# Period 28 High PT Lepton Efficiencies and SF -Final

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Tufts

# Electrons ID: Samples

Dataset bhelmm: Runs 287294-289197(P28)
MC sample : zektek (Feb 2009)
GRL :GRL for P28 Prelim
(goodrun_em_si_v34.list, goodrun_em_nosi_v34.list)

P28 skim leptons
MC dataset zektek (P25 and onward) on SAM

# Electron ID: Cuts

## CEM Selection Cuts

| Variable | Tight (CEM) |
|---|---|
| Region | == CEM |
| Fiducial | Fiducial == 1 |
| $E_T$ | $\geq$ 20 GeV |
| Track $Z_0$ | $\leq$ 60 cm |
| Track $p_T$ | $\geq$ 10 GeV/$c$ |
| COT Ax. Seg. | $\geq$ 3 |
| COT St. Seg. | $\geq$ 2 |
| Conversion | $\neq$ 1 |
| Had/em | $\leq (0.055 + (0.00045 \times E))$ |
| Isolation | $\leq$ 0.1 |
| LshrTrk | $\leq$ 0.2 |
| E/P | $\leq$ 2.0 unless $p_T \geq$ 50GeV/$c$ |
| CES $\Delta Z$ | $\leq$ 3.0 cm |
| Signed CES $\Delta X$ | $-3.0 \leq q \times \Delta X \leq 1.5$ |
| CES StripChi2 | $\leq$ 10.0 |

$Z$ candidates are used to calculate the efficiencies

## Plug Selection Cuts

| Variable | PHX | PEM |
|---|---|---|
| $E_T$ | $\geq$ 20GeV | $\geq$ 20GeV |
| Pes2dEta | $1.2 \leq \lvert\eta\rvert \leq 2.8$ | $1.2 \leq \lvert\eta\rvert \leq 2.8$ |
| Had/Em | $\leq$ 0.05 | $\leq$ 0.05 |
| Pem3x3FitTow | $\neq$ 0 | $\neq$ 0 |
| Pem3x3Chisq | $\leq$ 10 | $\leq$ 10 |
| Pes5by9U | $\geq$ 0.65 | $\geq$ 0.65 |
| Pes5by9V | $\geq$ 0.65 | $\geq$ 0.65 |
| Isolation | $\leq$ 0.1 | $\leq$ 0.1 |
| $\Delta R$ | $\leq$ 3.0 cm | $\leq$ 3.0 cm |
| PhxMatch | TRUE | - |
| $N_{hits}^{Si}$ | $\geq$ 3 | - |
| $\lvert z_0^{PHX} \rvert$ | $\leq$ 60 cm | - |

We calculate efficiencies using a set of very loose, or "probe" electrons as the denominator. For each tight electron in the event which passes the trigger, we look for probe electrons which have the opposite sign and which, paired with the tight electron, have an invariant mass in the $Z$ window 76 GeV/$c^2$ $< M <$ 106 GeV/$c^2$. (Central-Central)

We calculate Phoenix electron efficiencies using central-plug $Z$ candidates in the mass window 81 GeV/$c^2$ $< M <$ 101 GeV/$c^2$. Due to the non-negligible, and $\eta$-dependent, Phoenix charge fake rate, there is no opposite-sign requirement.

# P26 numbers vs P25

| | Period 27 | | Period 27 | |
|---|---|---|---|---|
| | bhelmm | zektek | bhelmm | zektek |
| CEM Eff | 0.779+\-0.004 | 0.793 +\-0.003 | 0.771+\-0.004 | 0.793 +\-0.003 |
| CEM SF | 0.981 +\-0.006 | N/A | 0.972 +\-0.006 | N/A |
| nisoCEM Eff | 0.814 +\-0.003 | 0.825 +\-0.003 | 0.808 +\-0.004 | 0.825 +\-0.003 |
| nisoCEM SF | 0.986 +\-0.005 | N/A | 0.979 +\-0.006 | N/A |
| LooseCEM Eff | 0.907 +/- 0.002 | 0.901 +\-0.003 | 0.902 +/- 0.003 | 0.901 +\-0.003 |
| LooseCEM SF | 1.007 +\-0.004 | N/A | 1.002 +\-0.004 | N/A |
| nisolooseCEM Eff | 0.948+\-0.002 | 0.940 +\-0.003 | 0.943+\-0.002 | 0.940 +\-0.003 |
| nisoloostCEM SF | 1.009 +\-0.004 | N/A | 1.004 +\-0.004 | N/A |

| | PHX | | PHX | |
|---|---|---|---|---|
| Eff \|Eta\| < 2.0 | 0.671+\-0.006 | 0.746+\-0.004 | 0.669+\-0.006 | 0.746+\-0.004 |
| SF \|Eta\| < 2.0 | 0.899+\-0.009 | NA | 0.897+\-0.009 | NA |
| | PHX | | PHX | |
| Eff \|Eta\| < 2.8 | 0.578+\-0.005 | 0.644+\-0.004 | 0.585+\-0.005 | 0.644+\-0.004 |
| SF \|Eta\| < 2.8 | 0.897+\-0.009 | NA | 0.908+\-0.010 | NA |

# CEM-PEM

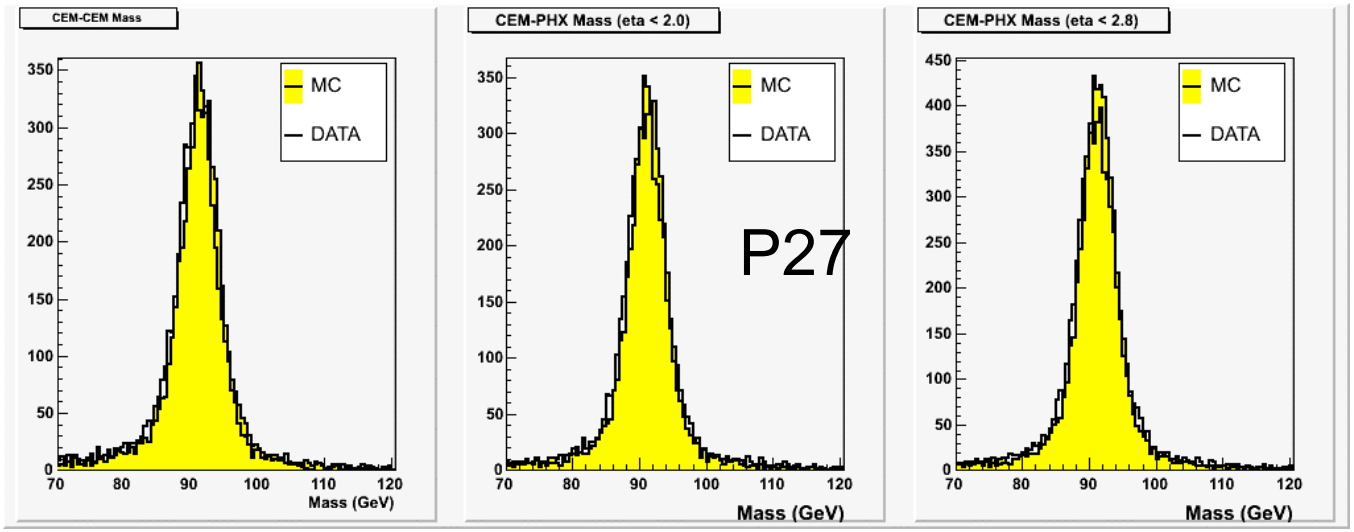
| | P25 | | P26 | |
|---|---|---|---|---|
| | PEM | | PEM | |
| Eff \|Eta\| < 2.0 | 0.739+\-0.006 | 0.843+\-0.003 | 0.781+\-0.006 | 0.843+\-0.003 |
| SF \|Eta\| < 2.0 | 0.876+\-0.008 | NA | 0.927+\-0.009 | NA |

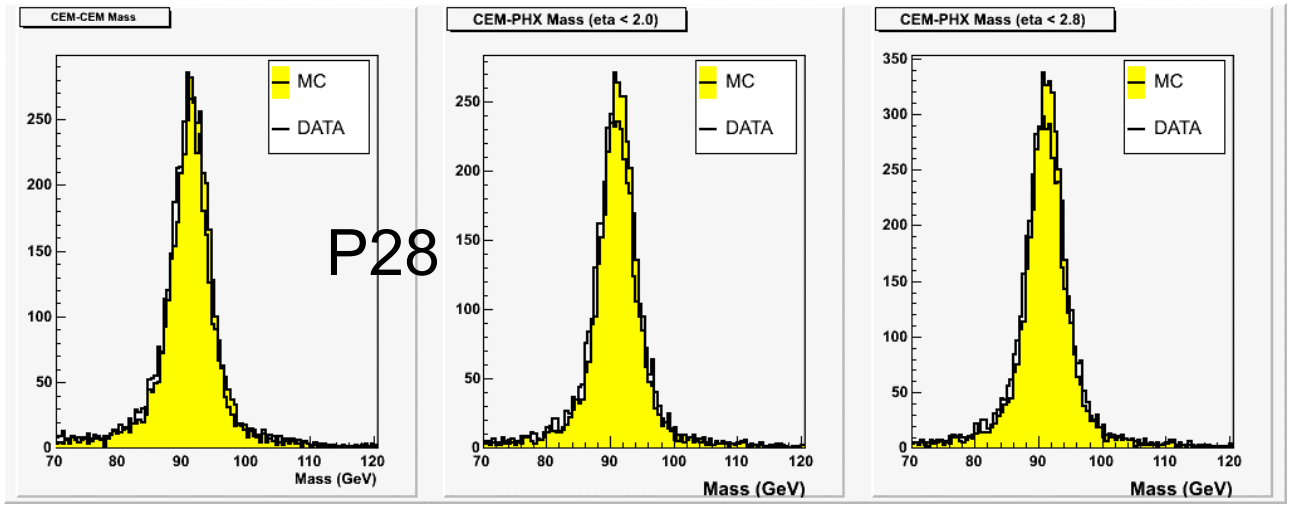
| | | | | |
|---|---|---|---|---|
| | PEM | | PEM | |
| Eff \|Eta\| < 2.8 | 0.697+\-0.006 | 0.803+\-0.003 | 0.739+\-0.006 | 0.803+\-0.003 |
| SF \|Eta\| < 2.8 | 0.867+\-0.008 | NA | 0.920+\-0.008 | NA |

| | P27 | | P28 | |
|---|---|---|---|---|
| | PEM | | PEM | |
| Eff \|Eta\| < 2.0 | 0.768+\-0.005 | 0.843+\-0.003 | 0.762+\-0.006 | 0.843+\-0.003 |
| SF \|Eta\| < 2.0 | 0.911+\-0.007 | NA | 0.904+\-0.008 | NA |

| | | | | |
|---|---|---|---|---|
| | PEM | | PEM | |
| Eff \|Eta\| < 2.8 | 0.723+\-0.004 | 0.803+\-0.003 | 0.723+\-0.005 | 0.803+\-0.003 |
| SF \|Eta\| < 2.8 | 0.900+\-0.006 | NA | 0.901+\-0.007 | NA |

