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MET PEM trigger efficiency for Pheonix electrons

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In this note we present the trigger efficiencies composed of the $\mathrm{MET\_PEM\_v11}$ trigger. The total $\mathrm{MET\_PEM\_v11}$ trigger efficiency is measured using a combination of sub-trigger efficiencies. This measurement is performed for Pheonix electrons in the plug region using data processed with the offline version 6.1.1 or "generation 6". The method used here to measure this trigger efficiency is based on a previous study for PEM electrons [1].

1 Introduction

Electron detection by the plug calorimeters along with missing energy, $\not\!\!E_{\mathrm{T}}$, are the key elements for the identification of $W \rightarrow e\nu$ events in the forward region. The $\mathrm{MET\_PEM}$ trigger is one of triggers which has been built for this purpose.

The basic idea for measuring the trigger efficiency is to measure the fraction of the number of events passing the trigger bit requirement of interest from a given signal event, e.g. a $W \rightarrow e\nu$ or $Z \rightarrow e^+e^-$(Central-Plug or CP) event.

We use generation 6 data for this study, processed using offline version 6.1.1, and includes all data taken from run number 190697 to 203799. All data runs used are required to be on the list of good runs in version 10.0, which are marked good for electrons and silicon.

2 Selection Criteria

In this section we describe the selection criteria used for signal events. We identify one Pheonix (PHX) electron from $Z \rightarrow e^+e^-$(CP) events or $W \rightarrow e\nu$ events in the plug region. Therefore, all candidate events are required to pass the offline selection criteria in Table 1. Specifically, $W \rightarrow e\nu$ candidates are a PHX electron and $\not\!\!E_{\mathrm{T}} \geq 20$ GeV and a $Z \rightarrow e^+e^-$ candidate is a CEM+PHX with 76 GeV $< M_{ee} <$ 106 GeV.

3 Trigger Efficiencies measurement

The $\mathrm{MET\_PEM}$ trigger is one of the trigger paths included in the $\mathrm{PLUG\_ELECTRON}$ stream. Therefore, we use other trigger paths in the same stream to evaluate trigger efficiencies of interest. The trigger paths used are listed in Table 2.

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Variable	CEM	variable	PHX
Region	== central	Region	== plug
Fiducial	TrkFiducial == 1	E_T	$\geq$ 20 GeV
E_T	$\geq$ 20 GeV	$Pes2dEta^*$	1.2 $\leq \|\eta\| \leq$ 2.8
Track Z_0	$\leq$ 60 cm	Had/Em	$\leq$ 0.05
Track p_T	$\geq$ 10 GeV/c	Pem3x3FitTow	$\neq$ 0
COT Ax. Seg.	$\geq$ 3	Pem3x3Chisq	$\leq$ 10
COT St. Seg.	$\geq$ 2	Pes5by9U	$\geq$ 0.65
Conversion	$\neq$ 1	Pes5by9V	$\geq$ 0.65
Had/em	$\leq (0.055 + (0.00045 \times E))$	Isolation	$\leq$ 0.1
Isolation	$\leq$ 0.1	Δ R	$\leq$ 3.0 cm
LshrTrk	$\leq$ 0.2	PhxMatch	TRUE
E/P	$\leq$ 2.0 unless $p_T \geq$ 50GeV/c	$N_{hits}^{Silicon}$	$\geq$ 3
CES ΔZ	$\leq$ 3.0 cm	$\|z_0^{PHX}\|$	$\leq$ 60 cm
Singed CES ΔX	-3.0 $\leq q \times \Delta X \leq$ 1.5		
CES StripChi2	$\leq$ 10.0		

Table 1: Central and Pheonix electron selection cuts.

level	MET_PEM	PLUG_ELECTRON_20
L1	L1_EM8_MET15	L1_EM8
L2	L2_PEM20_L1_EM8_MET15	L2_PEM20_PS10
L3	L3_PEM20_MET15	L3_PEM20

Table 2: List of trigger paths considered.

3.1 L1_MET15_L3_MET15

The efficiency of the combined L1_MET15_L3_MET15 trigger is measured using $W \to e\nu$ candidates selected using the requirements described in section 2. From Table 2 we find that the PLUG_ELECTRON_20 and MET_PEM triggers differ only in the requirement of $\not\!\!E_{\rm T}$ at L1 and L3 (and a prescale factor). Therefore, to measure the efficiency of the L1_MET15_L3_MET15 trigger we check how often $W \to e\nu$ events passing the PLUG_ELECTRON_20 trigger also pass the MET_PEM:

$$\epsilon(\text{L1\_MET15\_L3\_MET15}) = \frac{\text{PLUG\_ELECTRON\_20 \&\& MET\_PEM}}{\text{PLUG\_ELECTRON\_20}} \tag{1}$$

Figure 1 shows the efficiency of the L1_MET15_L3_MET15 trigger as a function of raw $\not\!\!E_{\rm T}$ (offline $\not\!\!E_{\rm T}$ calculated at $z = 0$ and used in the trigger), offline $\not\!\!E_{\rm T}$ (calculated at z of the highest sum p_T vertex and used in analysis) and η_{det} of the electron. The number of events passing our denominator and numerator criteria and the corresponding efficiency are shown in Table 3. We fit the turn-on curve vs. $\not\!\!E_{\rm T}$ with the function (as in [1]):

