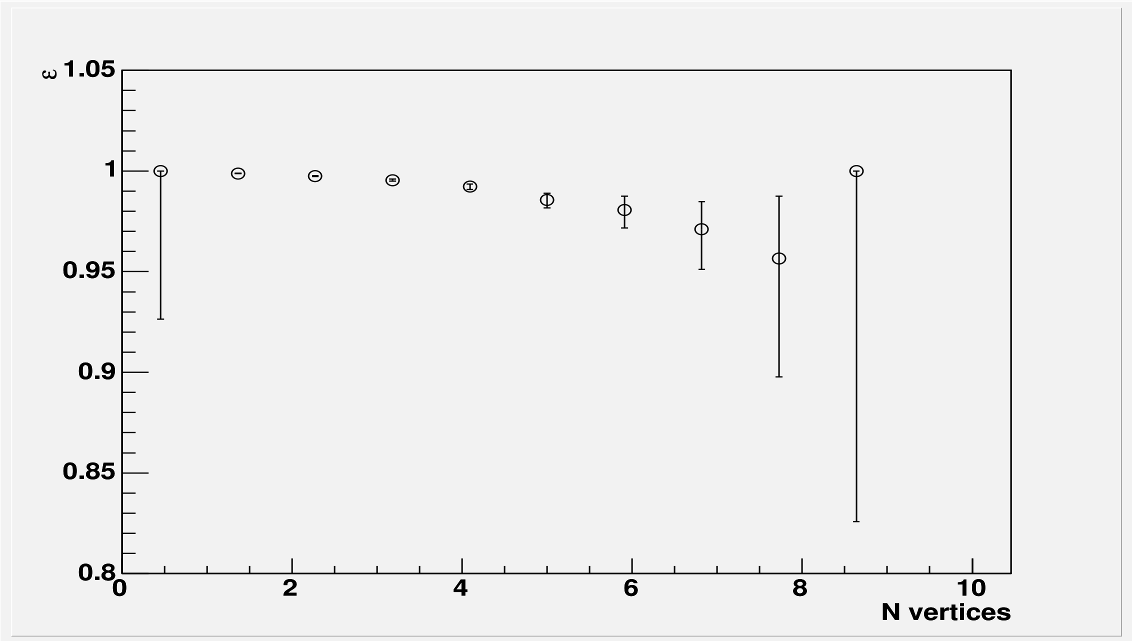

Figure 25: L3 tracking trigger efficiency vs number of vertices, with tight cuts (see text) for Gen6, without the silicon good run list.

4 Calorimeter trigger efficiencies

4.1 L1 Calorimeter Trigger Efficiency

This efficiency has been measured before to be 100% [1]. We repeated the study using the Gen6 data. We ran on the high p_T muon sample to have an unbias sample. We look at the L1_EM8 trigger because the L1_CEM8 is always combined with another trigger requirement. The idea is to select events with central electromagnetic energy and see if their L1_EM8 bit is set. More precisely, we get the offline energy of a trigger tower and we also require that the offline Had/Em value for this trigger tower be less than 0.05. We veto events with trigger towers in the plug region with $E_T > 3GeV$ to select central events. Since we are using the TopNtuple which doesn't contain physics tower information we make use of the electron information which contains the seed eta and seed phi for the electron (from which we can get the trigger tower id). We show the results in figures 26, 27, 28, 29.

We see that the efficiency below 14GeV is around 85% which comes from the Had/Em difference between offline and online. However the Gen4 study found an efficiency of around 99% for that region. We believe that we are getting a different result because the statistics is very low and because of the way we combine the electron information to get the trigger tower offline energy. We must point out that according to the Gen 4 study, only 1% of electrons from Z's with $20GeV < E_T < 25GeV$ have a

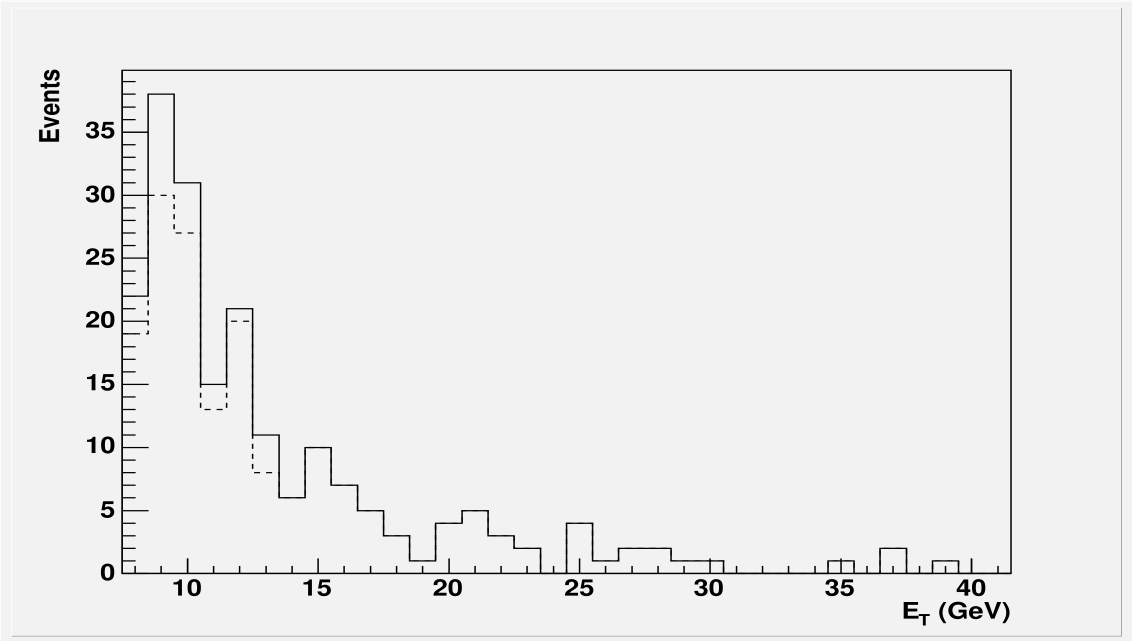

Figure 26: Trigger Tower offline E_T distribution for Gen6, solid is before the L1_EM8 requirement and dashed is after the L1_EM8 requirement, without the silicon good run list.

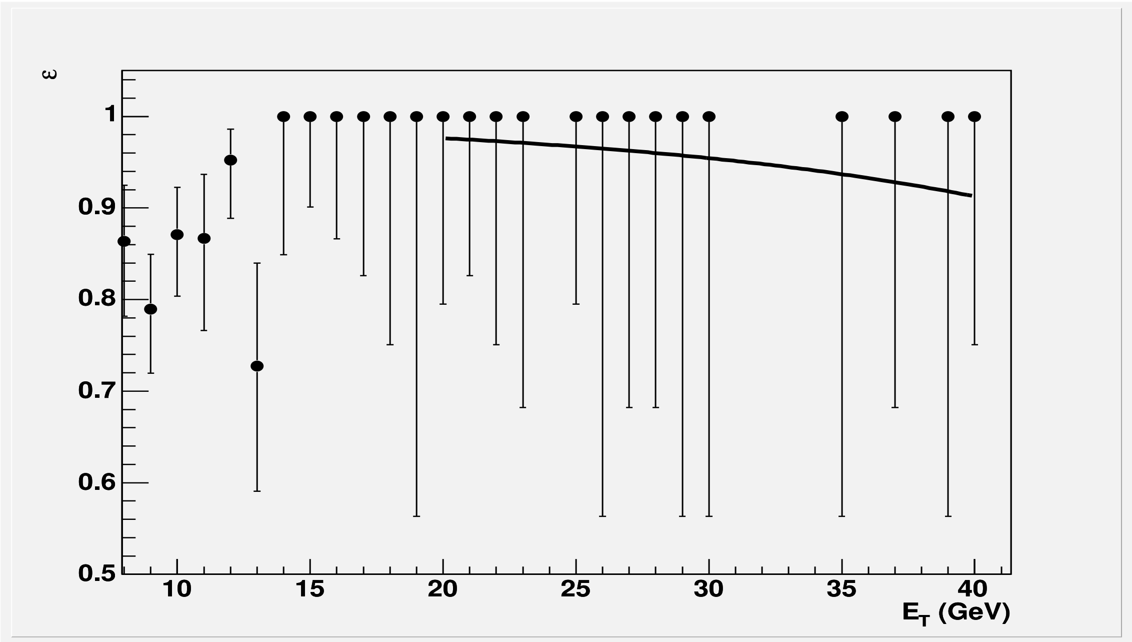

Figure 27: L1 calorimeter trigger efficiency for Gen6, without the silicon good run list.