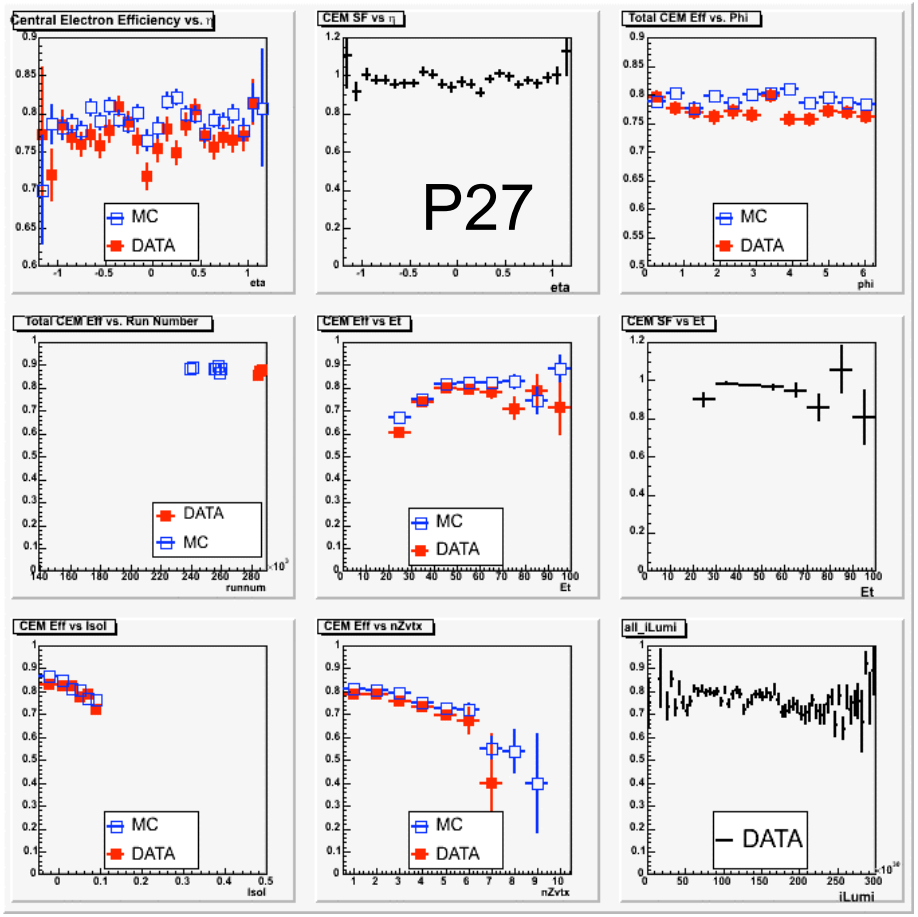
# EleID Plots

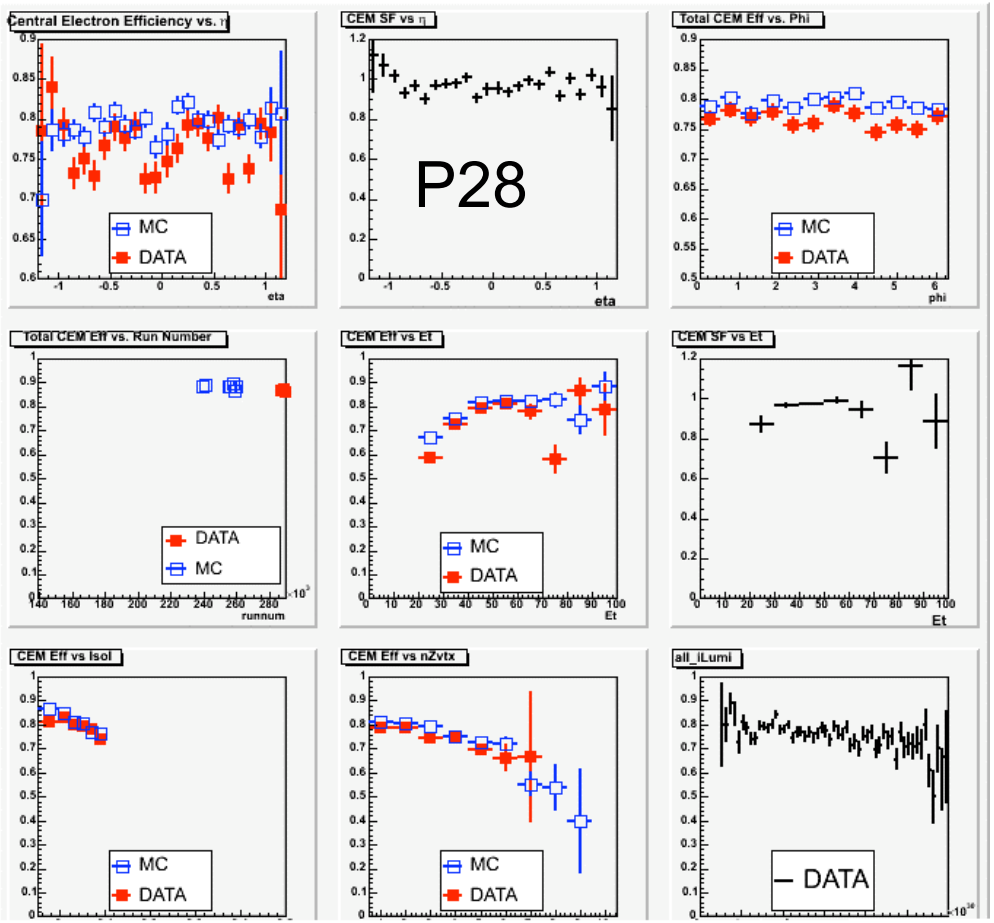

CEM-CEM Mass
CEM-PHX Mass (eta < 2.0)
CEM-PHX Mass (eta < 2.8)
MC
DATA
Mass (GeV)
P27


CEM-CEM Mass
CEM-PHX Mass (eta < 2.0)
CEM-PHX Mass (eta < 2.8)
MC
DATA
Mass (GeV)
P28