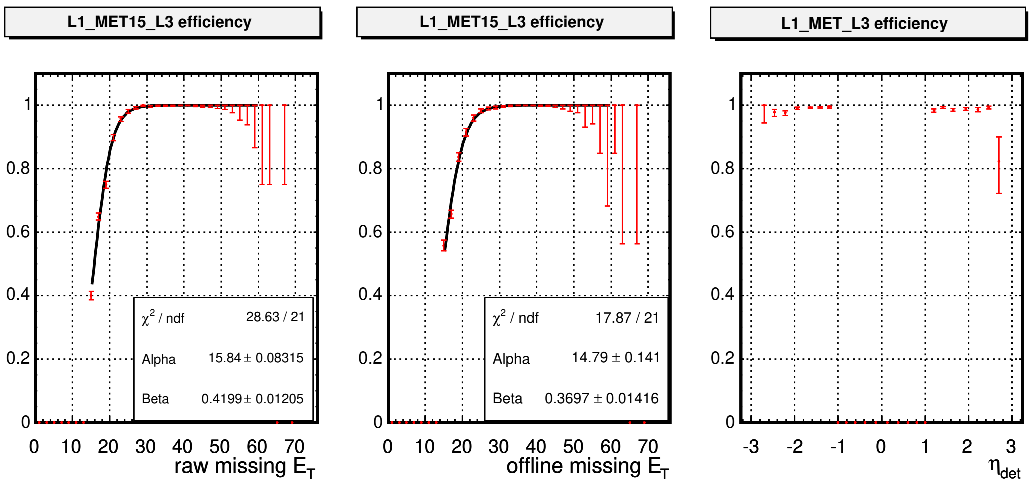

Figure 1: Efficiency of the L1_MET15_L3_MET15 trigger as a function of raw and offline $\not\!\!E_{\rm T}$ and η_{det} of the electron. The turn-on curve vs. $\not\!\!E_{\rm T}$ is fitted with the function in equation 2.

$$\epsilon(x) = \frac{1}{1 + e^{-\beta(x-\alpha)}}. \tag{2}$$

The values of the fit parameters, α and β, are also shown in Table 3.

3.1.1 Cross-check of the L1_MET15_L3_MET15 trigger efficiency

As a cross-check, we also separately measure the efficiencies of the L1 and L3 parts of the L1_MET15_L3_MET15 trigger and verify that their product is equal to the measurement above. Again, we use $W \to e\nu$ candidates in the plug to measure these efficiencies.

The L1_MET15 and L3_MET15 trigger efficiencies are evaluated by checking that the events pass the following trigger bits:

L1_MET15

$$\epsilon(\text{L1\_MET15}) = \frac{\text{PLUG\_ELECTRON\_20 \&\& L1\_EM8\_MET15}}{\text{PLUG\_ELECTRON\_20}} \tag{3}$$

L3_MET15

$$\epsilon(\text{L3\_MET15}) = \frac{\text{PLUG\_ELECTRON\_20 \&\& L2\_PEM20\_L1\_EM8\_MET15 \&\& MET\_PEM}}{\text{PLUG\_ELECTRON\_20 \&\& L2\_PEM20\_L1\_EM8\_MET15}} \tag{4}$$

The number of events passing our denominator and numerator criteria and the corresponding efficiencies for the L1_MET15 and L3_MET15 triggers are shown in Table 3. Figures 2 and 3 show the efficiencies of these triggers as a function of raw and offline $\not\!\!E_{\rm T}$ and η_{det} of the electron. We fit the turn-on curve vs. $\not\!\!E_{\rm T}$ with the function in equation 2. The values of the fit parameters, α and β, are also shown in Table 3. We find that the product of the L1_MET15 and L3_MET15 trigger efficiencies is consistent with the measurement of the combined L1_MET15_L3_MET15 efficiency.

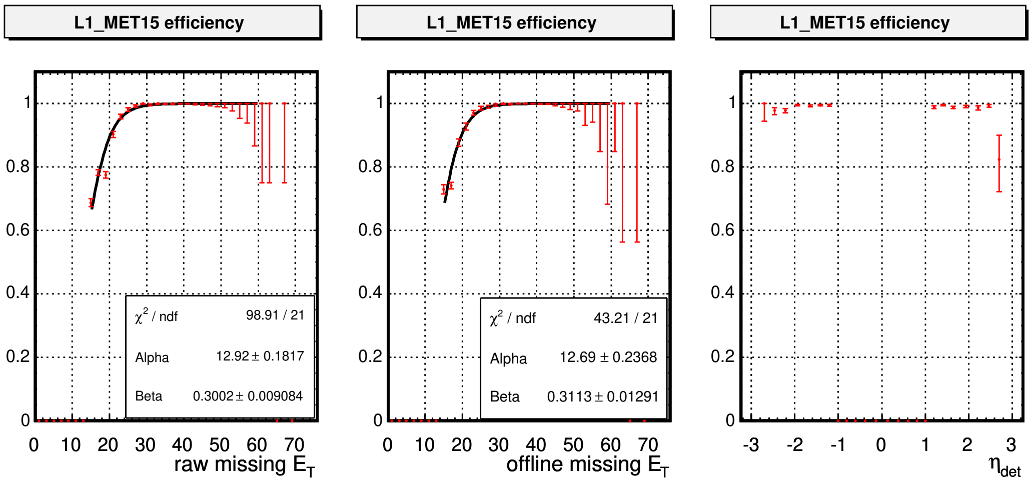

Figure 2: Efficiency of the L1_MET15 trigger as a function of raw and offline $\not\!\!E_{\mathrm{T}}$ and η_{det} of the electron. The turn-on curve vs. $\not\!\!E_{\mathrm{T}}$ is fitted with the function in equation 2.