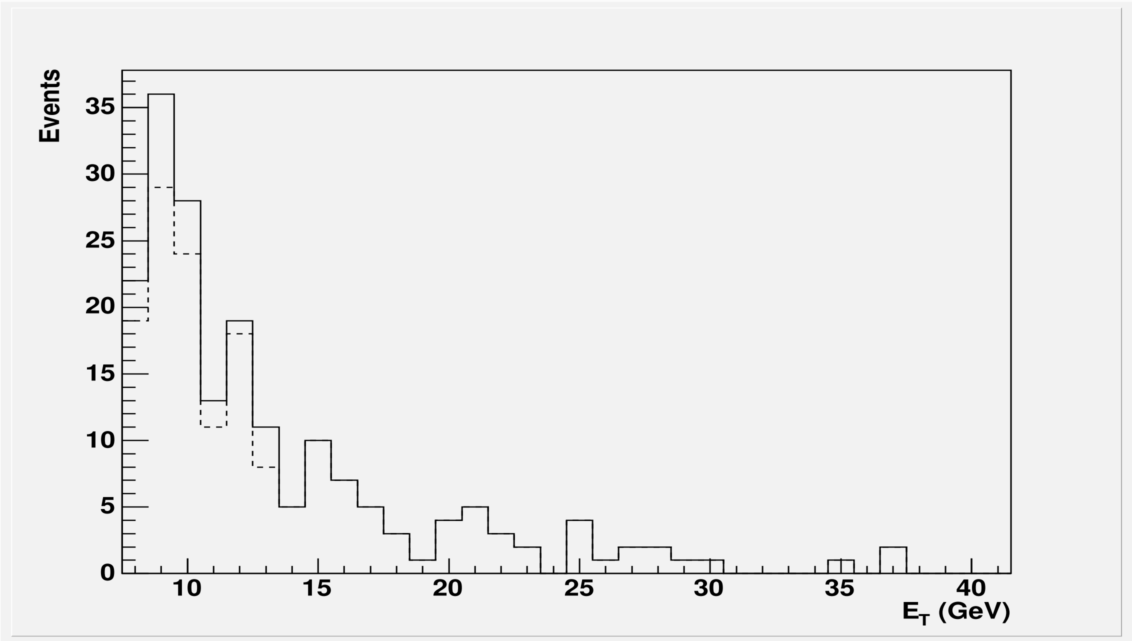

Figure 28: Trigger Tower offline E_T distribution fro Gen6, solid is before the L1_EM8 requirement and dashed is after the L1_EM8 requirement, with the silicon good run list.

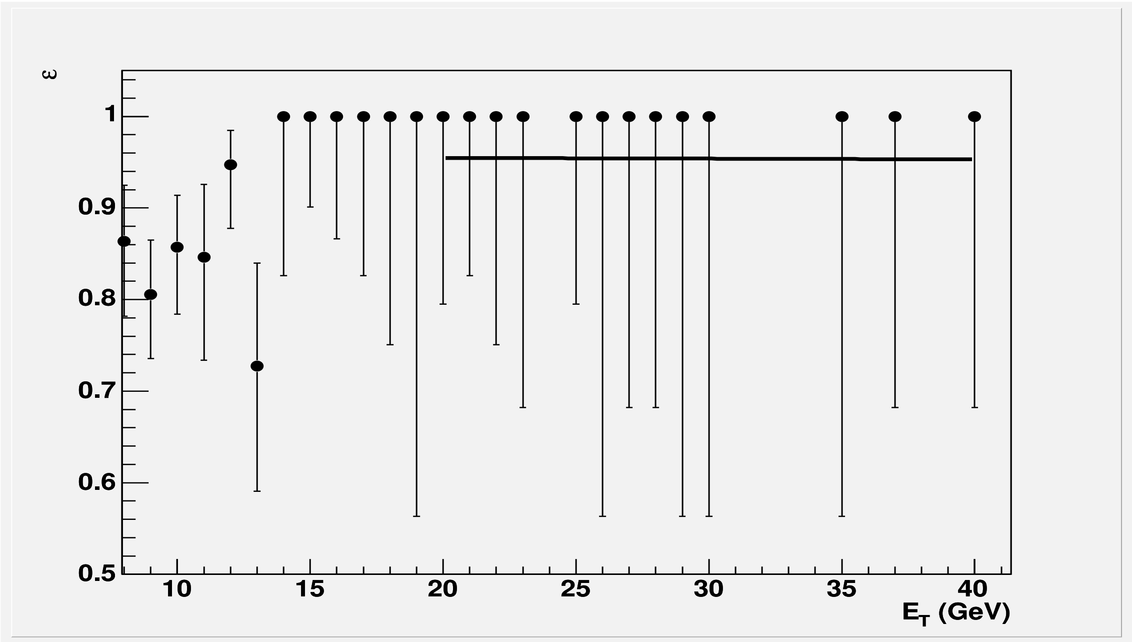

Figure 29: L1 calorimeter trigger efficiency for Gen6, with the silicon good run list.

trigger tower energy $< 14GeV$. Hence we believe that assuming the efficiency is 100% is adequate.

4.2 L2 Calorimeter Trigger Efficiency

In order to study the L2 calorimeter trigger efficiency we count the number of events that have at least 1 electron satisfying the baseline cuts except for the fact that we require $E_T > 18$ GeV (instead of 20 GeV, in order to study the turn on curve as a function of E_T) and we also require the isolation ratio to be less than 0.1 (to get rid of backgrounds). We also require that these electrons pass the L1_CEM8_PT8 triggers and also the L2_PS100_L1_CEM8_PT8 which is an auto accept L2 trigger part of the ELECTRON_CENTRAL_18_NO_L2 path and which also has L1_CEM8_PT8. Out of those electrons we look for events that had the L2_CEM16_PT8 bit set. The efficiency is then defined as:

$$\epsilon(L2\_CEM16) = \frac{numEl \ \& \ passedL1\_CEM8\_PT8 \ \& \ passedL2\_PS \ \& \ passedL2\_CEM16}{numEl \ \& \ passedL1\_CEM8\_PT8 \ \& \ passedL2\_PS} \quad (5)$$

The L2 calorimeter trigger efficiency is E_T dependent as a result of the tower clustering algorithm, tower energy calculation and corrections. As a function of E_T we get a turn on curve, which reaches 100% at about 30 GeV. We can fit a function for the turn on curve, so that the efficiency becomes:

$$\epsilon = A - Be^{-CE_t} \quad (6)$$

The values for the fit parameters are shown in table15. For the uncertainties on the fit parameters, since the parameters are correlated and since the uncertainties on the parameters are sometimes very large, what we do instead is we obtain a lower fit and an upper fit. The lower fit is obtained by decreasing the data points by their negative uncertainties and the upper fit is obtaining by increasing the data point by their positive uncertainties. When we do the convolution to get the uncertainty on the efficiency we take the difference of efficiency obtained from the upper fit minus the lower fit.

We show the E_T distribution of electron candidates passing the L2_PS trigger and the baseline cuts in figures 30, 31 and 36 and 37. We show the turn on curve with the fit in figures 32, 33 and 38 and 39.

4.3 L3 Calorimeter Trigger Efficiency

To measure this efficiency we make use of the ELECTRON_CENTRAL_8_NO_L2 path which is in the calibration dataset. This path is described in detail in table 16. To get the calorimeter efficiency we count the number of electrons satisfying the baseline cuts which pass this path and also which passed the L2_CEM16_PT8:

w/o silicon offline E_T	A	B	C
Period 9	0.9994	2969	0.56
Upper fit	0.9993	13339	0.65
Lower fit	0.9995	995	0.49
Period 10	0.9975	3.9	0.25
Upper fit	0.9973	2.78	0.27
Lower fit	0.9980	5.952	0.24
w/ silicon offline E_T			
Period 9	0.9993	1835	0.54
Upper fit	0.9992	6551	0.62
Lower fit	0.9994	717	0.48
Period 10	0.9965	0.23	0.15
Upper fit	0.9957	-0.014	0.14
Lower fit	0.9980	0.85	0.15
w/o silicon raw E_T			
Period 9	1.0000	59106	0.70
Upper fit	0.9999	97072	0.74
Lower fit	0.9999	10097	0.60
Period 10	0.9973	513	0.48
Upper fit	0.9965	10000	3.349
Lower fit	0.9952	1164	0.49
w/ silicon raw E_T			
Period 9	1.0000	41367	0.68
Upper fit	0.9999	60389	0.72
Lower fit	0.9999	7509	0.58
Period 10			

Table 15: Fit Parameters for the L2 calorimeter trigger efficiency. The fit for the raw E_T with silicon good run list for the COT compromised period did not give good parameters, we suggest to use the without silicon good run list parameters. Period 9 refers to the Gen6 time period (1-8 is Gen5). Period 10 is the COT compromised period.

$$\epsilon(L3\_CEM18) = \frac{numEl \;\&\; passedEL\_CENT\_8\_NO\_L2 \;\&\; passedL2\_CEM16 \;\&\; passedL3\_CEM18}{numEl \;\&\; passedEL\_CENT\_8\_NO\_L2 \;\&\; passedL2\_CEM16} \tag{7}$$

Since the offline cut is at $E_T > 20GeV$ and the L3 cut is at 18 GeV, we expect this trigger efficiency to be close to 100%. The L3 clustering algorithm is almost identical to the offline algorithm, so we expect the possible inefficiency to come from the energy determination. We show in figures 42 and 43 the turn on curve for the efficiency as a function of E_T. We fit with the following parametrization:

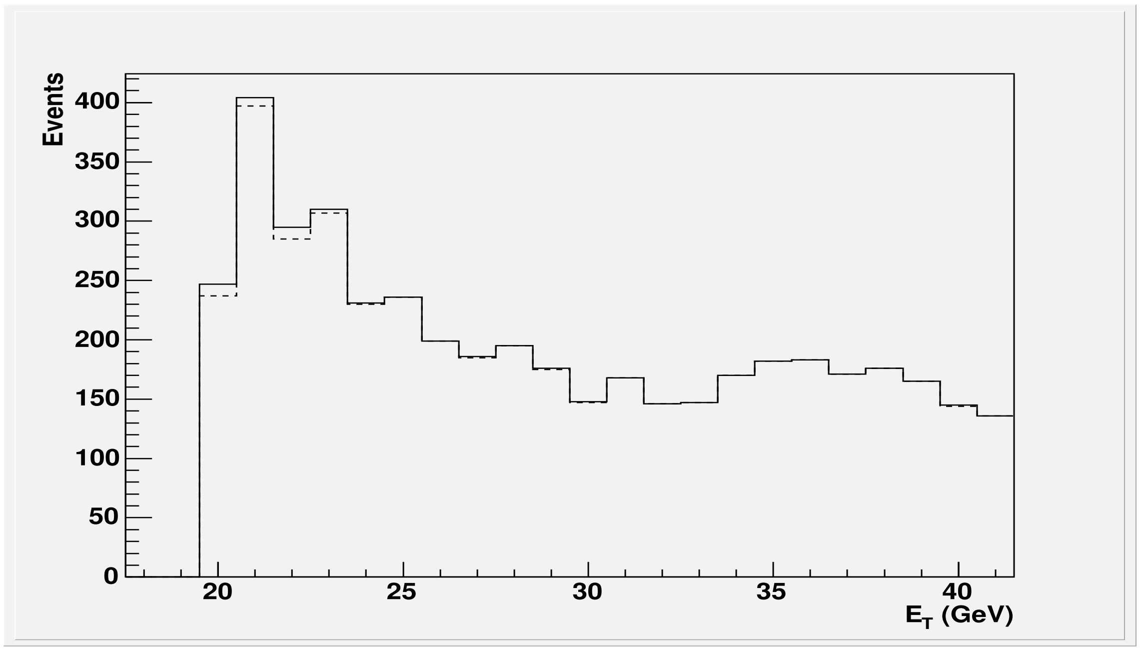

Figure 30: E_T distribution of electron candidates passing the L2_PS trigger and the baseline cuts, solid is before the L2_CEM16_PT8 requirement and dashed is after the L2_CEM16_PT8 requirement, without the silicon good run list.

$$\epsilon = 1 - Ae^{-B(E_t - C)} \tag{8}$$

The values for the fit parameters are shown in table17. For the uncertainties on the parameters, we give the upper fit and the lower fit as described in the previous section. For the COT compromised run period, those runs were not processed to make the top ntuple, so we suggest to use the Gen5 parametrization for that run period.

We see that the efficiency becomes 100% at about $E_T \approx 23GeV$. Summing over all E_T we get an efficiency of 0.9989(6) for w/o silicon and 0.9992(6) for w/ silicon. These results are consistent with the efficiency obtained during the Gen5 data period. If one were to

The fact that the L3 requirements for the backup trigger are different from the L3 requirements of the physics trigger should have little effect since the inefficiency comes from the E_T determination and the Had/Em cut in the physics L3 trigger is 100% efficient.

4.4 Summary of Calorimeter Trigger Efficiencies

To get the total calorimeter trigger efficiency, the end-user should convolute the electron E_T distribution of the sample of interest with the E_T dependent function shown in the previous subsections. For the case of $t\bar{t}$ events, we find that the L2 calorimeter trigger

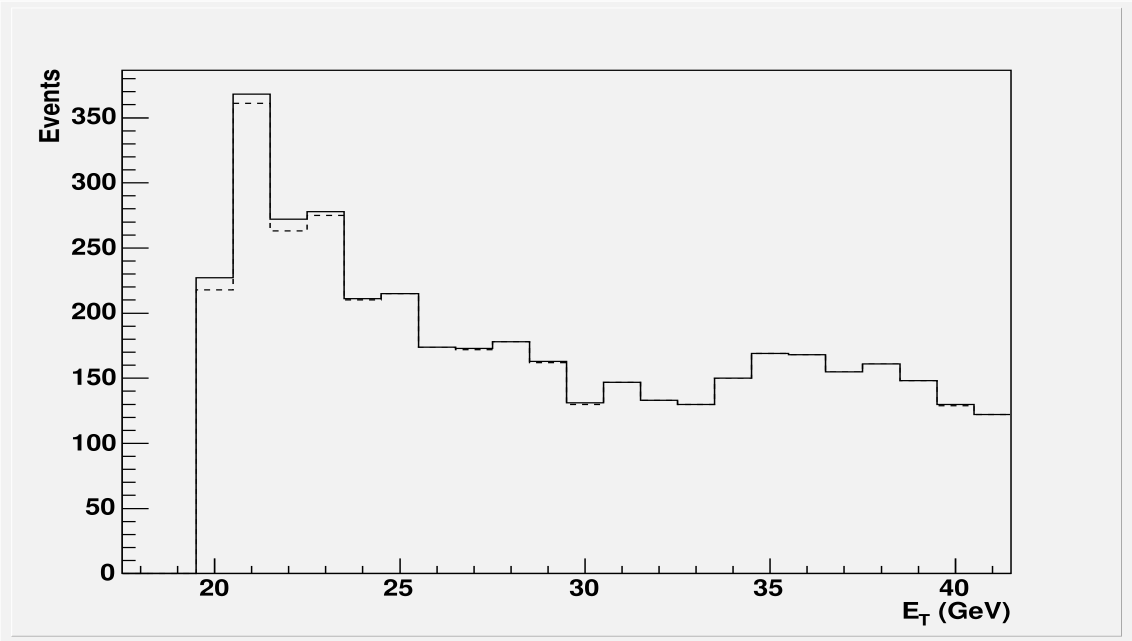

Figure 31: E_T distribution of electron candidates passing the L2_PS trigger and the baseline cuts, solid is before the L2_CEM16_PT8 requirement and dashed is after the L2_CEM16_PT8 requirement, with the silicon good run list.

efficiency is 0.9989(69) for w/o silicon and 0.9988(68) for w/ silicon for the Gen6 period. We find that the L3 calorimeter trigger efficiency reaches 100% at 23 GeV.

5 Convolution for the $t\bar{t}$ events in Gen6

To get the trigger efficiency relevant for top analysis we use the η distribution coming from $t\bar{t}$ signal MC passing the Lepton+Jets selection cuts (the η distribution for the dilepton selection is similar). This distribution is show in figure 46. We obtain a L1 tracking trigger efficiency of 0.9805(45) for both good run lists (with and without good silicon).

To get the calorimeter trigger efficiencies we need the E_T distribution of central electrons passing the Lepton+jets and dilepton selection. Those are shown in figure 47 and 48. To obtain the dilepton trigger efficiency one has to combine the efficiency coming from the convolution of the leading electron (most likely to fire the trigger) with the second electron (in case the leading electron didn't fire the trigger). The combined efficiency is then $1 - (1 - \epsilon_1)(1 - \epsilon_2)$ where 1 and 2 refer to the leading electron and second electron. The resulting trigger efficiencies are summarized in table 18. Combining together those trigger efficiencies with the L2 and L3 tracking trigger efficiencies we obtain a total trigger efficiency shown in table 19.

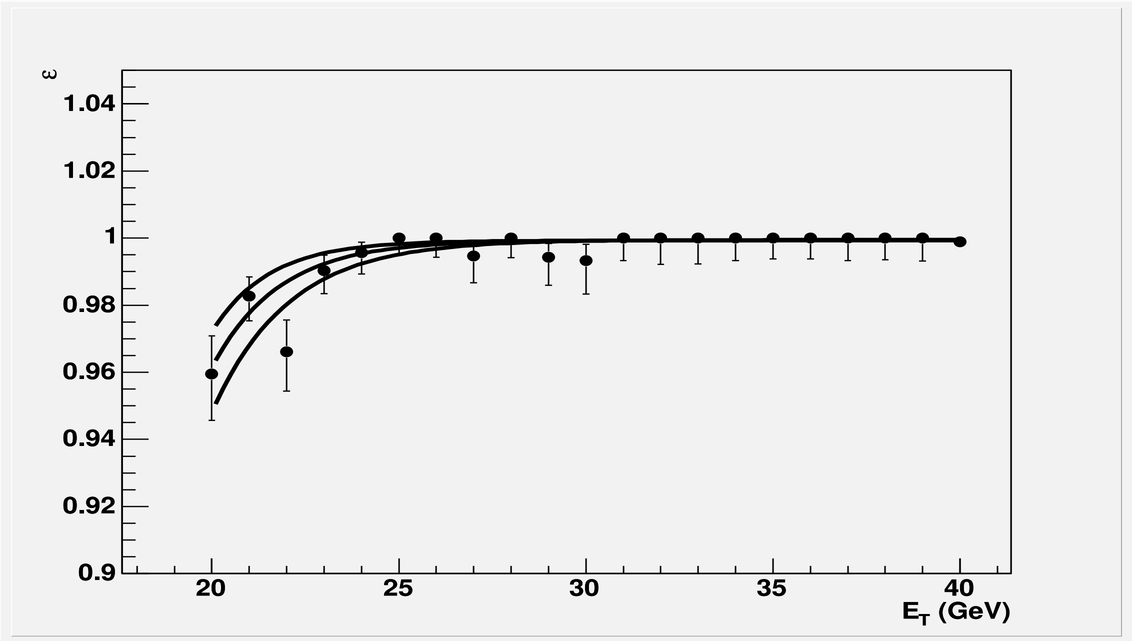

Figure 32: L2_CEM16 trigger efficiency as a function of E_T, without the silicon good run list.