# EleID Plots 1

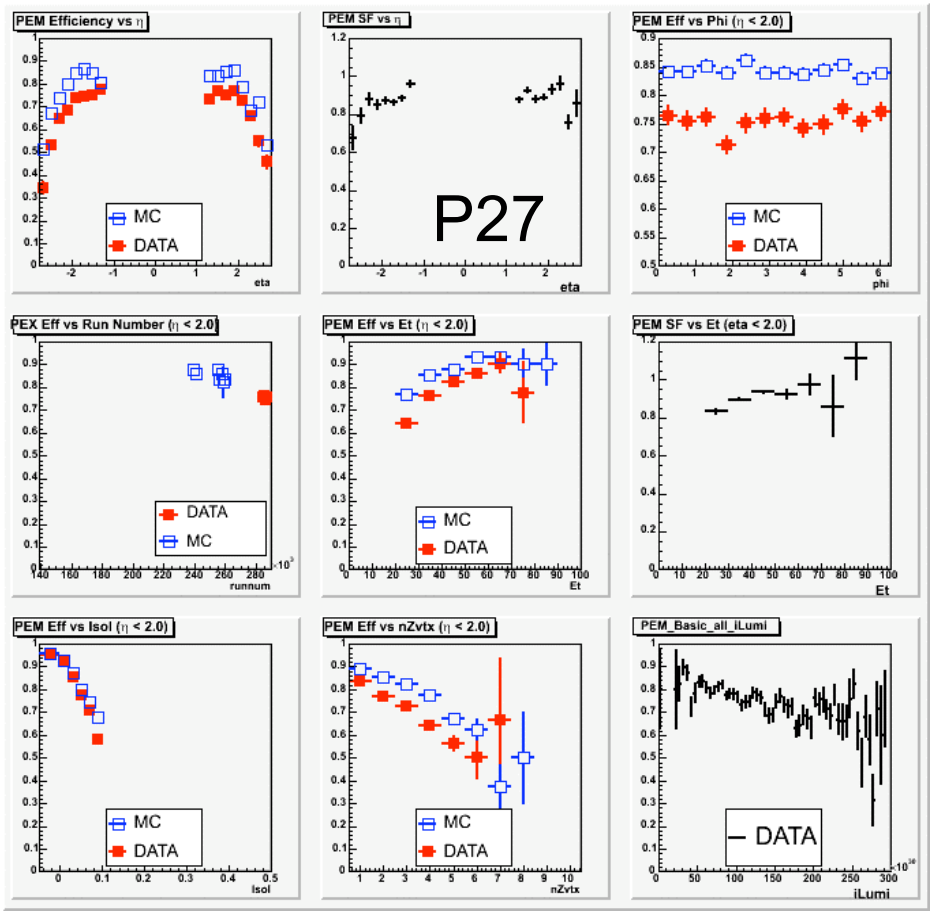
CEM Efficiencies

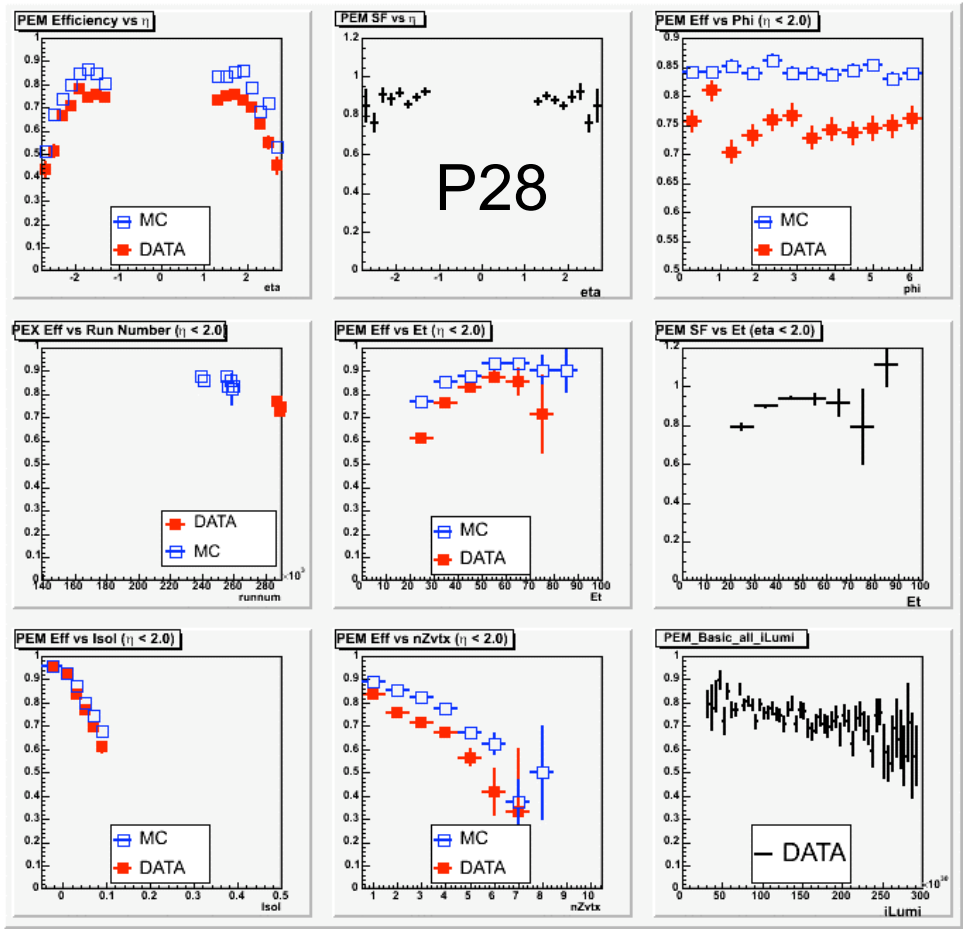


# EleID Plots 2

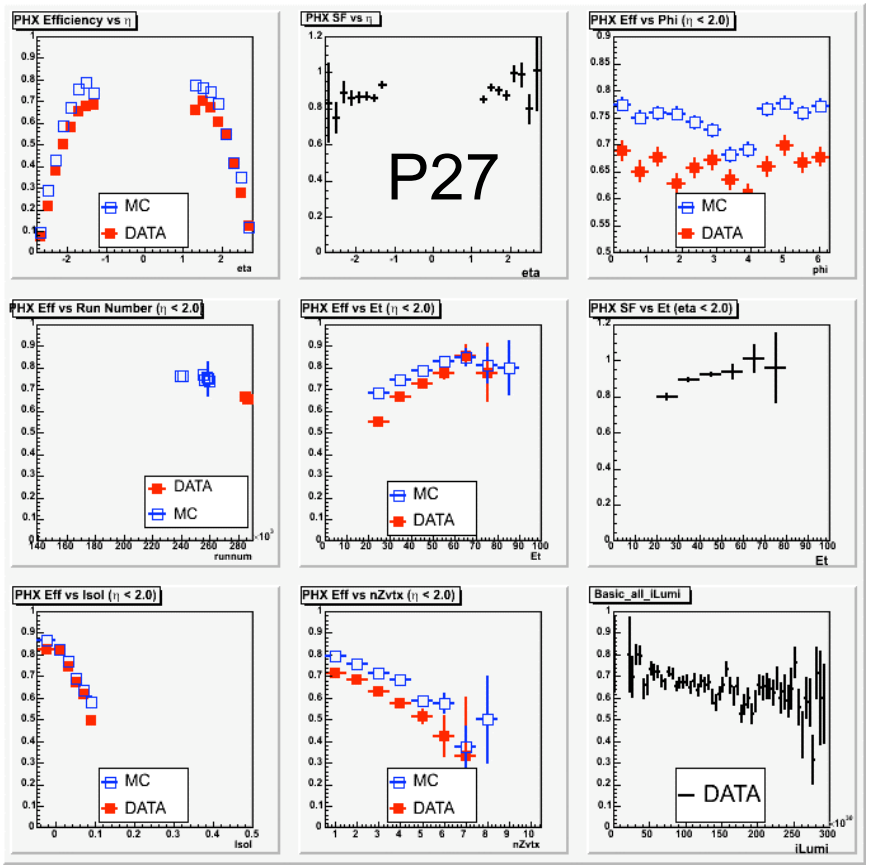
## PEM Efficiencies

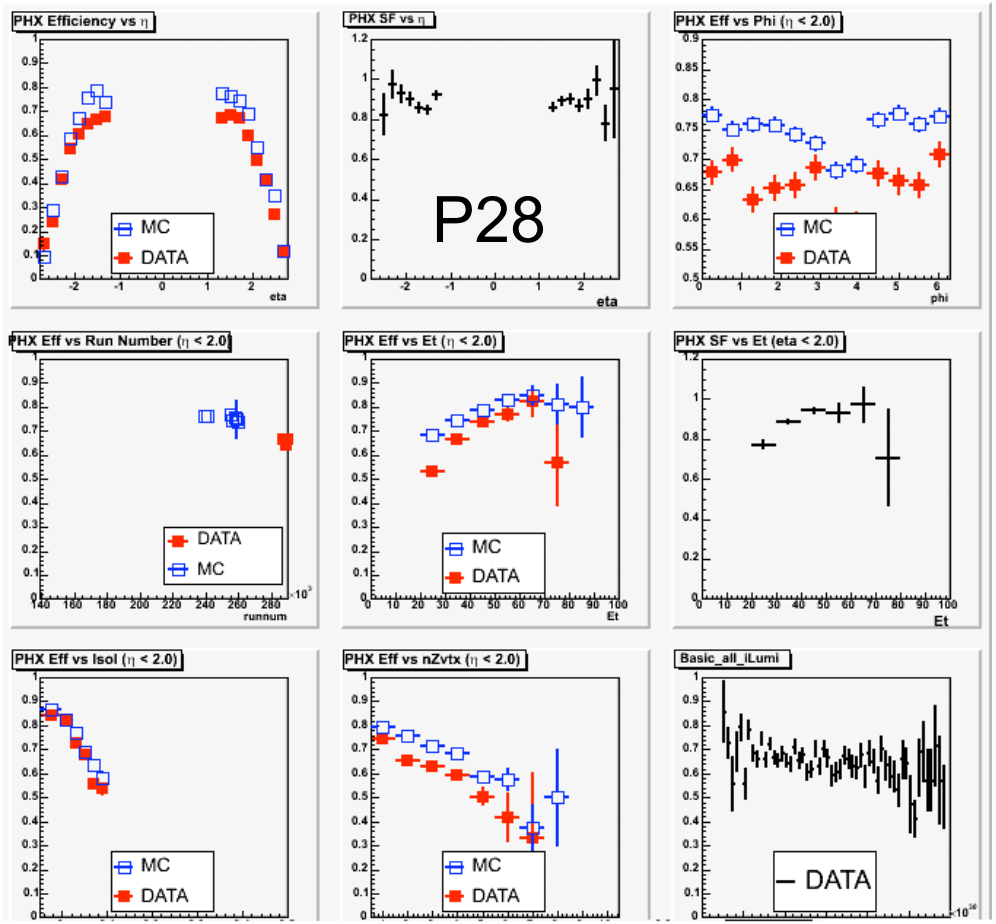


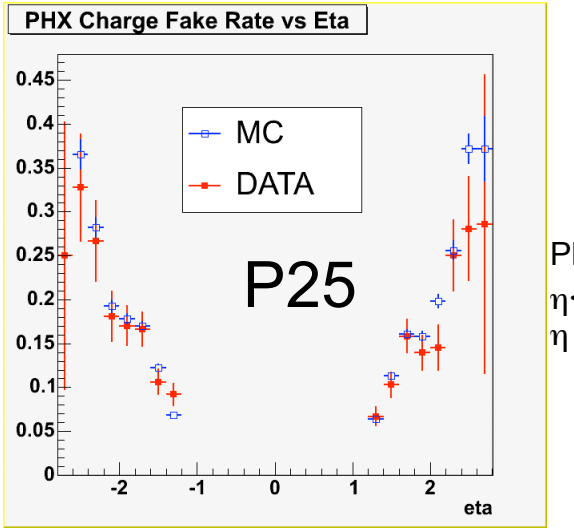
# EleID Plots 3

## PHX Efficiencies

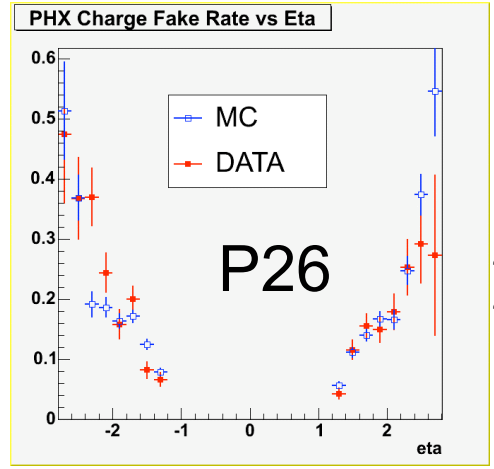


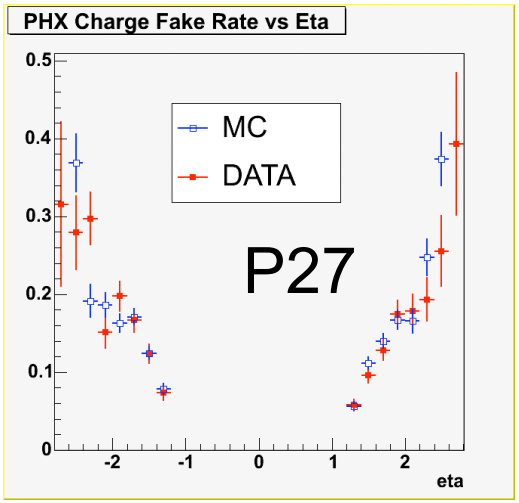
# PHX Fake Charge Rate



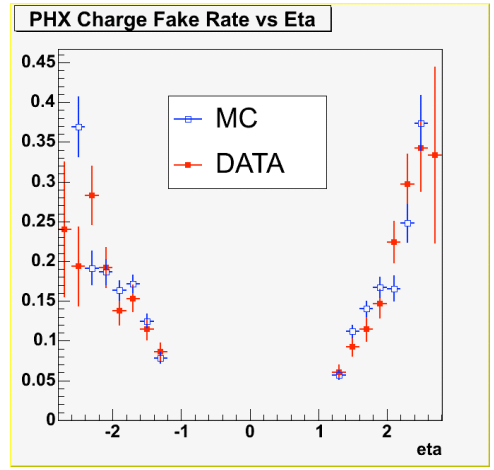

Phoenix charge fake rate
$\eta < 2.0$ 0.119 +/- 0.006
$\eta < 2.8$ 0.137 +/- 0.006




Phoenix charge Fake rate
$\eta < 2.0$: 0.113 +/- 0.006
$\eta < 2.8$: 0.144 +/- 0.006




Phoenix charge fake rate
$\eta < 2.0$ 0.118 +/- 0.005
$\eta < 2.8$ 0.137 +/- 0.005




Phoenix charge Fake rate
$\eta < 2.0$: 0.108 +/- 0.005
$\eta < 2.8$: 0.136 +/- 0.005

# Electron ID Conclusions

- P28 are in good agreement with previous periods

# Electron Trigger: Tracking

| |
|---|
| 1 electron with $E_T > 25GeV$ |
| $\not{E}_T > 25GeV$ |
| reject cosmic events |

**Table:** Offline *W* selection.

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

**Table:** Offline baseline cuts for central electrons.

## L1 Tracking Efficiency

$$\epsilon(\text{L1_XFT_PT8}) = \frac{\text{numW \& passed L1_CEM8_PT8}}{\text{numW}}$$

*numW* means the number of *W* candidates that passed the W_NOTRACK path.

## L2 Tracking Efficiency

At L2, there is no additional tracking done except for receiving the XFT information from L1.

$$\epsilon(\text{L2_XFT_PT8}) = \frac{\text{numW \& passed L1_CEM8_PT8 \& passed L2_CEM16_PT8}}{\text{numW \& passed L1_CEM8_PT8}}$$

## L3 Tracking Efficiency

$$\epsilon(\text{L3_PT9}) = \frac{\text{numW \& passed L1_CEM8_PT8 \& L2_CEM16_PT8 \& L3_CEM18_PT9}}{\text{numW \& passed L1_CEM8_PT8 \& L2_CEM16_PT8}}$$

# Electron Trigger: Calorimeter

## L2 Calorimeter Efficiency

- Require at least 1 electron satisfying the baseline cuts and $E_T >$ 18GeV.
- Use ELECTRON_CENTRAL_18_NO_L2 path.
- Efficiency reaches 100% at about 25 GeV.

$$\epsilon(\text{L2_CEM16}) = \frac{\text{numEl \& passed L1_CEM8_PT8 \& L2_PS \& L2_CEM16}}{\text{numEl \& passed L1_CEM8_PT8 \& L2_PS}}$$

## L3 Calorimeter Efficiency

- Use the calibration dataset(blpc).
- Use ELECTRON_CENTRAL_8_NO_L2 path.
- Efficiency reaches 100% at about 20 GeV.

$$\epsilon(\text{L3_CEM18}) = \frac{\text{numEl \& passed EL_CENT_8_NO_L2 \& L2_CEM16 \& L3_CEM18}}{\text{numEl \& passed EL_CENT_8_NO_L2 \& L2_CEM16}}$$

# Electron Trigger Results

| | |
|---|---|
| NofflW | 131985 |
| NcemL1 | 126616 |
| NcemL2 | 126544 |
| NcemL3 | 125539 |

| Trigger | Period 17 | Period 18 | Period 19 | Period 20 |
|---|---|---|---|---|
| L1_XFT_PT8 | 0.9694 ± 0.003 | 0.9697 ± 0.003 | 0.9674 ± 0.003 | 0.9686 ± 0.003 |
| L2_XFT_PT8 | 0.9995 ± 0.003 | 0.9995 ± 0.003 | 0.9993 ± 0.003 | 0.9995 ± 0.003 |
| L3 tracking | 0.9929 ± 0.003 | 0.9919 ± 0.003 | 0.9909 ± 0.003 | 0.9911 ± 0.003 |
| Total Tracking | 0.9622 ± 0.003 | 0.9615 ± 0.003 | 0.9615 ± 0.003 | 0.9594 ± 0.003 |

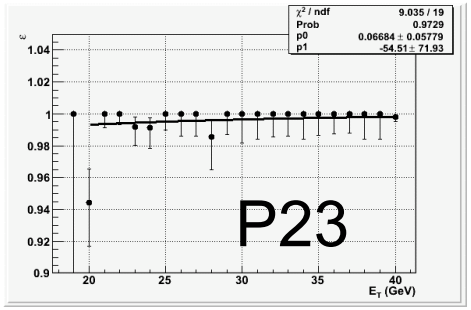
| Period 21 | Period 22 | Period 23 | Period 24 | Period 25 |
|---|---|---|---|---|
| 0.9681 ± 0.002 | 0.9704 ± 0.003 | 0.9705 ± 0.003 | 0.9698 ± 0.003 | 0.9695 ± 0.003 |
| 0.9993 ± 0.002 | 0.9995 ± 0.003 | 0.9995 ± 0.003 | 0.9995 ± 0.003 | 0.9995 ± 0.003 |
| 0.9903 ± 0.002 | 0.9901 ± 0.003 | 0.9892 ± 0.003 | 0.9899 ± 0.003 | 0.9906 ± 0.003 |
| 0.9580± 0.002 | 0.9580± 0.003 | 0.9596± 0.003 | 0.9596± 0.003 | 0.9599± 0.003 |

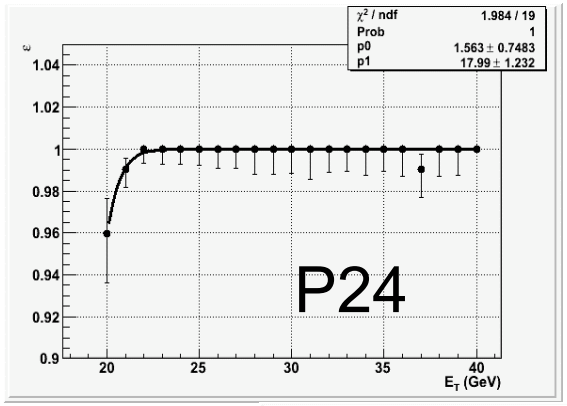
| Period 26 | Period 27 | Period 28 |
|---|---|---|
| 0.9595 ± 0.003 | 0.9596 ± 0.003 | 0.9593 ± 0.003 |
| 0.9995 ± 0.003 | 0.9995 ± 0.003 | 0.9994 ± 0.003 |
| 0.9931 ± 0.003 | 0.9926 ± 0.003 | 0.9926 ± 0.003 |
| 0.9525± 0.003 | 0.9521± 0.003 | 0.9521± 0.003 |