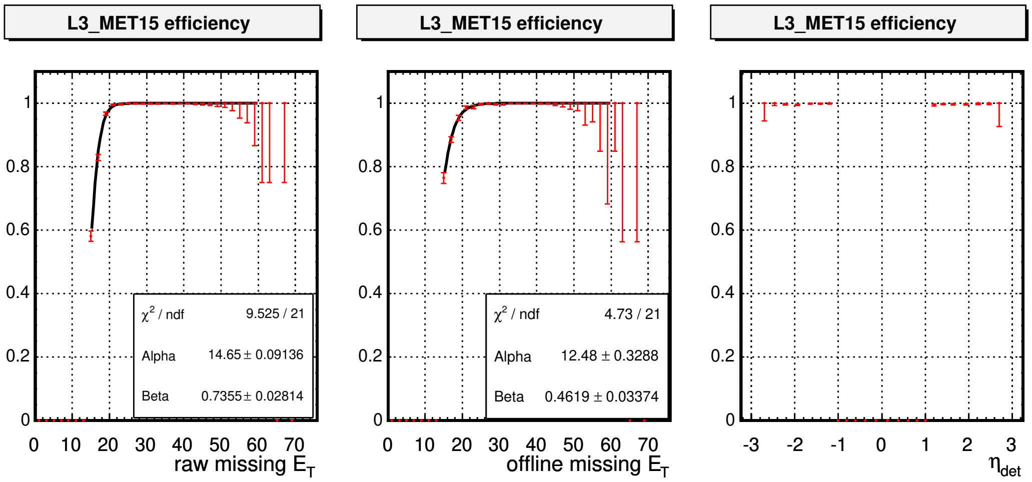

Figure 3: Efficiency of the L3_MET15 trigger as a function of raw and offline $\not\!\!E_{\mathrm{T}}$ and η_{det} of the electron. The turn-on curve vs. $\not\!\!E_{\mathrm{T}}$ is fitted with the function in equation 2.

3.2 L2_PEM20

Previously, in [1], the efficiency of the L2_PEM20 trigger was measured using $W \rightarrow e\nu$ events and the MET_PEM_L1_EM8 and MET_PEM trigger paths. See Appendix A. However, in this note we use the $Z \rightarrow e^+e^-$(CP) sample because it provides a higher statistics sample of unbiased electrons. The $Z \rightarrow e^+e^-$(CP) events are collected with the central electron trigger, ELECTRON_CENTRAL_18, which belongs to the HIGH_PT_ELECTRON_1 data stream. We require a CEM and a PHX electron where the selection criteria are shown in Table 1. In order to reproduce the L2_PEM20 trigger requirements we use the TL2D

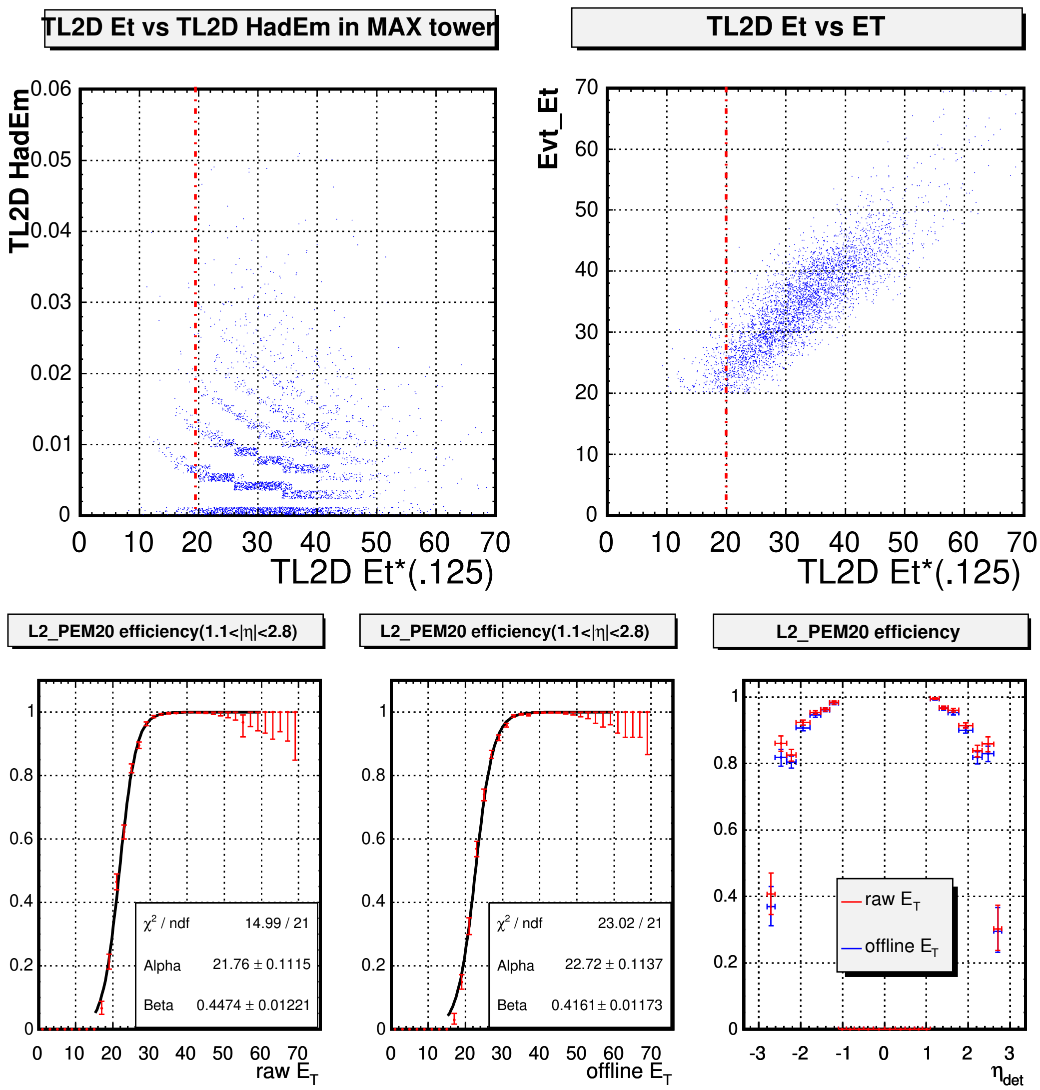

Figure 4: The top plots show the TL2D Had/Em vs. the TL2D E_T and the offline E_T vs. the TL2D E_T . The bottom plot shows L2_PEM20 trigger efficiency as a function of raw and offline E_T and the η_{det} dependence.