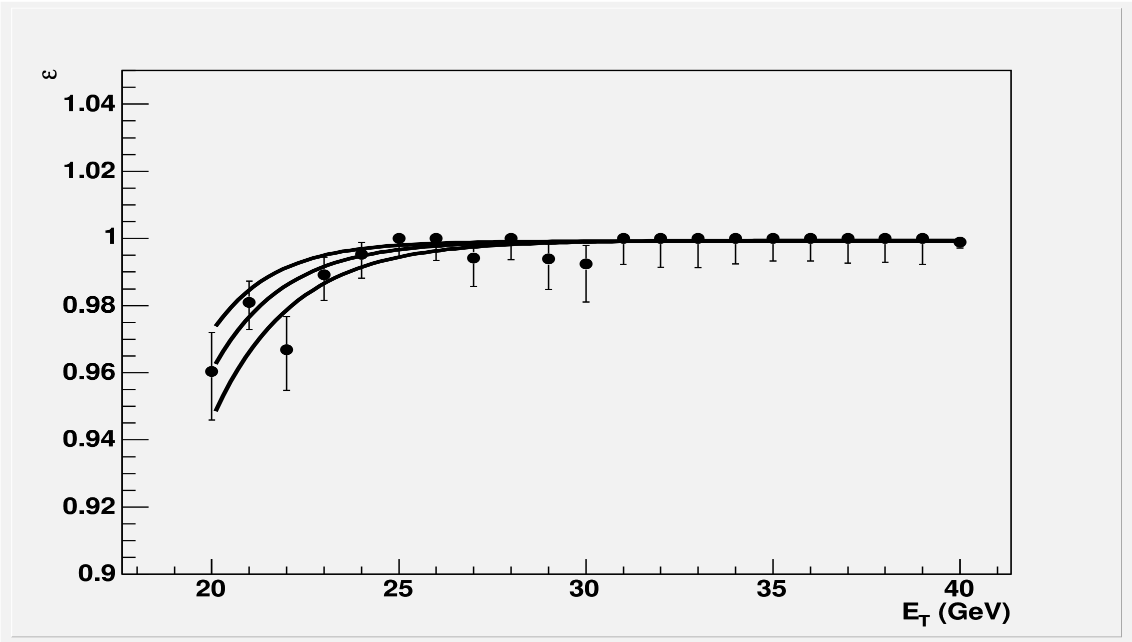

Figure 33: L2_CEM16 trigger efficiency as a function of E_T, with the silicon good run list.

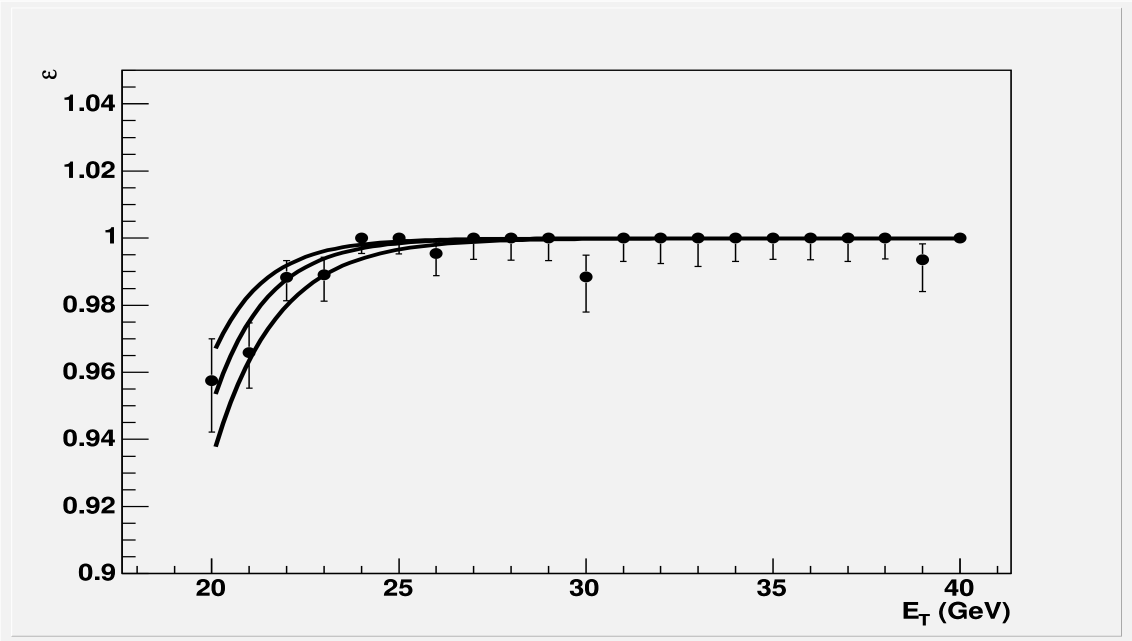

Figure 34: L2_CEM16 trigger efficiency as a function of raw E_T, without the silicon good run list.

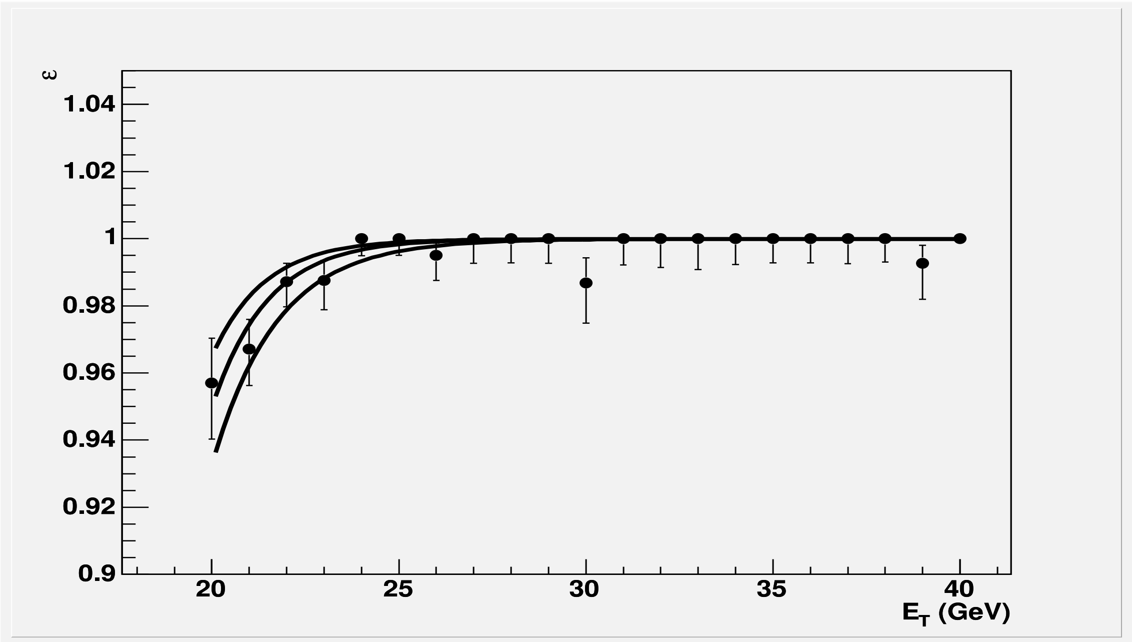

Figure 35: L2_CEM16 trigger efficiency as a function of raw E_T, with the silicon good run list.

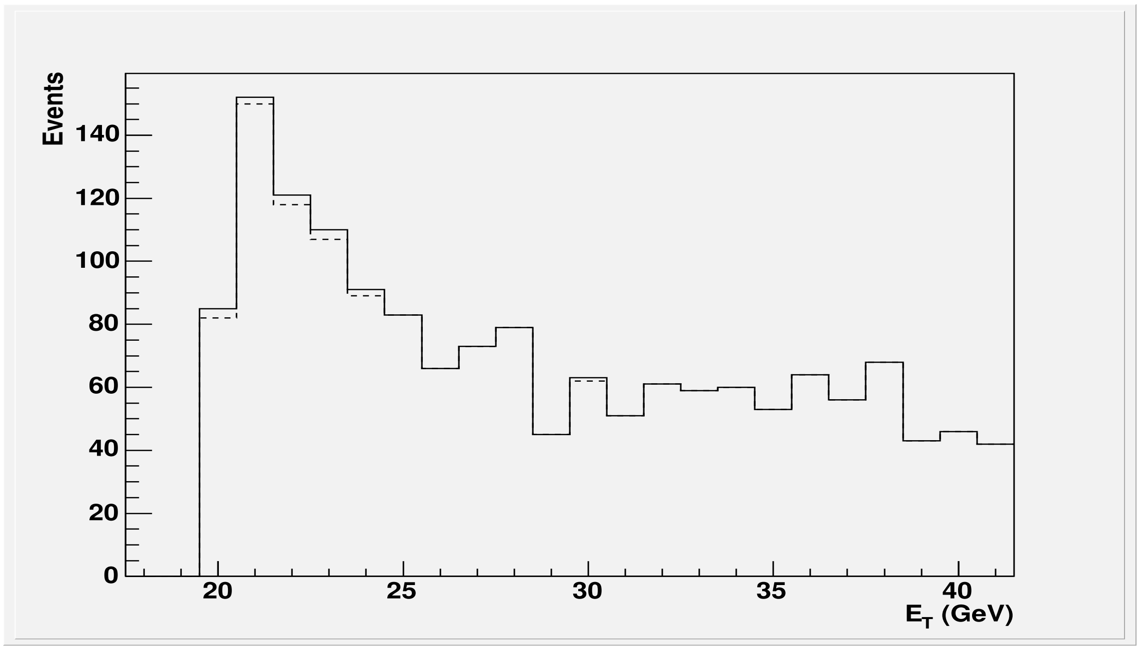

Figure 36: E_T distribution of electron candidates passing the L2_PS trigger and the baseline cuts for the COT compromised period, solid is before the L2_CEM16_PT8 requirement and dashed is after the L2_CEM16_PT8 requirement, without the silicon good run list.