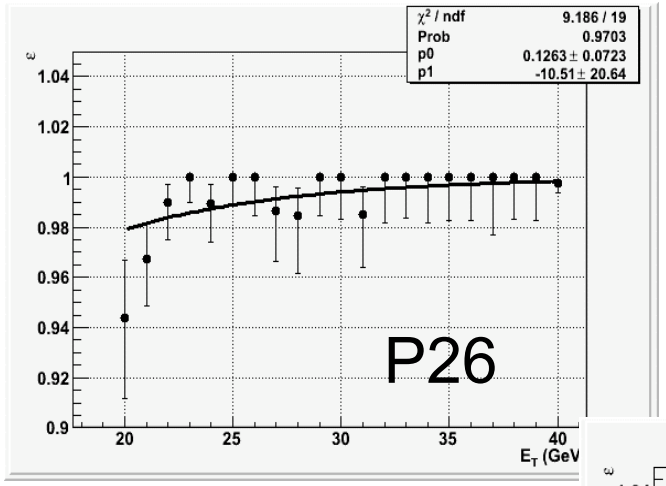
# L2 Calo Efficiency

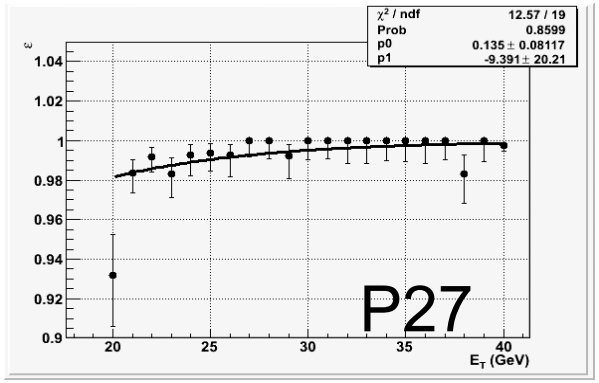
$$\epsilon = \frac{1}{1 + e^{-\beta(E_T - \alpha)}}.$$

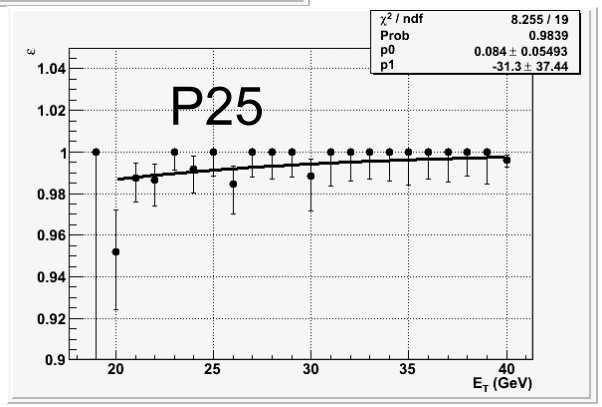
L2_CEM16 calorimeter efficiency

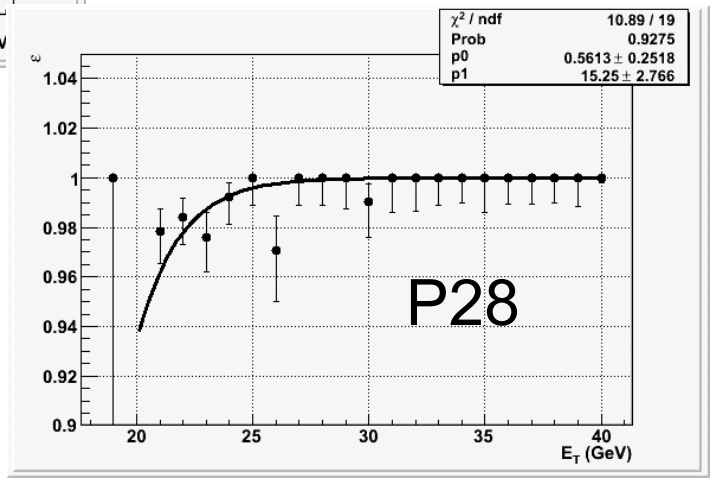


# MET_PEM Trigger

Dataset bhelmm: Runs 287294-289197 (P28)
Dataset bpelmm (and high eta PHX): Runs 287294-289197 (P28)

GRL :GRL Prelim for P28

P26 dataset :bpelmm, bhelmm, skim leptons, goodrun_em_si_v34Prelim.list

# MET_PEM Trigger: Evt Selection

Event Selection: $W \rightarrow e\nu$ and $Z \rightarrow e^+e^-$ (CP) candidates.

- Plug electrons selected according to the Phoenix Objects standard cuts,
- Central electrons are *UltraTight CEM* Objects
- Electron ID cuts: notes 8614 and 8274

| Variable | UltraTight CEM | Variable | PHX |
|---|---|---|---|
| Region | == Central | Region | == plug |
| Fiducial | TrkFiducial == 1 | *Pes2dEta* | $1.2 \leq \lvert\eta\rvert \leq 2.8$ |
| $E_T$ | $\geq$ 20 GeV | $E_T$ | $\geq$ 20 GeV |
| Track $Z_0$ | $\leq$ 60 cm | Had/Em | $\leq$ 0.05 |
| Track $p_T$ | $\geq$ 10 Gev | Pem3x3FitTow | $\neq$ 0 |
| COT Ax. Seg. | $\geq$ 3 | Pem3x3$\chi^2$ | $\leq$ 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 | $\leq$ 0.05 ($\leq$ 0.1 in TCEM) | $\Delta R$ | $\leq$ 3.0 cm |
| LshrTrk | $\leq$ 0.1 ($\leq$ 0.2 in TCEM) | PhxMatch | True |
| $E/p$ | $\leq$ 2.0 unless $p_T \geq$ 50 GeV/$c$ | $N^{siliconhits}$ | $\geq$ 3 |
| CES $\Delta Z$ | $\leq$ 3.0 cm | $Z_0^{PHX}$ | $\leq$ 60 cm |
| Single CES $\Delta X$ | $-3.0 \leq q \times \Delta X \leq 1.5$ | | |
| CES Strip$\chi^2$ | $\leq$ 10.0 | | |

# MET_PEM:L1 and L3 MET15 Eff

| MET_PEM | | PLUG_ELECTRON_20 | |
|---|---|---|---|
| L1 | L1_EM8_MET15 | L1 | L1_EM8 |
| L2 | L2_PEM20_L1_EM8_MET15 | L2 | L2_PEM20_PS10 (PS25) |
| L3 | L3_PEM20_MET15 | L3 | L3_PEM20 |

L1, L3 MET15 and L2, L3 PEM20 components of MET_PEM are separated thanks to PLUG_ELECTRON_20 back-up trigger.

- MET15: $W \to e\nu$ candidate searched in the bpel dataset:

$$\epsilon(\texttt{L1_MET15_L3_MET15}) = \frac{\texttt{PLUG_ELECTRON_20 \&\& MET_PEM}}{\texttt{PLUG_ELECTRON_20}} \quad (1)$$

- PEM20: $Z \to e^+e^-$ CP candidate searched in the bhel dataset:

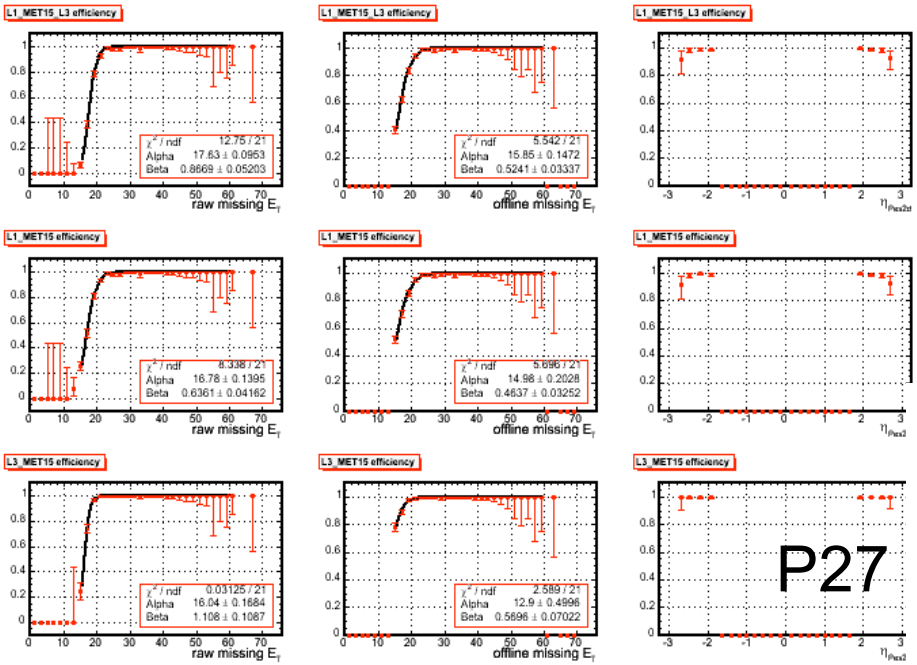
$$\epsilon(\texttt{L2_PEM20}) = \frac{Z \to e^+e^-(CP)\ \&\&\ \texttt{L2_PEM20_NoPS}}{Z \to e^+e^-(CP)} \quad (2)$$

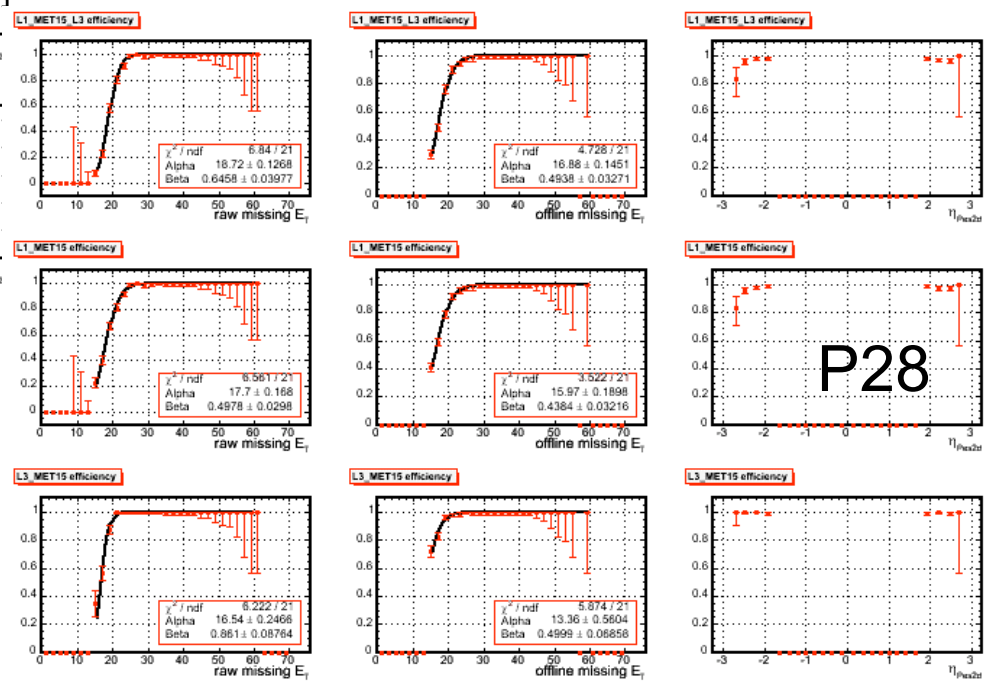
$$\epsilon(\texttt{L3_PEM20}) = \frac{Z \to e^+e^-(CP)\ \&\&\ \texttt{L2_PEM20_NoPS}\ \&\&\ \texttt{L3_PEM20}(L3Obj)}{Z \to e^+e^-(CP)\ \&\&\ \texttt{L2_PEM20_NoPS}} \quad (3)$$

Turn-on fit function

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

# MET15 Results



# MET15 Fit Results

$1.2 \leq |\eta| \leq 2.8$

L1_MET15_L3_MET15 Fit Values (electron $1.2 \leq |\eta| \leq 2.8$)

| period | $\epsilon$ ($\not{E}_T > 20$ GeV) | $\alpha$ | $\beta$ |
|---|---|---|---|
| $p00$ | $98.52^{+0.20}_{-0.22}$ | $14.20 \pm 0.24$ | $0.35 \pm 0.02$ |
| $[p01, p04]$ | $97.89^{+0.26}_{-0.28}$ | $14.80 \pm 0.22$ | $0.34 \pm 0.02$ |
| $[p05, p07]$ | $98.64^{+0.09}_{-0.10}$ | $14.74 \pm 0.10$ | $0.35 \pm 0.01$ |
| $p08$ | $98.85^{+0.12}_{-0.12}$ | $14.38 \pm 0.14$ | $0.37 \pm 0.01$ |
| $p09$ | $98.92^{+0.14}_{-0.15}$ | $13.78 \pm 0.20$ | $0.37 \pm 0.02$ |
| $p10$ | $98.54^{+0.17}_{-0.19}$ | $14.62 \pm 0.18$ | $0.37 \pm 0.02$ |
| $p11$ | $98.47^{+0.18}_{-0.19}$ | $14.67 \pm 0.18$ | $0.38 \pm 0.02$ |
| $p12$ | $98.20^{+0.24}_{-0.26}$ | $15.15 \pm 0.19$ | $0.38 \pm 0.02$ |
| $p13$ | $98.36^{+0.18}_{-0.20}$ | $14.51 \pm 0.18$ | $0.37 \pm 0.02$ |
| $p14$ | $98.96^{+0.33}_{-0.41}$ | $13.57 \pm 0.50$ | $0.41 \pm 0.05$ |
| $p15$ | $98.44^{+0.21}_{-0.23}$ | $14.81 \pm 0.19$ | $0.39 \pm 0.02$ |
| $p16$ | $98.20^{+0.28}_{-0.32}$ | $15.34 \pm 0.21$ | $0.39 \pm 0.03$ |
| $p17$ | $98.23^{+0.22}_{-0.24}$ | $14.52 \pm 0.21$ | $0.39 \pm 0.02$ |