bank which includes the Plug EM(PEM) calorimeter E_T, Had/Em and η_{trig} for the trigger tower. At level 2 this trigger requires a cluster in the PEM calorimeter with $E_T > 20$GeV, $Had/Em < 0.125$ and $1.1 < |\eta_{trig}| < 3.6$. The L2_PEM20 trigger efficiency is measured by checking that the Z CP events pass the level 2 requirements. Specifically, the efficiency is:

$$\epsilon(\mathrm{L2\_PEM20}) = \frac{\mathrm{Z} \rightarrow \mathrm{e^+e^-(CP)\ \&\&\ L2\_PEM20\ \ using\ TL2D\ bank}}{\mathrm{Z} \rightarrow \mathrm{e^+e^-(CP)}}. \tag{5}$$

In Figure 4 (top), we show the TL2D Had/Em vs. the TL2D E_T of a PHX electron

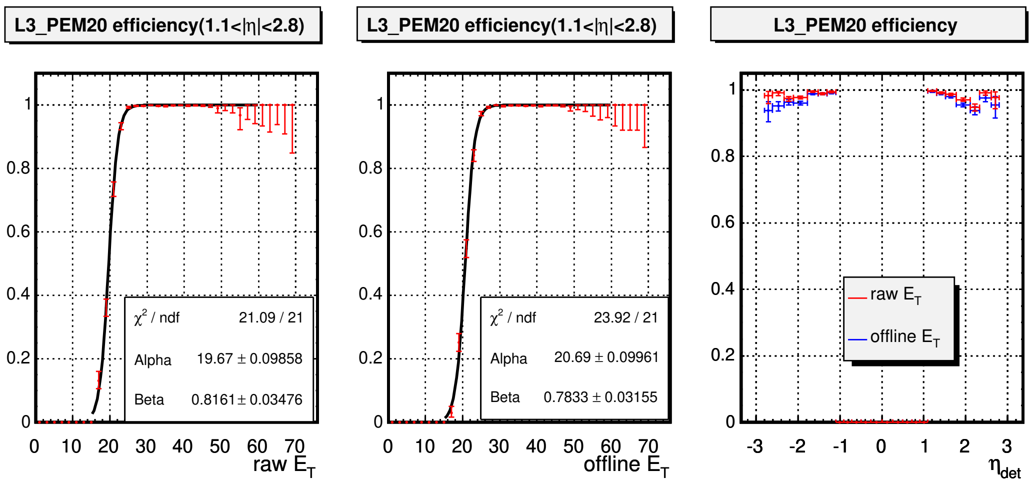

Figure 5: Efficiency of the L3_PEM20 trigger as a function of raw and offline E_T and η_{det} of the electron, The turn-on curve vs. E_T is fitted with the function in equation 2.

level 2 before passing the L2_PEM20 trigger. We also show the offline E_T vs. the TL2D E_T. In Figure 4 (bottom) we show the turn-on curve as a function of the raw electromagnetic cluster E_T and offline E_T (StdPEM electron transverse energy and adding the Ppr energy and applying the leakage correction). However, since the L2_PEM20 trigger efficiency decreases as it goes to high $|\eta|$, we measure E_T turn-on curve in different η ranges. These are shown in Appendix B.

3.3 L3_PEM20

The $Z \to e^+e^-$(CP) events are also used to evaluate the L3_PEM20 trigger efficiency. We define it as:

$$\epsilon(\mathrm{L3\_PEM20}) = \frac{\mathrm{Z \to e^+e^-(CP)\ \&\&\ L2\_PEM20\ from\ L3SumObject}}{\mathrm{Z \to e^+e^-(CP)\ \&\&\ L2\_PEM20\_PS10}}. \tag{6}$$

This L3_PEM20 trigger requires that an event has EM transverse energy greater than 20GeV and Had/Em less than 0.125. We can get Level3 trigger variables by accessing the L3SummaryObject. Figure 5 shows the turn-on curve vs. raw and offline E_T and η. Although the η dependence is weak, we nevertheless provide η dependent E_T turn-on curves in Appendix B.

Although known to be small, we also consider the background contamination in $Z \to e^+e^-$ events and find that the background effect does not change the L2 and L3_PEM20 trigger efficiencies. Therefore, the systematic uncertainty from background is negligible. These are shown in Appendix C.

4 Conclusion

We have measured the PHX electron efficiencies of the sub-triggers for the MET_PEM trigger path. The PHX electrons are selected from $W \rightarrow e\nu$ and $Z \rightarrow e^+e^-$ events. The MET_PEM trigger efficiency is obtained by combining the sub-trigger paths and it is shown with the sub-trigger efficiencies and the turn-on curve fit parameters in Table 3. We use the offline $\not\!\!E_{\mathrm{T}}$ and E_T to measure the efficiencies in Table 3.

	L1_MET15_L3	L1_MET15	L3_MET15	L2_PEM20	L3_PEM20
numer.	7464	7449	7449	9397	9902
denom.	7530	7464	7530	10061	10061
eff.(%)	$99.18^{+0.10}_{-0.11}$	$99.79^{+0.05}_{-0.06}$	$98.98^{+0.11}_{-0.12}$	93.40±0.25	$98.42^{+0.12}_{-0.13}$
α	14.79±0.14	12.69±0.24	12.48±0.33	22.72±0.11	20.69±0.09
β	0.370±0.014	0.311±0.013	0.46±0.034	0.41±0.01	0.78±0.03

MET_PEM eff.	91.0 ± 0.3

Table 3: Trigger efficiencies summary. All uncertainties listed are statistical only and offline $\not\!\!E_{\mathrm{T}}$ and E_T are used.

References

[1] G. Chiarelli, I. Fedorko, A. Sidoti CDF Note 6864.

[2] C. Hill, J. Incandela, C. Mills CDF Note 7309.

A OLD Method for L2_PEM20

Since the MET_PEM_L1_EM8_MET15 trigger has same requirements as MET_PEM trigger except for the L2_PEM20 trigger bit, the MET_PEM_L1_EM8_MET15 trigger path was used to measure the efficiency of the L2_PEM20 trigger.

level	MET_PEM_L1_EM8_MET15
L1	L1_EM8_MET15
L2	L2_PSX_L1_EM8_MET15
L3	L3_PEM20_MET15

Table 4: List of the MET_PEM_L1_EM8_MET15 trigger path.