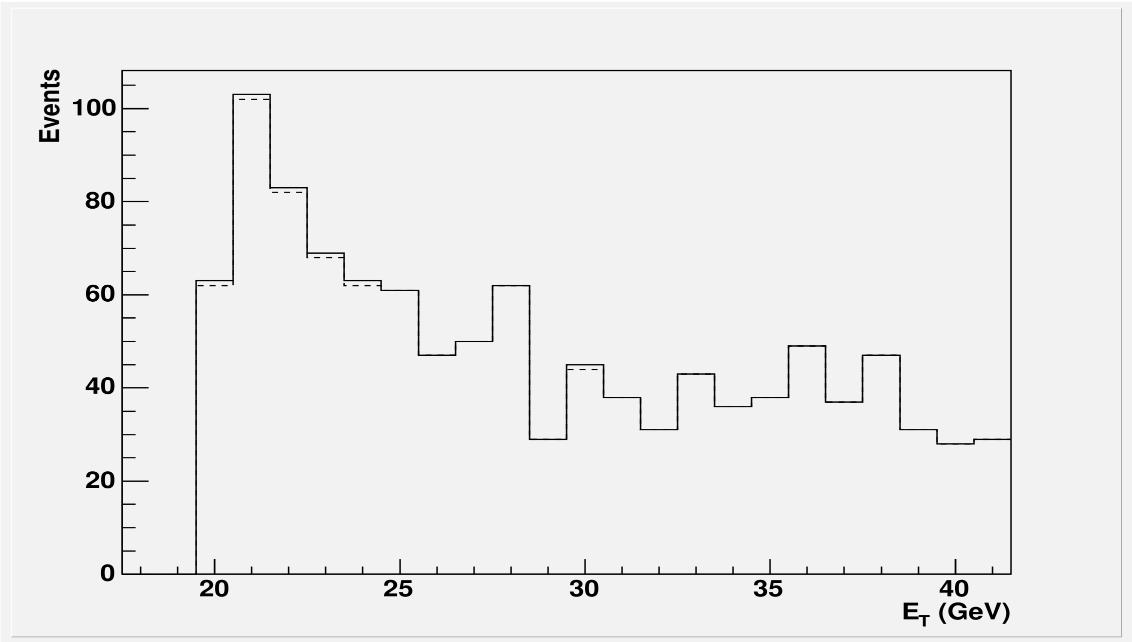

Figure 37: E_T distribution of electron candidates passing the L2_PS trigger and the baseline cuts for the COT compromised period, solid is before the L2_CEM16_PT8 requirement and dashed is after the L2_CEM16_PT8 requirement, with the silicon good run list.

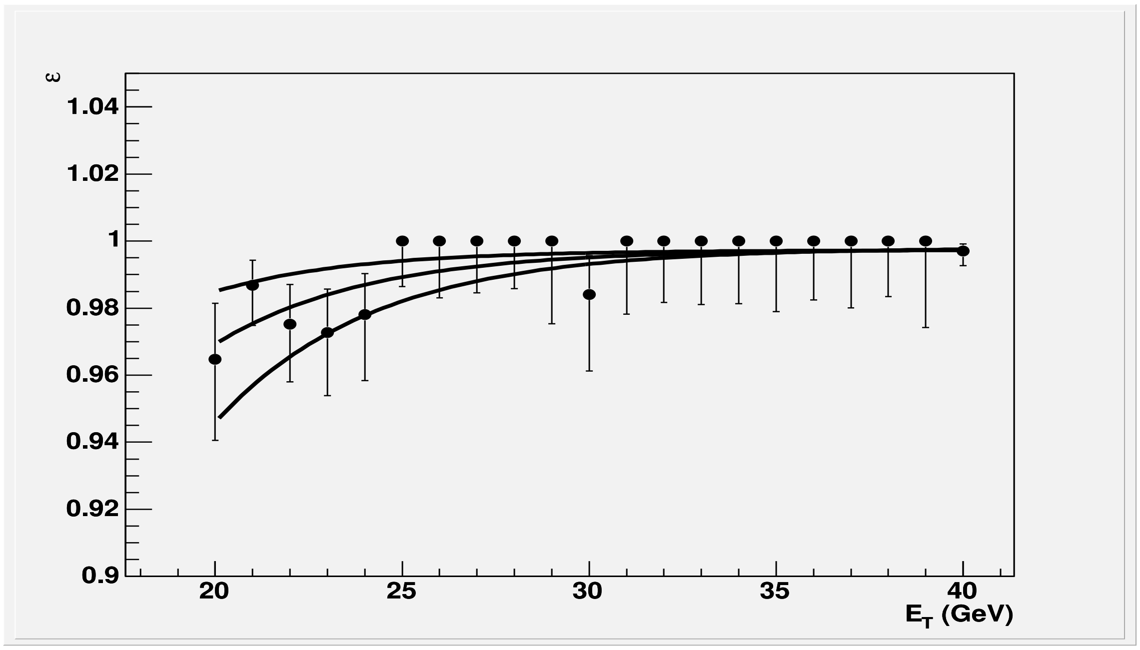

Figure 38: L2_CEM16 trigger efficiency as a function of E_T for the COT compromised period, without the silicon good run list.

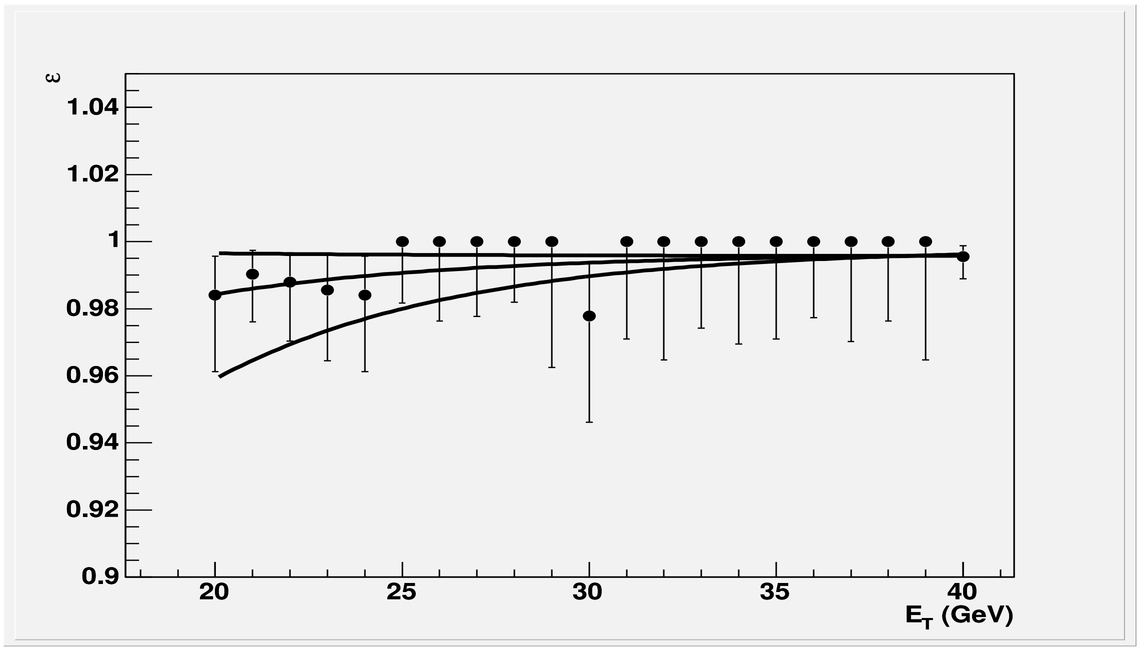

Figure 39: L2_CEM16 trigger efficiency as a function of E_T for the COT compromised period, with the silicon good run list.