# MET15 Fit Results $1.2 \leq |\eta| \leq 2.8$

| | | | |
|---|---|---|---|
| P18 | $98.46^{+0.15}_{-0.16}$ | 15.05 ± 0.12 | 0.387 ±0.014 (1.2 ≤ \|η\| ≤ 2.8) |
| P19 | $98.48^{+0.18}_{-0.20}$ | 14.92+/-0.16 | 0.382+/-0.018 (1.2 ≤ \|η\| ≤ 2.8) |
| P20 | $97.63^{+0.25}_{-0.26}$ | 15.05+/-0.17 | 0.361+/-0.017 (1.2 ≤ \|η\| ≤ 2.8) |
| P21 | $98.52^{+0.12}_{-0.12}$ | 12.113+/-0.40 | 0.688+/-0.067 (1.2 ≤ \|η\| ≤ 2.8) |
| P22 | $98.33^{+0.29}_{-0.132}$ | 14.01+/-0.427 | 0.569+/-0.012 (1.2 ≤ \|η\| ≤ 2.8) |
| P23 | $99.63^{+00.18}_{-00.27}$ | 14.16+/-0.27 | 0.601+/-0.064 |
| P24 | $99.60^{+00.17}_{-00.24}$ | 14.89+/-0.17 | 0.627+/-0.044 |
| P25 | $99.11^{+00.30}_{-00.38}$ | 13.95+/-0.31 | 0.527+/-0.054 |
| P26 | $99.71^{+00.17}_{-00.27}$ | 14.18+/-0.28 | 0.591+/-0.064 |
| P27 | $99.82^{+00.10}_{-00.17}$ | 12.90+/-0.50 | 0.570+/-0.070 |
| P28 | $99.45^{+00.21}_{-00.29}$ | 13.36+/-0.56 | 0.500+/-0.070 |

# PEM_20: L3 Results

$1.2 \leq |\eta| \leq 2.8$

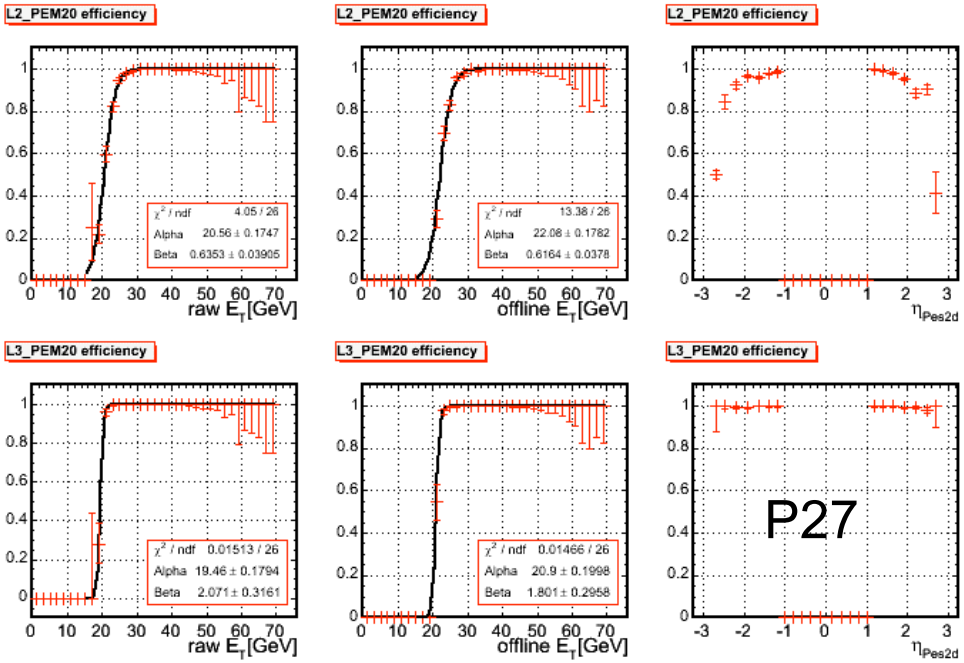
| period | $\epsilon$ | $\alpha$ | $\beta$ |
|---|---|---|---|
| $p00$ | $99.65^{+0.06}_{-0.07}$ | $20.68 \pm 0.23$ | $1.38 \pm 0.20$ |
| $[p01, p04]$ | $99.67^{+0.06}_{-0.06}$ | $20.42 \pm 0.21$ | $1.53 \pm 0.24$ |
| $[p05, p07]$ | $99.67^{+0.06}_{-0.06}$ | $20.80 \pm 0.22$ | $1.40 \pm 0.20$ |
| $p08$ | $99.47^{+0.11}_{-0.13}$ | $21.03 \pm 0.17$ | $1.95 \pm 0.33$ |
| $p09$ | $99.59^{+0.10}_{-0.12}$ | $21.48 \pm 0.21$ | $1.94 \pm 0.35$ |
| $p10$ | $99.45^{+0.10}_{-0.11}$ | $20.95 \pm 0.18$ | $1.58 \pm 0.24$ |
| $p11$ | $99.69^{+0.08}_{-0.09}$ | $20.75 \pm 0.23$ | $1.88 \pm 0.68$ |
| $p12$ | $99.66^{+0.09}_{-0.11}$ | $20.73 \pm 0.26$ | $1.75 \pm 0.42$ |
| $p13$ | $99.59^{+0.08}_{-0.09}$ | $20.69 \pm 0.23$ | $1.49 \pm 0.25$ |
| $p14$ | $99.32^{+0.24}_{-0.32}$ | $21.00 \pm 0.07$ | $1.67 \pm 0.37$ |
| $p15$ | $99.59^{+0.10}_{-0.12}$ | $20.43 \pm 0.30$ | $1.55 \pm 0.33$ |
| $p16$ | $99.52^{+0.13}_{-0.16}$ | $20.62 \pm 0.34$ | $1.49 \pm 0.35$ |
| $p17$ | $99.51^{+0.11}_{-0.13}$ | $20.53 \pm 0.34$ | $1.21 \pm 0.24$ |

# PEM_20: L3 Results

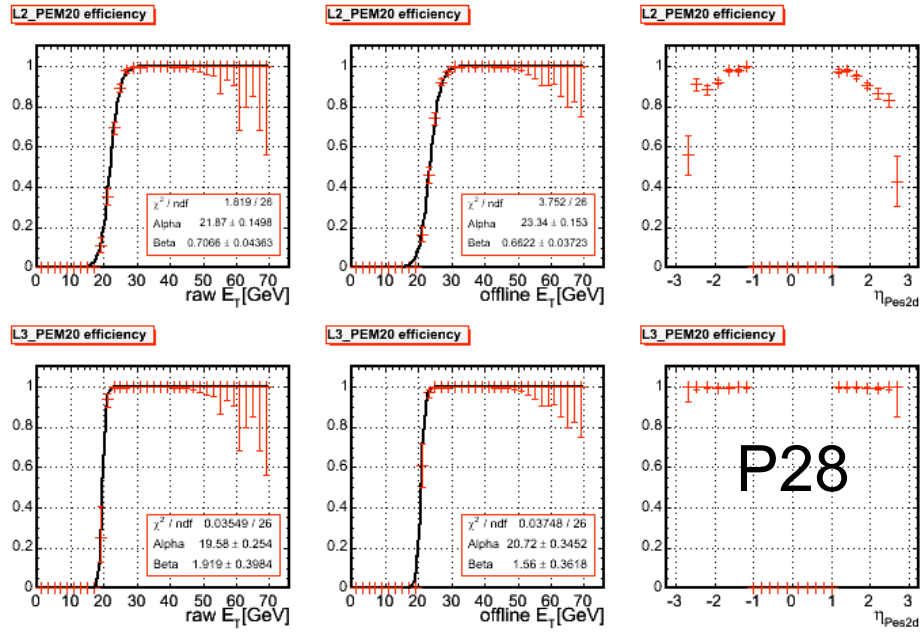
$1.2 \leq |\eta| \leq 2.8$

| | | | |
|---|---|---|---|
| P18 | $99.48^{+0.08}_{-0.09}$ | 20.91+/-0.18 | 1.45+/-0.18 |
| P19 | $99.49^{+0.10}_{-0.11}$ | 21.15+/-0.14 | 2.17+/-0.33 |
| P20 | $99.55^{+0.10}_{-0.12}$ | 20.85+/-0.23 | 1.73+/-0.34 |
| P21 | $99.61^{+0.07}_{-0.08}$ | 20.71+/-0.17 | 1.74+/-0.25 |
| P22 | $99.64^{+0.08}_{-0.10}$ | 20.68+/-0.21 | 1.97+/-0.40 |
| P23 | $99.62^{+00.10}_{-00.11}$ | 20.51+/-0.37 | 1.37+/-0.30 |
| P24 | $99.60^{+00.09}_{-00.11}$ | 20.73+/-0.18 | 2.03+/-0.40 |
| P25 | $99.64^{+00.09}_{-00.11}$ | 20.16+/-0.44 | 1.18+/-0.27 |
| P26 | $99.58^{+00.11}_{-00.13}$ | 20.46+/-0.41 | 1.17+/-0.26 |
| P27 | $99.64^{+00.08}_{-00.09}$ | 20.90+/-0.20 | 1.80+/-0.30 |
| P28 | $99.79^{+00.06}_{-00.08}$ | 20.72+/-0.36 | 1.56+/-0.36 |

# PEM_20 Plots

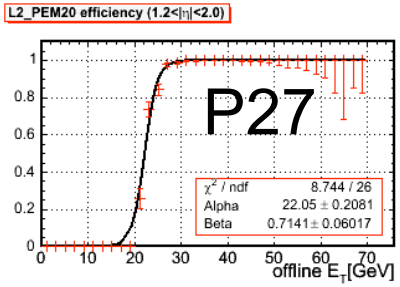


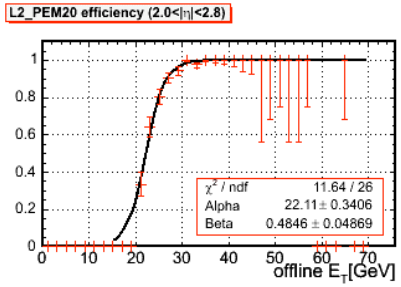

P27

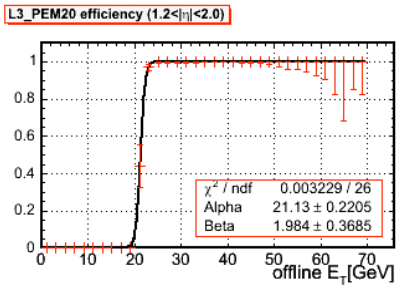


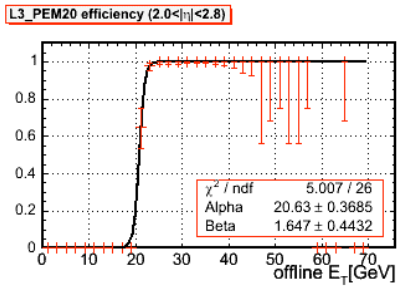

P28

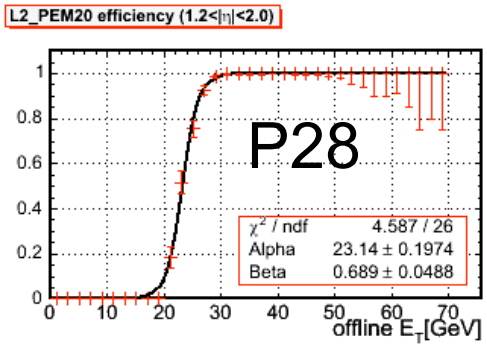
# PEM_20 Plots

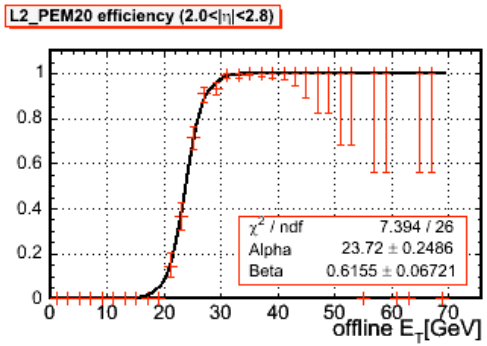

L2_PEM20 efficiency (1.2<|η|<2.0)
P27
χ² / ndf 8.744 / 26
Alpha 22.05 ± 0.2081
Beta 0.7141 ± 0.06017
offline E_T[GeV]