The efficiency for L2_PEM20 is measured by studying:

$$\epsilon(\mathrm{L2\_PEM20}) = \frac{\mathrm{MET\_PEM\_L1\_EM8\_MET15\ \&\&\ MET\_PEM}}{\mathrm{MET\_PEM\_L1\_EM8\_MET15}} \tag{7}$$

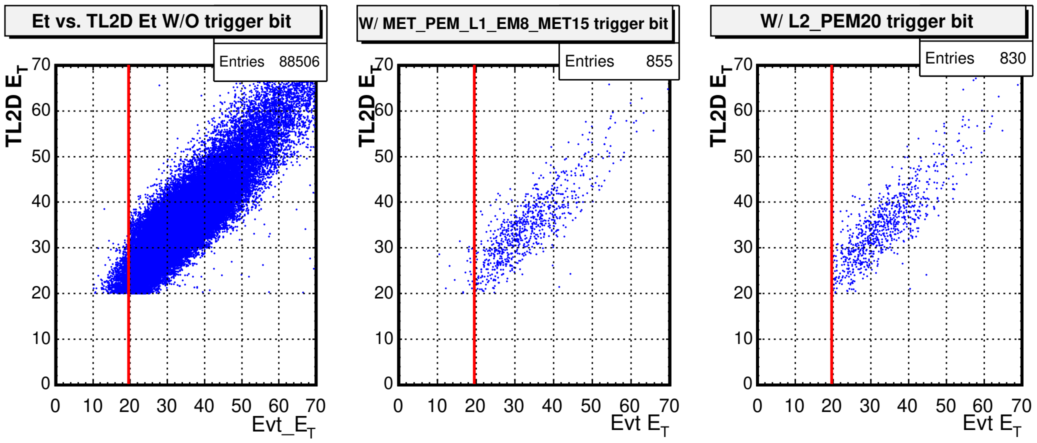

Figure 6: The left plot shows offline E_T vs. TL2D E_T distribution of electron candidates and the middle events are passed by L3_PEM20. In the right plot, we require L2_PEM20 trigger path from the middle events.

The L2_PEM20 efficiency measured using this method is 97.5 +- 0.6$\%$ and is higher than the measurement using the method described in section 3.2. This method has the disadvantage of using a biased electron sample since the electron sample having the MET_PEM_L1_EM8_MET15 trigger bit has already passed through L3_PEM20. As shown in Figure 6, the electron candidates we need for measuring the L2_PEM20 efficiency are lost from the L3_PEM20 trigger requirement. Therefore, the measurement presented here is shown only as a cross check and not recommended for use in analysis.

B η dependent E_T turn-on curves for L2_PEM20 and L3_PEM20

Since the L2_PEM20 trigger efficiency decreases as it goes to high $|\eta|$, we measure E_T turn-on curve in different η ranges. These are shown in Figures 7 and 8.

Although the η dependence is weak for the L3_PEM20 trigger efficiency, we nevertheless provide η dependent E_T turn-on curves. These are shown in Figures 9 and 10.

C Background

In this measurement, we make the assumption that backgrounds in $Z \rightarrow e^+e^-$ events are negligible. In this section, we consider the effect of this assumption on our efficiency measurement. The QCD background contamination can be further suppressed by requiring a tighter isolation cut to the central electron leg and requiring low $\not\!\!E_{\mathrm{T}}$. The ratio of isolation and E_T of the electron is required to be less than 0.05 and $\not\!\!E_{\mathrm{T}}$ less than 20 GeV. As shown in Figure 11, the background effect is very small and the systematic uncertainty from background on this measurement is negligible.