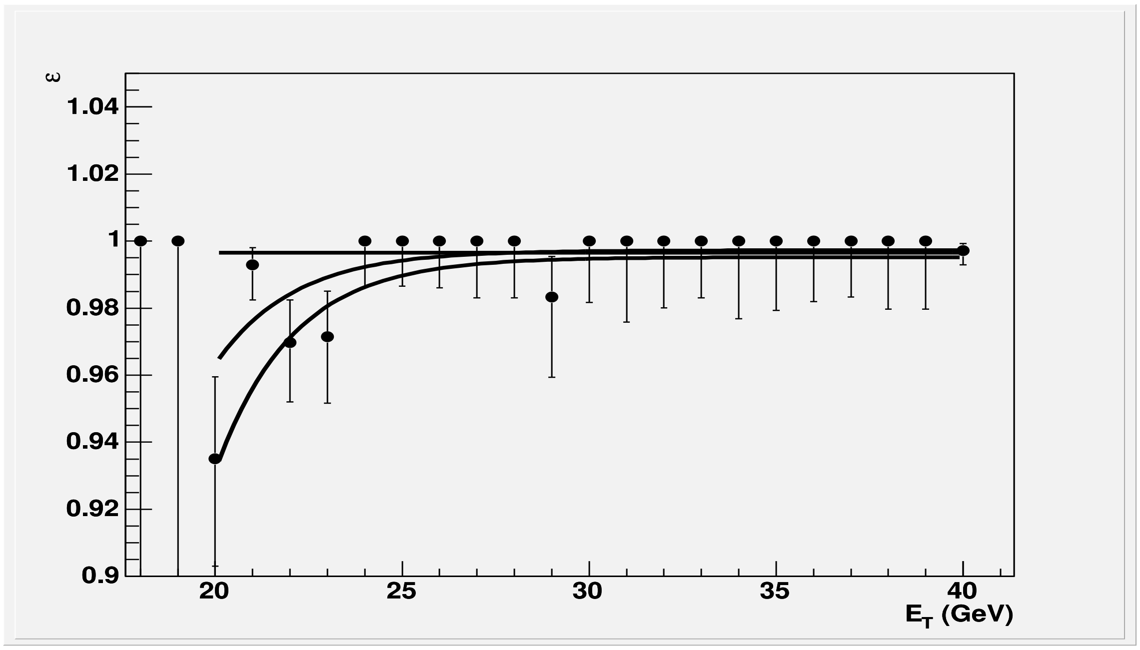

Figure 40: L2_CEM16 trigger efficiency as a function of raw E_T for the COT compromised period, without the silicon good run list.

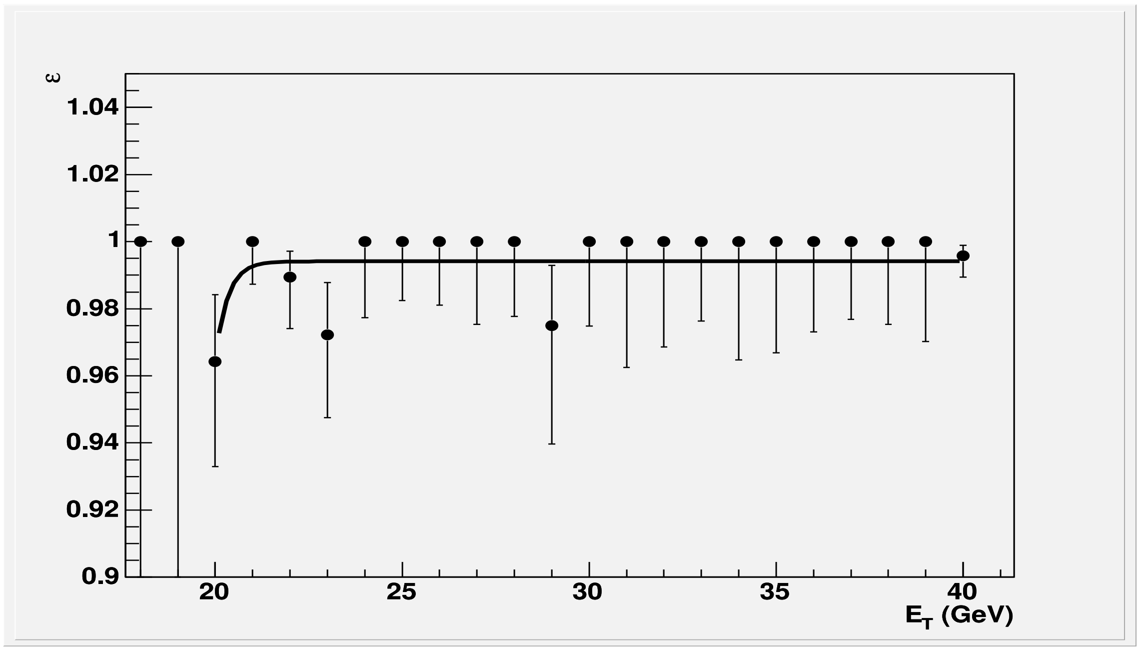

Figure 41: L2_CEM16 trigger efficiency as a function of raw E_T for the COT compromised period, with the silicon good run list.

Trigger Name	Requirements
L1_CEM8_PT8	≥ 1 trigger tower ET_CENTRAL ≥ 8 GeV HAD_EM_CENTRAL ≤ 0.125 *(this Had/EM cut has no effect for ET_CENTRAL > 14GeV)* XFT_PT ≥ 8.34 GeV/c XFT_LAYERS ≥ 3 XFT hits per superlayer ≥ 11
L2_PS100_L1_CEM8_PT8	
L3_ELECTRON_CENTRAL_8_PT8	nEmObj ≥ 1 CalorRegion $= 0$ CenEt > *8 GeV* cenHadEm $\leq$ *0.055* lshr $\leq$ *0.2* cenDeltaZ ≤ 5 cm ZVert $= 2$ nTowersHadEm $= 3$ cenTrackPt $\geq$ *8.0* GeV/c *CesChiSqX* $\leq$ *15* *CesChiSqZ* $\leq$ *10* *cenDeltaX* $\leq$ *3 cm*

Table 16: Description of the ELECTRON_CENTRAL_8 path. The requirements in italics are the ones that are different from the ELECTRON_CENTRAL_18 path.

w/o silicon offline E_T	A	B	C
Period 9	2528	0.68	1.13
Upper fit	353	0.60	0.92
Lower fit	210	0.42	-1.42
w/ silicon offline E_T			
Period 9	6	0.37	-0.1
Upper fit	2.7	0.37	-0.09
Lower fit	250	0.37	-5.14
w/o silicon raw E_T			
Period 9	0.60	0.27	-0.14
Upper fit	0.39	0.30	-0.07
Lower fit	0.87	0.22	-0.44
w/ silicon raw E_T			
Period 9	35	0.25	-19
Upper fit	0.25	0.25	-4.7
Lower fit	0.60	0.21	-0.48

Table 17: Fit Parameters for the L3 calorimeter trigger efficiency. . Period 9 refers to the Gen6 time period (1-8 is Gen5).

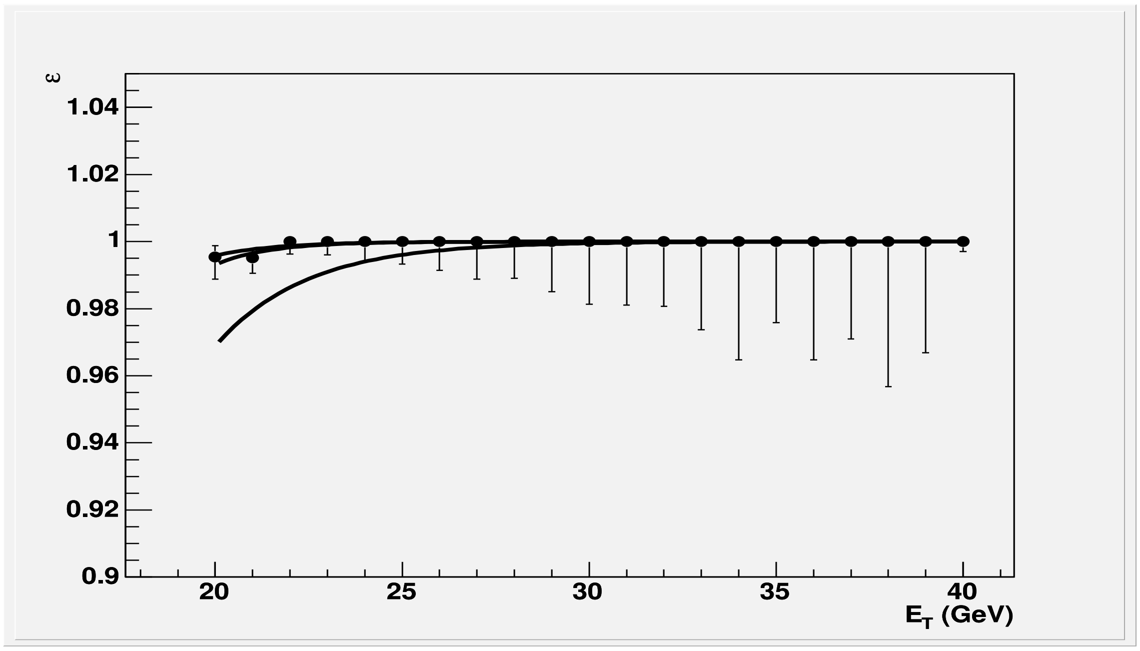

Figure 42: L3_CEM18 trigger efficiency as a function of E_T, without the silicon good run list.