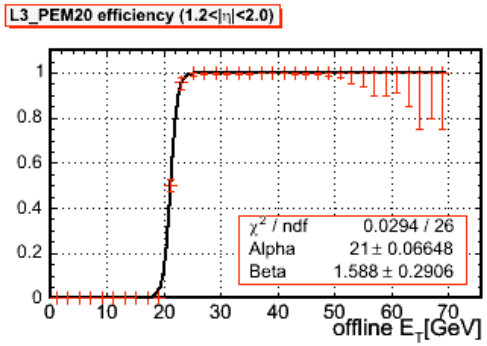

L2_PEM20 efficiency (2.0<|η|<2.8)
χ² / ndf 11.64 / 26
Alpha 22.11 ± 0.3406
Beta 0.4846 ± 0.04869
offline E_T[GeV]

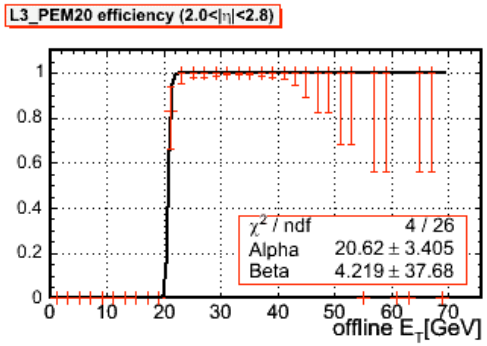

L3_PEM20 efficiency (1.2<|η|<2.0)
χ² / ndf 0.003229 / 26
Alpha 21.13 ± 0.2205
Beta 1.984 ± 0.3685
offline E_T[GeV]


L3_PEM20 efficiency (2.0<|η|<2.8)
χ² / ndf 5.007 / 26
Alpha 20.63 ± 0.3685
Beta 1.647 ± 0.4432
offline E_T[GeV]


L2_PEM20 efficiency (1.2<|η|<2.0)
P28
χ² / ndf 4.587 / 26
Alpha 23.14 ± 0.1974
Beta 0.689 ± 0.0488
offline E_T[GeV]


L2_PEM20 efficiency (2.0<|η|<2.8)
χ² / ndf 7.394 / 26
Alpha 23.72 ± 0.2486
Beta 0.6155 ± 0.06721
offline E_T[GeV]


L3_PEM20 efficiency (1.2<|η|<2.0)
χ² / ndf 0.0294 / 26
Alpha 21 ± 0.06648
Beta 1.588 ± 0.2906
offline E_T[GeV]


L3_PEM20 efficiency (2.0<|η|<2.8)
χ² / ndf 4 / 26
Alpha 20.62 ± 3.405
Beta 4.219 ± 37.68
offline E_T[GeV]

# Muons

Dataset bhmumm: Runs 287294-289197 (P28)
MC sample : zemtjm (Feb 2009)
GRL : GRL for P28 v34 prelim
goodrun_em_mu_nosi_cmxignored_v34.list,
goodrun_em_mu_si_cmxignored_v34.list

Data: P28 Data skim Leptons : bhmumm
MC: dataset zemtjm on SAM

# Muon ID Efficiency: ID Cuts

For all events:

| |
|---|
| No cosmic tag. |

For all muon types (including stubless muons):

| | | |
|---|---|---|
| $P_T$ | $>$ | 20 GeV/$c$ |
| $E_{EM}$ | $<$ | 2+max(0, $(p-100)\cdot 0.0115$) GeV |
| $E_{HAD}$ | $<$ | 6+max(0, $(p-100)\cdot 0.028$) GeV |
| $E_T^{isol.}/P_T$ | $<$ | 0.1 |
| Number of axial SL with $\geq$ 5 hits | $\geq$ | 3 |
| Number of stereo SL with $\geq$ 5 hits | $\geq$ | 2 |
| $\lvert z_0 \rvert$ | $<$ | 60 cm |
| Tracks w/ no silicon hits: $\lvert d_0 \rvert$ | $<$ | 0.2 cm |
| Tracks w/ silicon hits: $\lvert d_0 \rvert$ | $<$ | 0.02 cm |

Additionally for tight CMUP muons:

| | | |
|---|---|---|
| $\lvert \Delta x_{CMU} \rvert$ | $<$ | 7 cm |
| $\lvert \Delta x_{CMP} \rvert$ | $<$ | 5 cm |
| No bluebeam muons, run | $<$ | 154449 |

Additionally for tight CMX muons:

| | | |
|---|---|---|
| $\lvert \Delta x_{CMX} \rvert$ | $<$ | 6 cm |
| Run | $>$ | 150144 |
| No miniskirt or keystone muons, run | $<$ | 190697 |
| No muons in wedge 14 west, runs | $\geq$ | 190697 and $\leq$ 209760 |

Table 1: Standard muon ID cuts for 6.1.4 data MC.

# Fiducial cuts

For CMUP muons:

| | | |
|---|---|---|
| Fiducial distance from CMU: | | |
| $x$-fid | $<$ | 0 cm |
| $z$-fid | $<$ | 0 cm |
| Fiducial distance from CMP: | | |
| $x$-fid | $<$ | 0 cm |
| $z$-fid | $<$ | $-3$ cm |
| No muons from bluebeam region for run $<$ 154449 | | |

For CMX muons:

| | | |
|---|---|---|
| $\rho_{COT}$ | $>$ | 140 cm |
| Fiducial distance from CMX: | | |
| $x$-fid | $<$ | 0 cm |
| $z$-fid | $<$ | $-3$ cm |
| No muons from keystone region for run $<$ 190697 | | |
| No muons from miniskirt region for run $<$ 190697 | | |
| No muons wedge 14 west for runs $\geq$ 190697 and $\leq$ 209760 | | |

Table 2: Suggested muon fiducial cuts for tight muons in release 6.1.4.

| |
|---|
| Arches: |
| $0^\circ \leq \phi \leq 75^\circ$ or $105^\circ \leq \phi \leq 225^\circ$ or $315^\circ \leq \phi < 360^\circ$ |
| Additionally, for runs 190697 - 209760, remove: |
| $210^\circ < \phi \leq 225^\circ$ if $\eta < 0$ |
| Keystone: |
| $75^\circ < \phi < 105^\circ$ and $\eta < 0$ |
| Miniskirt: |
| $225^\circ < \phi < 315^\circ$ |

Table 3: Cuts on $\phi$ for distinguishing parts of the CMX detector when determining reconstruction efficiencies.

# ID Efficiency Calculation

- A first leg must be a CMUP or CMX muon passing all the cuts given in Tables 1 and 2.
- A second leg must be a muon with a CMUP or CMX stub and satisfy:
  - $P_T > 20$ GeV.
  - fiducial requirements in Table 2.
- The event must not have a cosmic tag.
- The $z_0$ of the two legs must pass: $|z_0^{(1)} - z_0^{(2)}| < 4$ cm.
- The invariant mass of the two tracks must pass: $81 < m(\mu^+\mu^-)$ GeV/$c^2 < 101$.

We then test the second leg to determine if it passes each of the muon ID cuts given in Table 1.

# CMUP ID Efficiency

P27

| Cut | Count | Efficiency (%) |
|---|---|---|
| No cut | 4285 | |
| $E_{EM}$ cut | 4156 | $96.99^{+0.25}_{-0.29}$ |
| $E_{HAD}$ cut | 4198 | $97.97^{+0.21}_{-0.23}$ |
| COT hits cut | 4283 | $99.95^{+0.03}_{-0.06}$ |
| $d_0$ cut | 4262 | $99.46^{+0.12}_{-0.14}$ |
| Isolation cut | 4103 | $95.75^{+0.32}_{-0.32}$ |
| $\Delta x_{CMU}$ cut | 4266 | $99.56^{+0.10}_{-0.12}$ |
| $\Delta x_{CMP}$ cut | 4206 | $98.16^{+0.20}_{-0.22}$ |
| All above cuts | 3812 | $88.96^{+0.47}_{-0.51}$ |
| All cuts excl. isol. | 3970 | $92.65^{+0.39}_{-0.44}$ |
| Sliding isol. cut | 4159 | $97.06^{+0.28}_{-0.26}$ |
| All cuts (sliding isol.) | 3862 | $90.13^{+0.47}_{-0.46}$ |
| $\chi^2$ cut | 4285 | $100.00^{+0.00}_{-0.04}$ |
| All cuts ($\chi^2$) | 3812 | $88.96^{+0.47}_{-0.51}$ |
| All track cuts | 3894 | $90.88^{+0.46}_{-0.47}$ |
| All trk cuts excl. isol. | 4055 | $94.63^{+0.36}_{-0.37}$ |

: Dataset bhmummP27: Muon ID efficiencies for CMUP

P28

| Cut | Count | Efficiency (%) |
|---|---|---|
| No cut | 3255 | |
| $E_{EM}$ cut | 3162 | $97.14^{+0.29}_{-0.34}$ |
| $E_{HAD}$ cut | 3190 | $98.00^{+0.25}_{-0.29}$ |
| COT hits cut | 3255 | $100.00^{+0.00}_{-0.06}$ |
| $d_0$ cut | 3239 | $99.51^{+0.11}_{-0.16}$ |
| Isolation cut | 3075 | $94.47^{+0.38}_{-0.45}$ |
| $\Delta x_{CMU}$ cut | 3246 | $99.72^{+0.09}_{-0.12}$ |
| $\Delta x_{CMP}$ cut | 3187 | $97.91^{+0.26}_{-0.28}$ |
| All above cuts | 2860 | $87.86^{+0.56}_{-0.61}$ |
| All cuts excl. isol. | 3015 | $92.63^{+0.46}_{-0.46}$ |
| Sliding isol. cut | 3137 | $96.37^{+0.33}_{-0.35}$ |
| All cuts (sliding isol.) | 2916 | $89.59^{+0.53}_{-0.55}$ |
| $\chi^2$ cut | 3255 | $100.00^{+0.00}_{-0.06}$ |
| All cuts ($\chi^2$) | 2860 | $87.86^{+0.56}_{-0.61}$ |
| All track cuts | 2925 | $89.86^{+0.54}_{-0.58}$ |
| All trk cuts excl. isol. | 3086 | $94.81^{+0.38}_{-0.40}$ |

: Dataset bhmummP28: Muon ID efficiencies for CMUP

# CMUP ID SF

P27

| Cut | Scale Factor |
|---|---|
| No cut | |
| $E_{EM}$ cut | $1.0070^{+0.0026}_{-0.0030}$ |
| $E_{HAD}$ cut | $0.9960^{+0.0022}_{-0.0023}$ |
| COT hits cut | $0.9996^{+0.0003}_{-0.0006}$ |
| $d_0$ cut | $0.9960^{+0.0012}_{-0.0014}$ |
| Isolation cut | $0.9827^{+0.0033}_{-0.0033}$ |
| $\Delta x_{CMU}$ cut | $0.9956^{+0.0010}_{-0.0012}$ |
| $\Delta x_{CMP}$ cut | $0.9869^{+0.0020}_{-0.0022}$ |
| All above cuts | $0.9688^{+0.0051}_{-0.0056}$ |
| All cuts excl. isol. | $0.9846^{+0.0042}_{-0.0047}$ |
| Sliding isol. cut | $0.9919^{+0.0029}_{-0.0027}$ |
| All cuts (sliding isol.) | $0.9776^{+0.0052}_{-0.0050}$ |
| $\chi^2$ cut | $1.0000^{+0.0000}_{-0.0004}$ |
| All cuts ($\chi^2$) | $0.9688^{+0.0051}_{-0.0056}$ |
| All track cuts | $0.9844^{+0.0050}_{-0.0051}$ |
| All trk cuts excl. isol. | $1.0003^{+0.0039}_{-0.0039}$ |

bhmummP27_zemtjm_1: Muon ID Scale Factors for CMUP

P28

| Cut | Scale Factor |
|---|---|
| No cut | |
| $E_{EM}$ cut | $1.0086^{+0.0031}_{-0.0036}$ |
| $E_{HAD}$ cut | $0.9964^{+0.0026}_{-0.0029}$ |
| COT hits cut | $1.0001^{+0.0000}_{-0.0006}$ |
| $d_0$ cut | $0.9965^{+0.0011}_{-0.0016}$ |
| Isolation cut | $0.9695^{+0.0039}_{-0.0046}$ |
| $\Delta x_{CMU}$ cut | $0.9973^{+0.0009}_{-0.0012}$ |
| $\Delta x_{CMP}$ cut | $0.9844^{+0.0026}_{-0.0028}$ |
| All above cuts | $0.9569^{+0.0062}_{-0.0067}$ |
| All cuts excl. isol. | $0.9844^{+0.0050}_{-0.0050}$ |
| Sliding isol. cut | $0.9849^{+0.0034}_{-0.0036}$ |
| All cuts (sliding isol.) | $0.9717^{+0.0058}_{-0.0060}$ |
| $\chi^2$ cut | $1.0000^{+0.0000}_{-0.0006}$ |
| All cuts ($\chi^2$) | $0.9569^{+0.0062}_{-0.0067}$ |
| All track cuts | $0.9734^{+0.0059}_{-0.0063}$ |
| All trk cuts excl. isol. | $1.0022^{+0.0041}_{-0.0042}$ |

bhmummP28_zemtjm_1: Muon ID Scale Factors for CMUP

# CMX ID Efficiencies

P27

| Cut | Count | Efficiency (%) |
|---|---|---|
| No cut | 2754 | |
| $E_{EM}$ cut | 2669 | $96.91^{+0.33}_{-0.36}$ |
| $E_{HAD}$ cut | 2688 | $97.60^{+0.27}_{-0.31}$ |
| COT hits cut | 2753 | $99.96^{+0.03}_{-0.08}$ |
| $d_0$ cut | 2746 | $99.71^{+0.10}_{-0.14}$ |
| Isolation cut | 2645 | $96.04^{+0.37}_{-0.41}$ |
| $\Delta x_{CMX}$ cut | 2743 | $99.60^{+0.11}_{-0.16}$ |
| All above cuts | 2498 | $90.70^{+0.56}_{-0.62}$ |
| All cuts excl. isol. | 2593 | $94.15^{+0.45}_{-0.48}$ |
| Sliding isol. cut | 2675 | $97.13^{+0.31}_{-0.38}$ |
| All cuts (sliding isol.) | 2522 | $91.58^{+0.54}_{-0.58}$ |
| $\chi^2$ cut | 2754 | $100.00^{+0.00}_{-0.07}$ |
| All cuts ($\chi^2$) | 2498 | $90.70^{+0.56}_{-0.62}$ |
| All track cuts | 2506 | $90.99^{+0.56}_{-0.61}$ |
| All trk cuts excl. isol. | 2601 | $94.44^{+0.45}_{-0.47}$ |