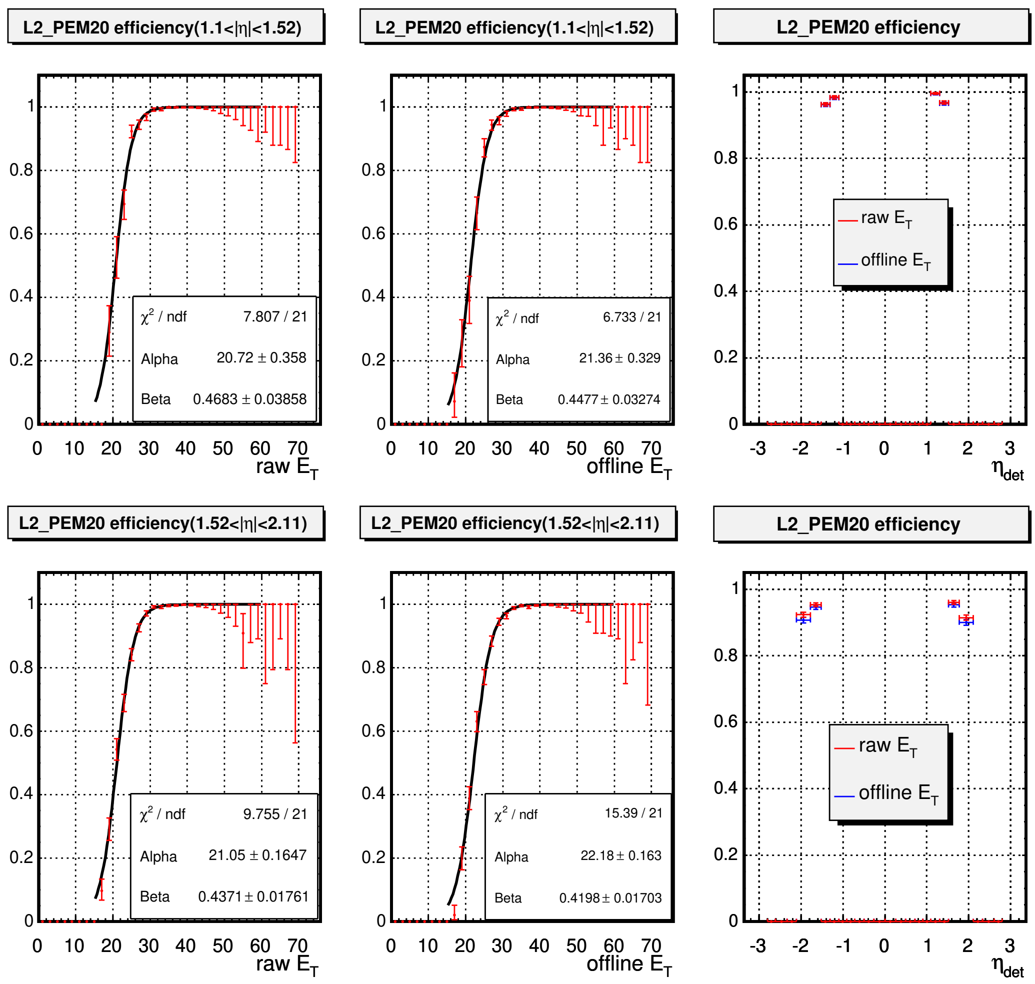

Figure 7: The L2_PEM20 trigger efficiency as a function of raw and offline E_T and the η_{det} dependence for $1.1 < |\eta| < 1.52$ (top) and $1.52 < |\eta| < 2.11$ (bottom).

D Run Number dependence

In Figure 12 we show run dependence of the MET_PEM trigger sub-trigger components. We find that they are consistent with being flat.

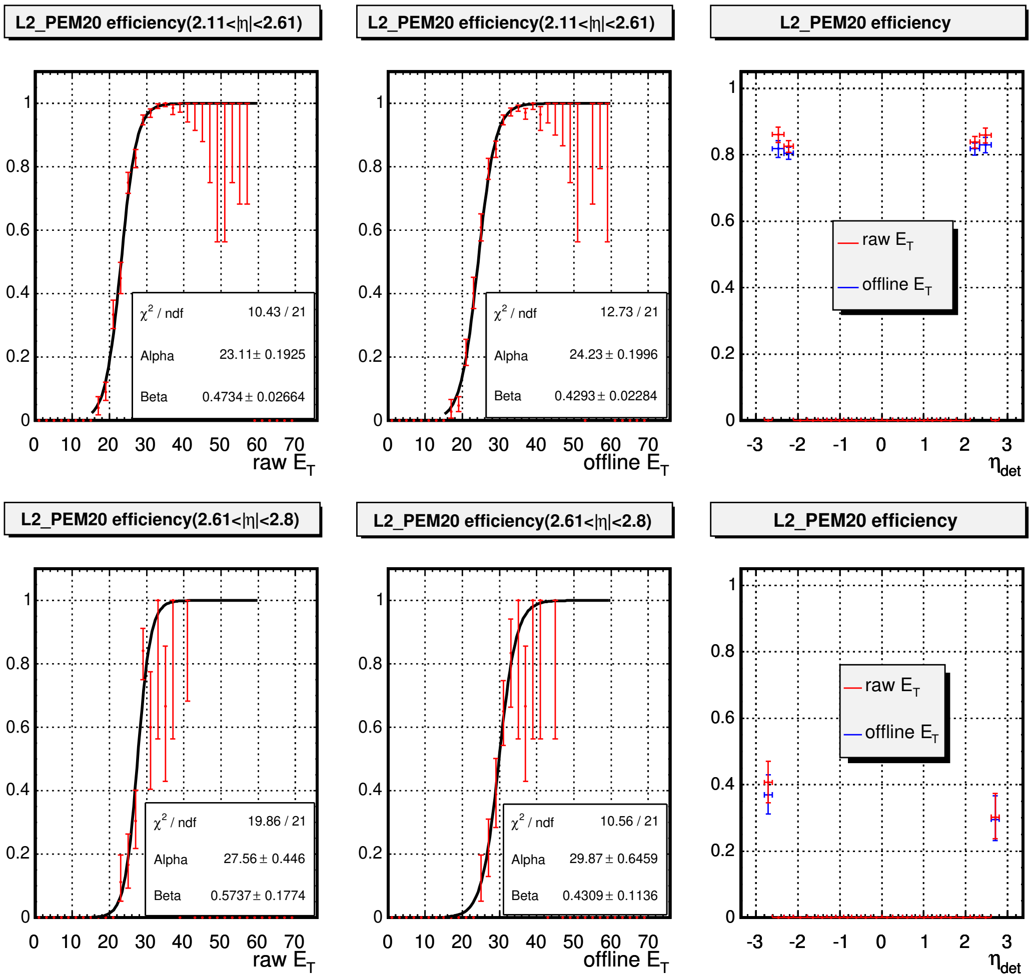

Figure 8: The L2_PEM20 trigger efficiency as a function of raw and offline E_T and the η_{det} dependence for $2.11 < |\eta| < 2.61$ (top) and $2.61 < |\eta| < 2.8$ (bottom).