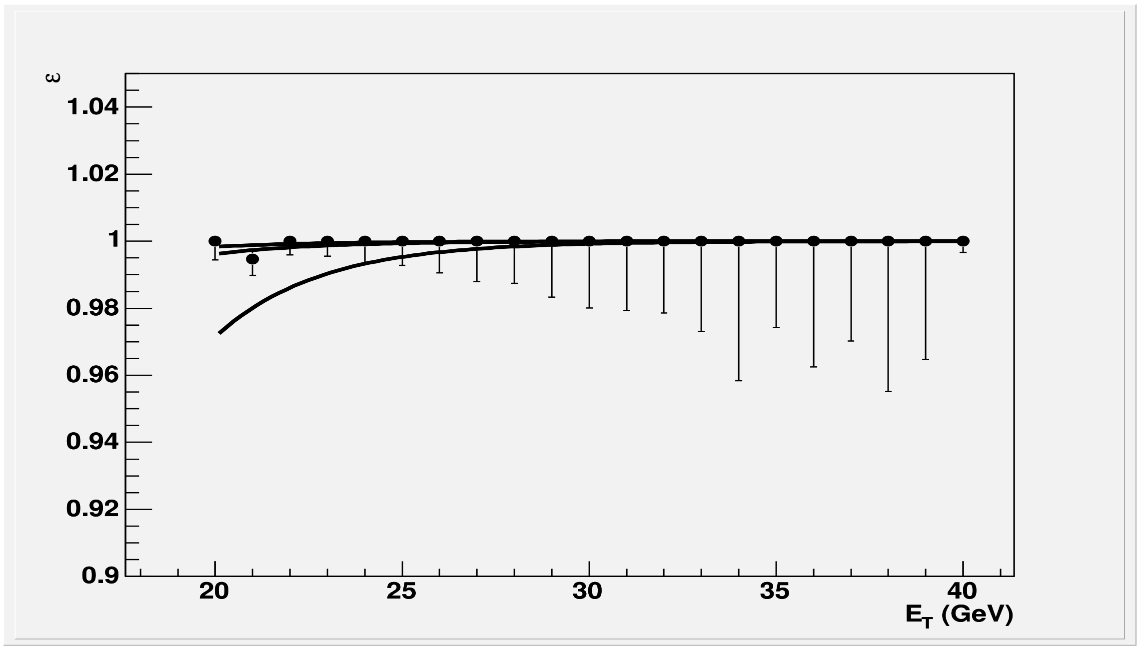

Figure 43: L3_CEM18 trigger efficiency as a function of E_T, with the silicon good run list.

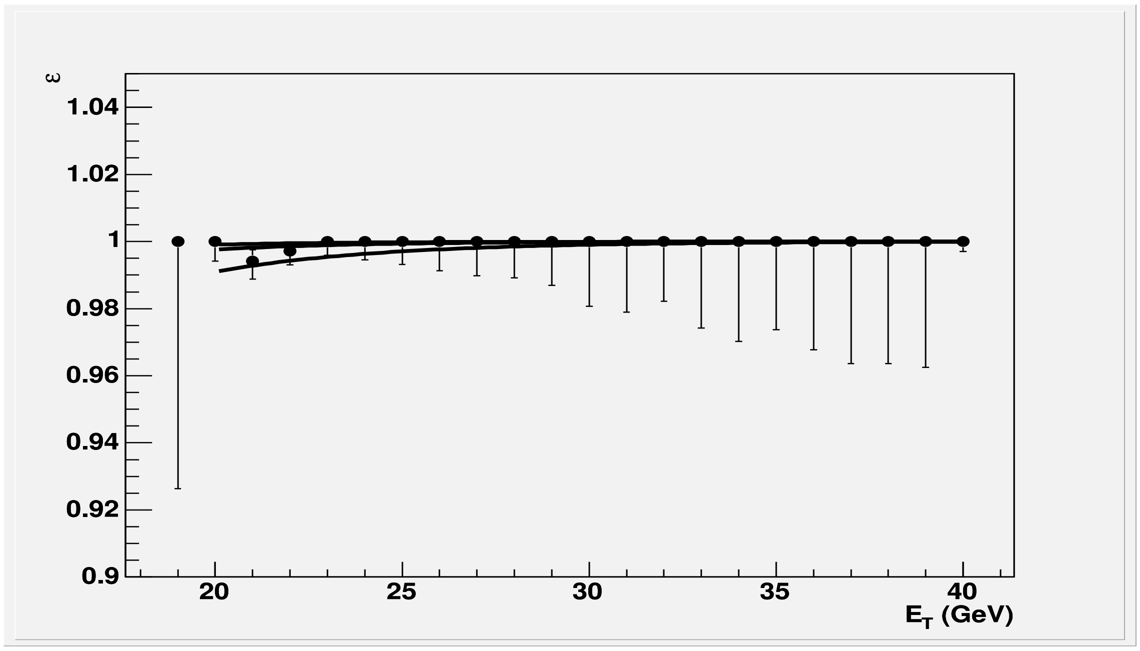

Figure 44: L3_CEM18 trigger efficiency as a function of raw E_T, without the silicon good run list.

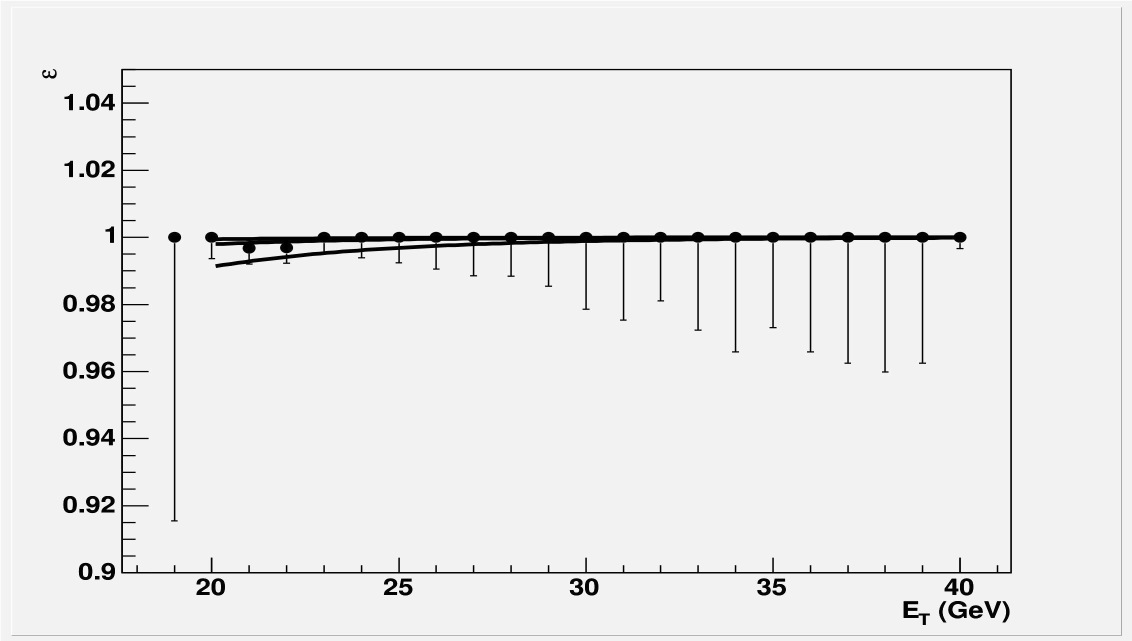

Figure 45: L3_CEM18 trigger efficiency as a function of raw E_T, with the silicon good run list.

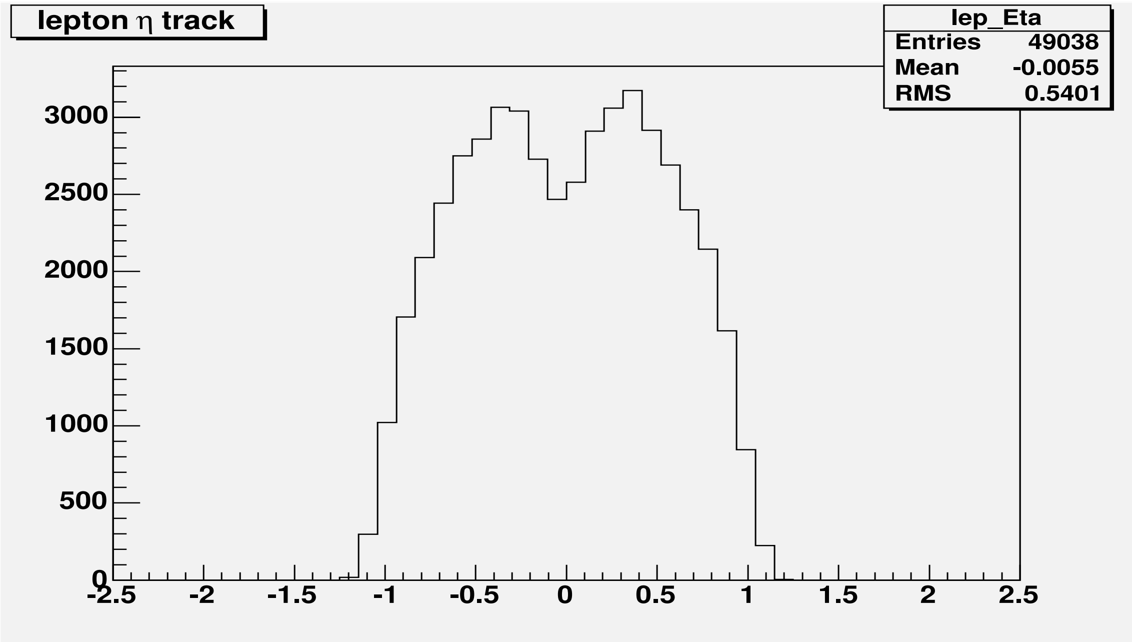

Figure 46: η distribution of central electrons passing the Lepton+Jets selection cut in $t\bar{t}$ signal MC.