I: Dataset bhmummP27: Muon ID efficiencies for CMX

P28

| Cut | Count | Efficiency (%) |
|---|---|---|
| No cut | 2199 | |
| $E_{EM}$ cut | 2114 | $96.13^{+0.42}_{-0.46}$ |
| $E_{HAD}$ cut | 2161 | $98.27^{+0.29}_{-0.35}$ |
| COT hits cut | 2198 | $99.95^{+0.04}_{-0.10}$ |
| $d_0$ cut | 2191 | $99.64^{+0.13}_{-0.19}$ |
| Isolation cut | 2088 | $94.95^{+0.48}_{-0.49}$ |
| $\Delta x_{CMX}$ cut | 2195 | $99.82^{+0.09}_{-0.14}$ |
| All above cuts | 1966 | $89.40^{+0.68}_{-0.68}$ |
| All cuts excl. isol. | 2065 | $93.91^{+0.50}_{-0.57}$ |
| Sliding isol. cut | 2132 | $96.95^{+0.39}_{-0.40}$ |
| All cuts (sliding isol.) | 2009 | $91.36^{+0.58}_{-0.69}$ |
| $\chi^2$ cut | 2199 | $100.00^{+0.00}_{-0.08}$ |
| All cuts ($\chi^2$) | 1966 | $89.40^{+0.68}_{-0.68}$ |
| All track cuts | 1969 | $89.54^{+0.64}_{-0.72}$ |
| All trk cuts excl. isol. | 2069 | $94.09^{+0.52}_{-0.56}$ |

I: Dataset bhmummP28: Muon ID efficiencies for CMX

# CMX ID SF

P27

| Cut | Scale Factor |
|---|---|
| No cut | |
| $E_{EM}$ cut | $1.0056^{+0.0034}_{-0.0037}$ |
| $E_{HAD}$ cut | $0.9988^{+0.0028}_{-0.0032}$ |
| COT hits cut | $0.9997^{+0.0003}_{-0.0008}$ |
| $d_0$ cut | $0.9979^{+0.0010}_{-0.0014}$ |
| Isolation cut | $0.9852^{+0.0038}_{-0.0043}$ |
| $\Delta x_{CMX}$ cut | $0.9975^{+0.0011}_{-0.0016}$ |
| All above cuts | $0.9890^{+0.0061}_{-0.0068}$ |
| All cuts excl. isol. | $1.0020^{+0.0049}_{-0.0051}$ |
| Sliding isol. cut | $0.9923^{+0.0031}_{-0.0039}$ |
| All cuts (sliding isol.) | $0.9945^{+0.0059}_{-0.0064}$ |
| $\chi^2$ cut | $1.0000^{+0.0000}_{-0.0007}$ |
| All cuts ($\chi^2$) | $0.9890^{+0.0061}_{-0.0068}$ |
| All track cuts | $0.9907^{+0.0061}_{-0.0067}$ |
| All trk cuts excl. isol. | $1.0036^{+0.0049}_{-0.0051}$ |

bhmummP27_zemtjm_1: Muon ID Scale Factors for CMX

P28

| Cut | Scale Factor |
|---|---|
| No cut | |
| $E_{EM}$ cut | $0.9976^{+0.0044}_{-0.0048}$ |
| $E_{HAD}$ cut | $1.0056^{+0.0030}_{-0.0036}$ |
| COT hits cut | $0.9996^{+0.0004}_{-0.0010}$ |
| $d_0$ cut | $0.9972^{+0.0013}_{-0.0019}$ |
| Isolation cut | $0.9740^{+0.0050}_{-0.0051}$ |
| $\Delta x_{CMX}$ cut | $0.9997^{+0.0009}_{-0.0014}$ |
| All above cuts | $0.9748^{+0.0075}_{-0.0075}$ |
| All cuts excl. isol. | $0.9994^{+0.0054}_{-0.0061}$ |
| Sliding isol. cut | $0.9905^{+0.0040}_{-0.0041}$ |
| All cuts (sliding isol.) | $0.9922^{+0.0064}_{-0.0075}$ |
| $\chi^2$ cut | $1.0000^{+0.0000}_{-0.0008}$ |
| All cuts ($\chi^2$) | $0.9748^{+0.0075}_{-0.0075}$ |
| All track cuts | $0.9749^{+0.0071}_{-0.0079}$ |
| All trk cuts excl. isol. | $0.9998^{+0.0055}_{-0.0060}$ |

bhmummP28_zemtjm_1: Muon ID Scale Factors for CMX

# Reconstruction Efficiency

The reconstruction efficiency is defined as the probability to find a muon stub and link it to a track. First, to know whether we should find a stub or not we have to know that the muon is fiducial in any of the muon chambers. We use the **MuonFiducialTool** class for this purpose. We define a track as being fiducial in a given muon system if it passes the cuts defined in Tables 2 and 3 for that system.

Events Selection
No cosmic tag and 2 tracks passing the following:

- Oppositely charged.
- $|z_0^{(1)} - z_0^{(2)}| < 4$ cm.
- $81\ \mathrm{GeV}/c^2 < m(\mu^+\mu^-) < 101\ \mathrm{GeV}/c^2$
- The first leg must be a reconstructed **CdfMuon** passing all the ID and fiducial cuts given in Tables 1 and 2. It must also match to the level 1 trigger information.
- The second leg must be fiducial in both the CMU and CMP sub-detectors (or the CMX sub-detector) and satisfy:
  - $P_T > 20$ GeV.
  - $E_{EM} < 1.5 \cdot (2+\max(0, (p-100) \cdot 0.0115))$ GeV
  - $E_{HAD} < 1.5 \cdot (6+\max(0, (p-100) \cdot 0.028)$ GeV

$$\varepsilon_{Reco} = \frac{\#\text{tracks fiducial and linked to a stub}}{\#\text{ tracks fiducial}}$$

# Reconstruction Efficiency

The first leg must pass all the ID and Fid. cuts and must match to the level 1 trigger information. If the second leg is Fiducial, and pass "$P_T$, $E_{EM}$, $E_{HAD}$" cuts, we examine this track to see if is linked to a muon stub or not.

P25

| Category | Fiducial | w/ Stub | Efficiency (%) |
|---|---|---|---|
| CMUP | 3427 | 2961 | $86.40^{+0.56}_{-0.61}$ |
| CMX | 1978 | 1863 | $94.19^{+0.49}_{-0.58}$ |
| CMX Arches | 1561 | 1506 | $96.48^{+0.47}_{-0.55}$ |
| CMX Miniskirt | 343 | 289 | $84.26^{+1.97}_{-2.13}$ |
| CMX Keystone | 74 | 68 | $91.89^{+3.23}_{-4.59}$ |
| CMU-only | 822 | 722 | $87.83^{+1.13}_{-1.21}$ |
| CMP-only | 948 | 821 | $86.60^{+1.14}_{-1.20}$ |
| CMX MiniKey | 417 | 357 | $85.61^{+1.79}_{-1.92}$ |

P26

| Category | Fiducial | w/ Stub | Efficiency (%) |
|---|---|---|---|
| CMUP | 2432 | 2118 | $87.09^{+0.66}_{-0.71}$ |
| CMX | 1551 | 1480 | $95.42^{+0.52}_{-0.55}$ |
| CMX Arches | 1233 | 1206 | $97.81^{+0.41}_{-0.52}$ |
| CMX Miniskirt | 254 | 216 | $85.04^{+2.36}_{-2.52}$ |
| CMX Keystone | 64 | 58 | $90.62^{+3.71}_{-5.27}$ |
| CMU-only | 620 | 535 | $86.29^{+1.31}_{-1.43}$ |
| CMP-only | 687 | 613 | $89.23^{+1.10}_{-1.24}$ |
| CMX MiniKey | 318 | 274 | $86.16^{+2.02}_{-2.28}$ |

P27

| Category | Fiducial | w/ Stub | Efficiency (%) |
|---|---|---|---|
| CMUP | 4718 | 4158 | $88.13^{+0.47}_{-0.51}$ |
| CMX | 2813 | 2664 | $94.70^{+0.44}_{-0.44}$ |
| CMX Arches | 2192 | 2134 | $97.35^{+0.33}_{-0.41}$ |
| CMX Miniskirt | 511 | 435 | $85.13^{+1.69}_{-1.83}$ |
| CMX Keystone | 110 | 95 | $86.36^{+3.28}_{-4.14}$ |
| CMU-only | 1071 | 947 | $88.42^{+0.98}_{-1.07}$ |
| CMP-only | 1260 | 1099 | $87.22^{+0.91}_{-1.04}$ |
| CMX MiniKey | 621 | 530 | $85.35^{+1.47}_{-1.65}$ |

P28

| Category | Fiducial | w/ Stub | Efficiency (%) |
|---|---|---|---|
| CMUP | 3676 | 3169 | $86.21^{+0.56}_{-0.59}$ |
| CMX | 2246 | 2136 | $95.10^{+0.48}_{-0.50}$ |
| CMX Arches | 1742 | 1691 | $97.07^{+0.41}_{-0.47}$ |
| CMX Miniskirt | 421 | 369 | $87.65^{+1.71}_{-1.81}$ |
| CMX Keystone | 83 | 76 | $91.57^{+3.16}_{-4.26}$ |
| CMU-only | 886 | 769 | $86.79^{+1.19}_{-1.20}$ |
| CMP-only | 1000 | 877 | $87.70^{+1.02}_{-1.13}$ |
| CMX MiniKey | 504 | 445 | $88.29^{+1.45}_{-1.67}$ |

# Reconstruction SF

P25

| Category | Scale Factor |
|---|---|
| CMUP | $0.8867^{+0.0058}_{-0.0063}$ |
| CMX | $0.9456^{+0.0049}_{-0.0059}$ |
| CMX Arches | $0.9668^{+0.0047}_{-0.0056}$ |
| CMX Miniskirt | $0.8505^{+0.0199}_{-0.0215}$ |
| CMX Keystone | $0.9306^{+0.0327}_{-0.0465}$ |
| CMU-only | $0.9003^{+0.0116}_{-0.0125}$ |
| CMP-only | $0.8813^{+0.0116}_{-0.0122}$ |
| CMX MiniKey | $0.8647^{+0.0181}_{-0.0181}$ |

P26

| Category | Scale Factor |
|---|---|
| CMUP | $0.8927^{+0.0067}_{-0.0073}$ |
| CMX | $0.9573^{+0.0053}_{-0.0055}$ |
| CMX Arches | $0.9800^{+0.0041}_{-0.0052}$ |
| CMX Miniskirt | $0.8588^{+0.0239}_{-0.0255}$ |
| CMX Keystone | $0.9125^{+0.0374}_{-0.0531}$ |
| CMU-only | $0.8840^{+0.0134}_{-0.0146}$ |
| CMP-only | $0.9089^{+0.0113}_{-0.0126}$ |
| CMX MiniKey | $0.8696^{+0.0204}_{-0.0204}$ |