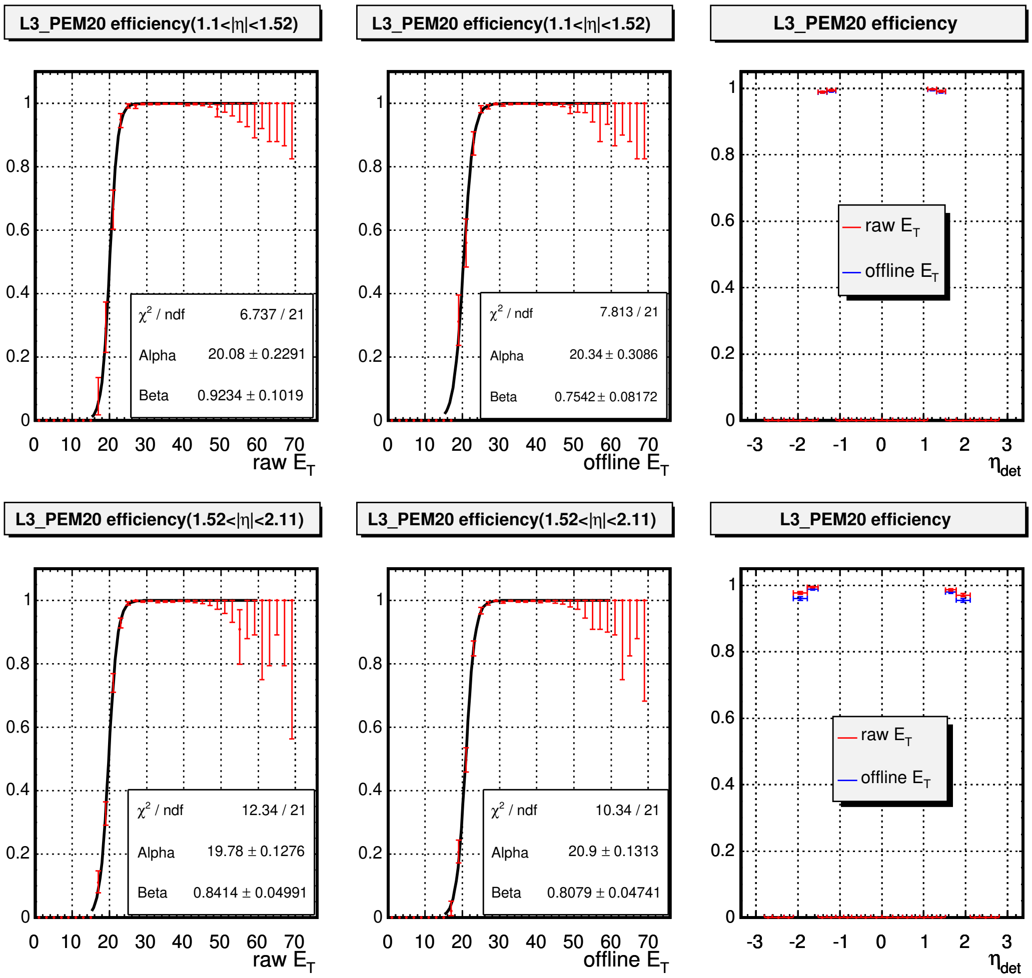

Figure 9: Efficiency of the L3_PEM20 trigger as a function of raw and offline E_T and η of the electron for $1.1 < |\eta| < 1.52$ (top) and $1.52 < |\eta| < 2.11$ (bottom).

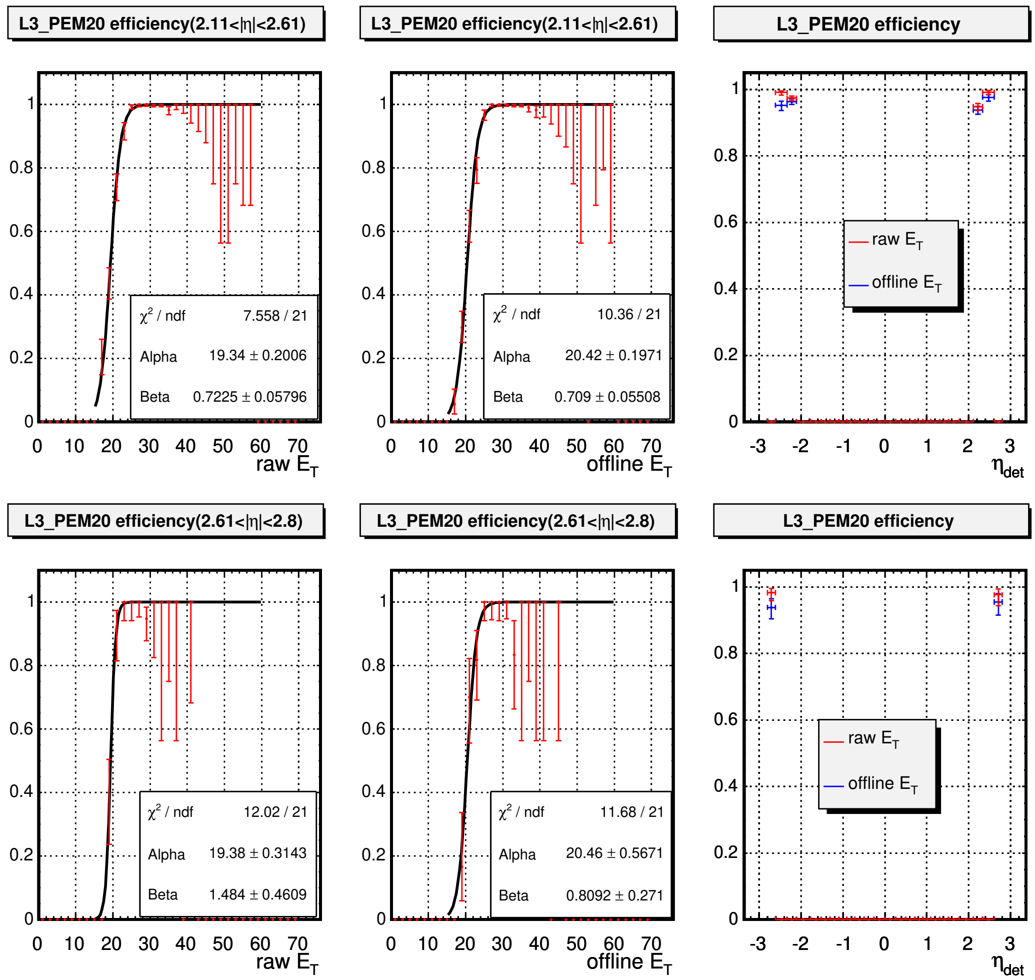

Figure 10: Efficiency of the L3_PEM20 trigger as a function of raw and offline E_T and η of the electron for $2.11 < |\eta| < 2.61$ (top) and $2.61 < |\eta| < 2.8$ (bottom).