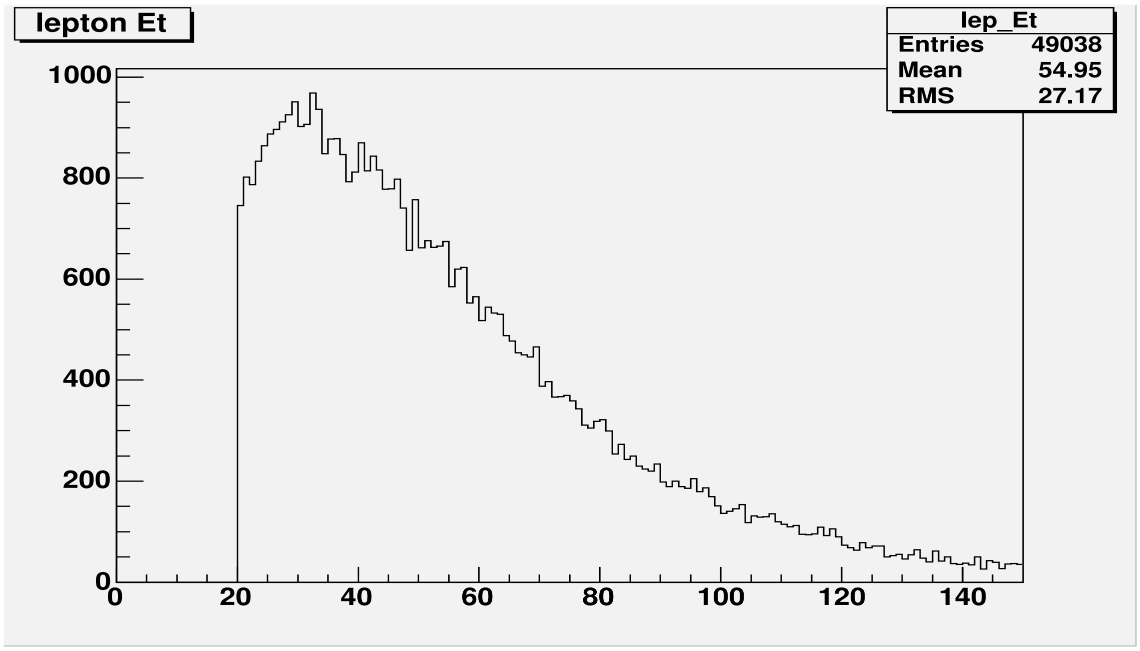

Figure 47: E_T distribution of central electrons passing the Lepton+Jets selection cut in $t\bar{t}$ signal MC.

w/o silicon	L+J	dil
L1 tracking trigger eff.	0.9805(45)	0.9805(45)
L2 calorimeter trigger eff.	0.9984(24)	1.0000± 0.000002
L3 calorimeter trigger eff.	0.9998(24)	1.0000± 0.0000003
w/ silicon		
L1 tracking trigger eff.	0.9805(45)	0.9805(45)
L2 calorimeter trigger eff.	0.9983(24)	1.0000± 0.0000003
L3 calorimeter trigger eff.	0.9998(24)	1.0000± 0.0000003

Table 18: Trigger efficiencies obtained from the convolution of central electrons after the Lepton+Jets or dilepton selection in $t\bar{t}$ signal MC.

6 Conclusions

We have presented the various trigger efficiencies applicable for the ELECTRON_CENTRAL_18 path: the L1, L2 and L3 tracking trigger efficiencies, as well as the L1, L2, L3 calorimeter trigger efficiencies. Tables 20 and 21 summarizes all the results. The trigger efficiencies show no dependence on various variables studies, except for η for the L1 tracking trigger efficiency and E_T for the calorimeter trigger efficiencies. The results are also

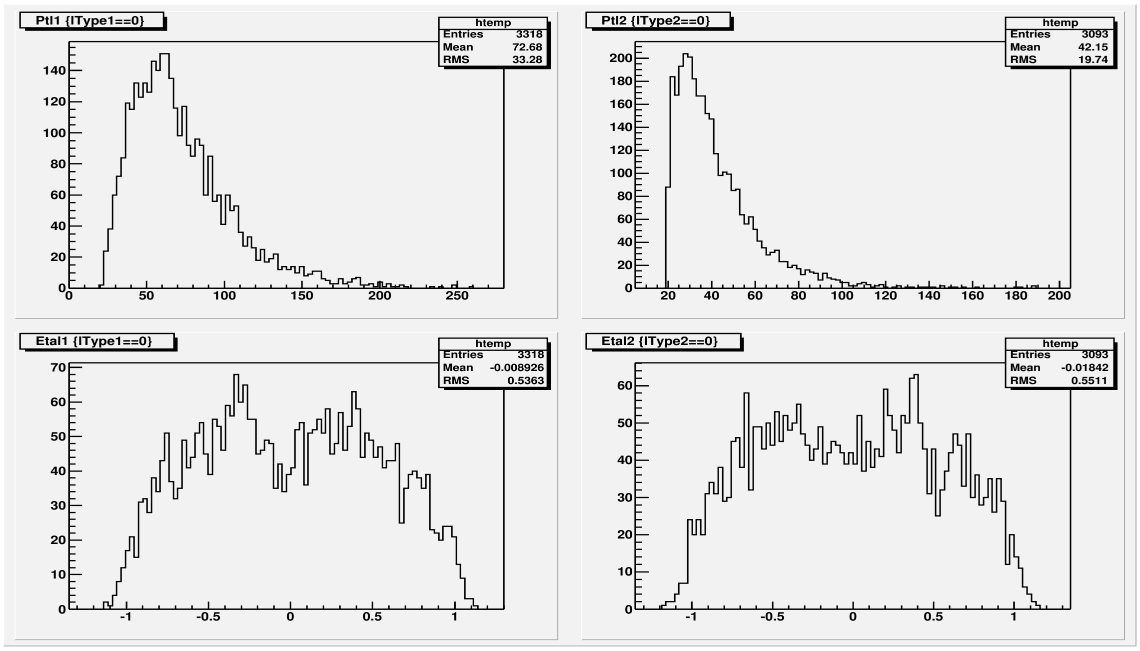

Figure 48: E_T and η distribution of central electrons passing the dilepton selection cut in $t\bar{t}$ signal MC. On the left is for the leading E_T electron while on the right is for the other electron

	L+J	dil
w/o silicon	0.9755(55)	0.9772(44)
w/ silicon	0.9752(55)	0.9771(44)

Table 19: Total trigger efficiencies obtained from the convolution of central electrons after the Lepton+Jets or dilepton selection in $t\bar{t}$ signal MC.

compatible with the last period of running of the Gen5 data. Throughout these studies we find very good agreement between the results using the good run list requiring good silicon and using the good run list not requiring good silicon.

We have reported in the previous section on the trigger efficiency to be used for top analysis. The overall Gen5 trigger efficiencies was $0.9620^{+0.0063}_{-0.0066}$ for w/o silicon and $0.9617^{+0.0064}_{-0.0067}$ for w/o silicon for the top analysis. If one were to compute the total trigger efficiency just using the last period of running, one would find an efficiency of: 0.9766(63) for w/o silicon and 0.9765(63) for w/ silicon. We see that the Gen6 total trigger efficiency for $t\bar{t}$ is compatible with the last period of running of Gen5.

Trigger	Efficiency
L1_XFT_PT8	0.9831(3) *
L2_XFT_PT8	0.9993(1)
L3 tracking	0.9974(1)
Total Tracking	0.9798(3)
L1_CEM8	100%
L2_CEM16	$0.9994 - 2969e^{-0.56E_t}$ (Isol<0.1)
L3_CEM18	$1 - 2528e^{-0.68(E_t - 1.13)}$

Table 20: Summary of trigger efficiencies for central electrons without silicon good run list. *) total L1 tracking efficiency, use η parametrization shown in table 9.

Trigger	Efficiency
L1_XFT_PT8	0.9830(3)*
L2_XFT_PT8	0.9992(1)
L3 tracking	0.9973(1)
Total Tracking	0.9796(3)
L1_CEM8	100%
L2_CEM16	$0.9993 - 1835e^{-0.54E_t}$ (Isol<0.1)
L3_CEM18	$1 - 6e^{-0.37(E_t + 0.1)}$

Table 21: Summary of trigger efficiencies for central electrons with silicon good run list. *) total L1 tracking efficiency, use η parametrization shown in table 9.

7 Acknowledgments

I would like to thank Yoshio Ishizawa and Jason Nielsen for providing me their code and macros for these studies. I would also like to thank Jason, David Waters, Beate Heinemann and Charles Pager for useful discussions. Kevin Lannon provided the Lepton+Jets plots for the $t\bar{t}$ convolution.

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[1] Trigger Efficiencies for High E_T Electrons, Jason Nielsen, Lauren Tompkins, Doug Hoffman, Young-Kee Kim and Greg Veramendi, CDF Note 6234

[2] Trigger Efficiencies for high E_T Electrons, Yoshio Ishizawa, Jason Nielsen, CDF Note 7401