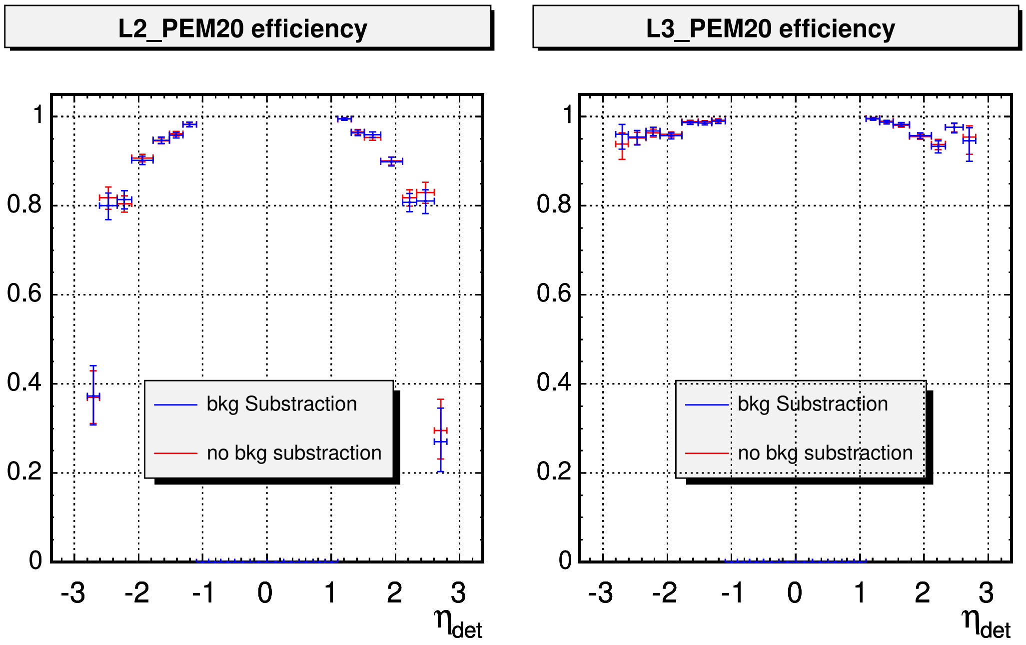

Figure 11: L2_ and L3_PEM20 trigger efficiency. The blue line shows the efficiency when we tighten the cuts and further suppress the background in $Z \to e^+e^-$ events.

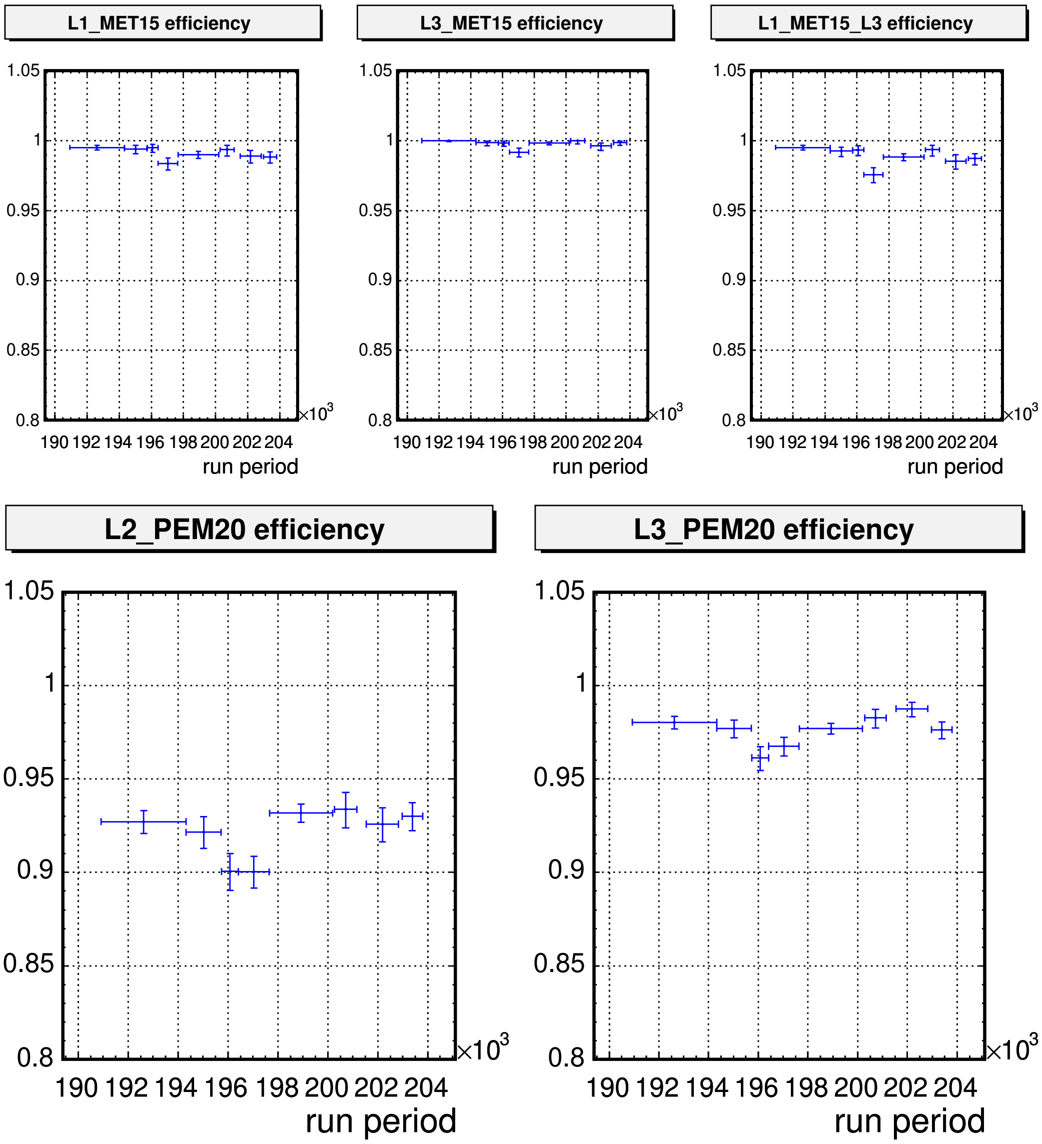

Figure 12: Run dependence of the MET_PEM trigger sub-trigger components.