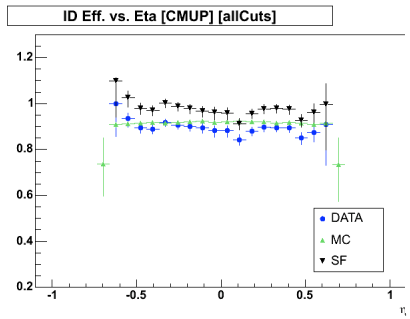
P27

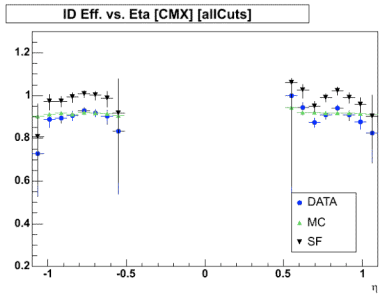
| Category | Scale Factor |
|---|---|
| CMUP | $0.9034^{+0.0048}_{-0.0052}$ |
| CMX | $0.9501^{+0.0044}_{-0.0044}$ |
| CMX Arches | $0.9754^{+0.0033}_{-0.0041}$ |
| CMX Miniskirt | $0.8596^{+0.0171}_{-0.0185}$ |
| CMX Keystone | $0.8696^{+0.0331}_{-0.0417}$ |
| CMU-only | $0.9059^{+0.0101}_{-0.0110}$ |
| CMP-only | $0.8885^{+0.0093}_{-0.0106}$ |
| CMX MiniKey | $0.8614^{+0.0149}_{-0.0149}$ |

P28

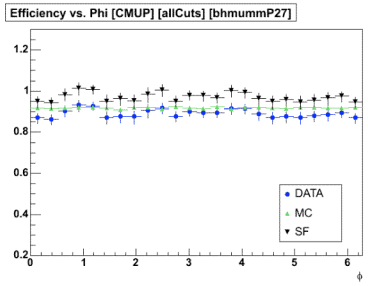
| Category | Scale Factor |
|---|---|
| CMUP | $0.8837^{+0.0057}_{-0.0060}$ |
| CMX | $0.9541^{+0.0048}_{-0.0050}$ |
| CMX Arches | $0.9726^{+0.0041}_{-0.0047}$ |
| CMX Miniskirt | $0.8851^{+0.0173}_{-0.0183}$ |
| CMX Keystone | $0.9220^{+0.0318}_{-0.0429}$ |
| CMU-only | $0.8892^{+0.0122}_{-0.0123}$ |
| CMP-only | $0.8934^{+0.0104}_{-0.0115}$ |
| CMX MiniKey | $0.8911^{+0.0147}_{-0.0147}$ |

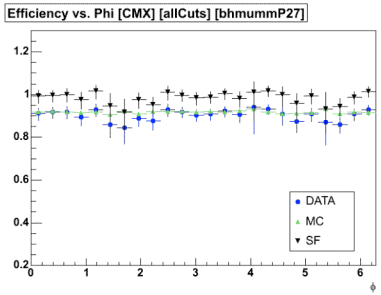
# Reco and ID Plots

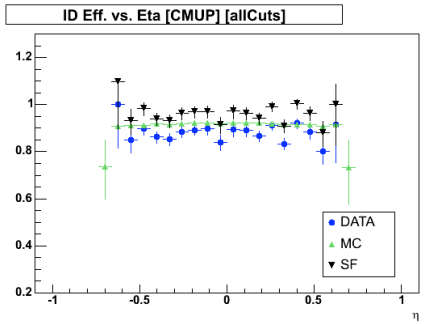


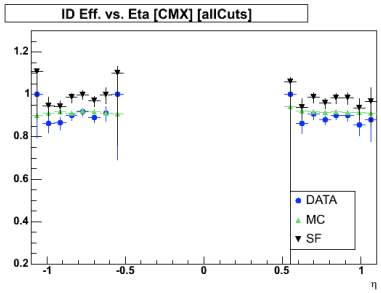




P27

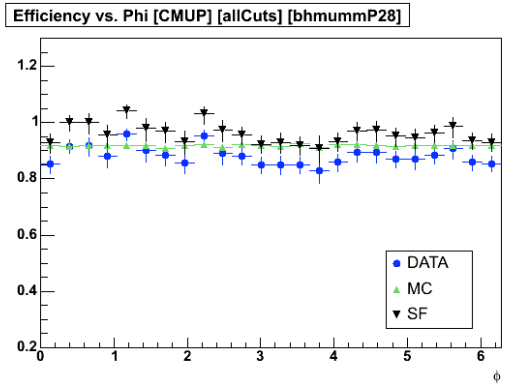


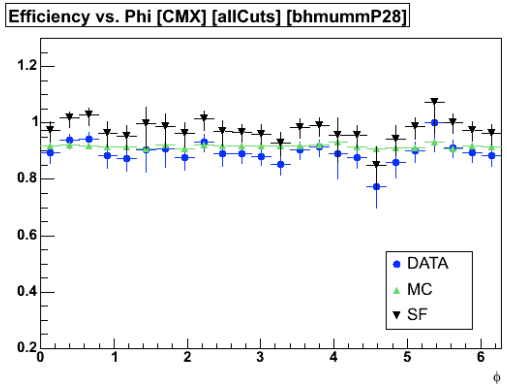



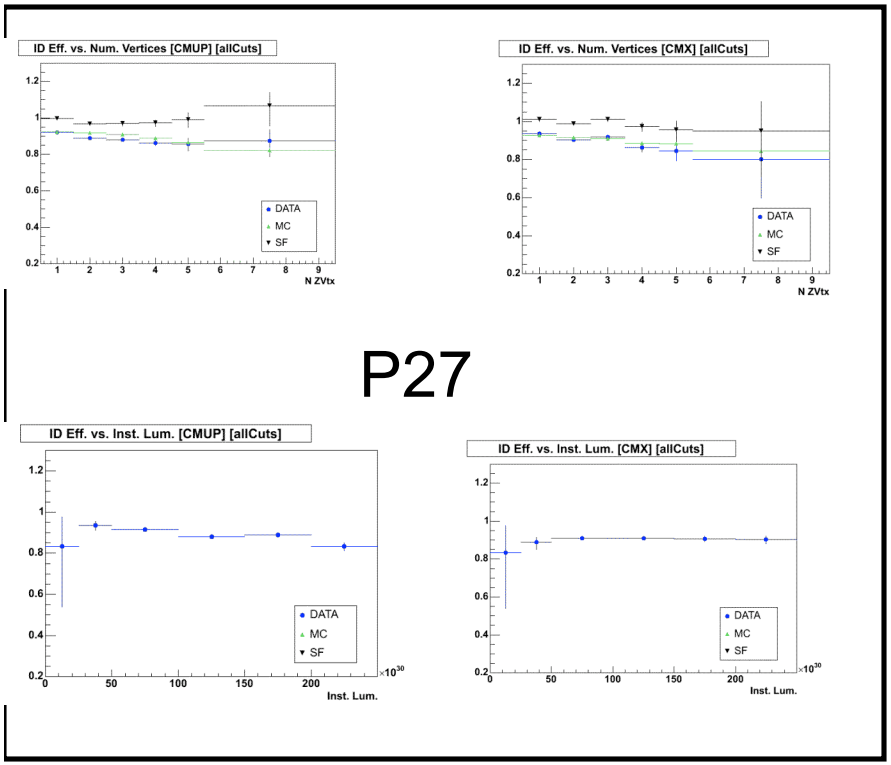




P28



# Reco and ID Plots

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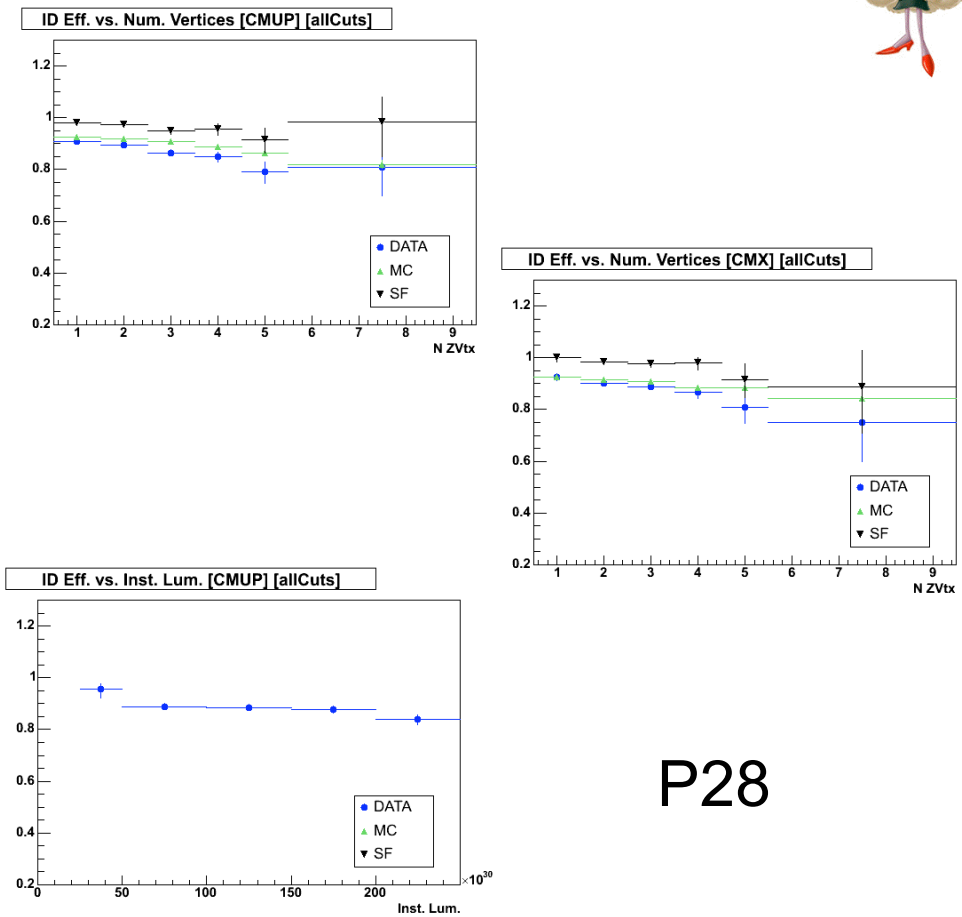
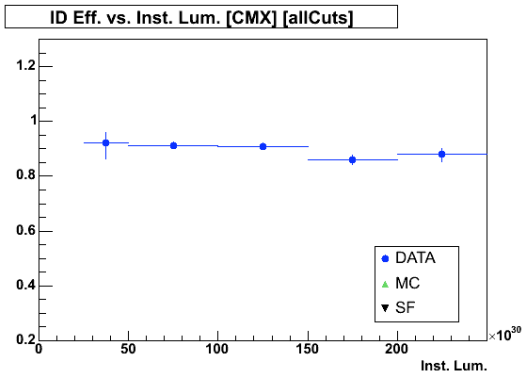
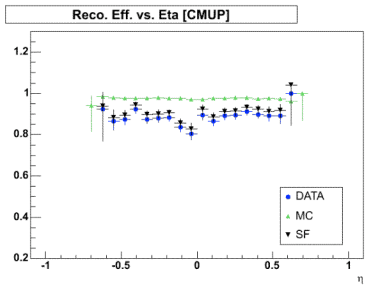
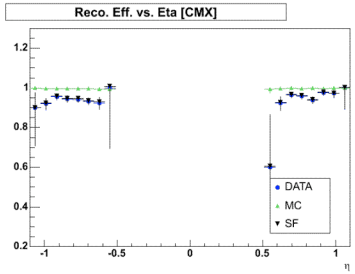



P28



# Reco and ID Plots

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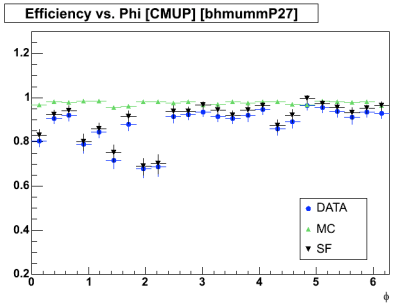
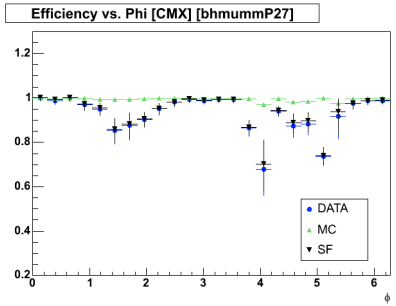
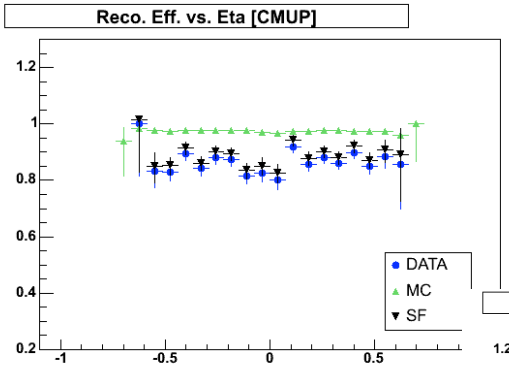
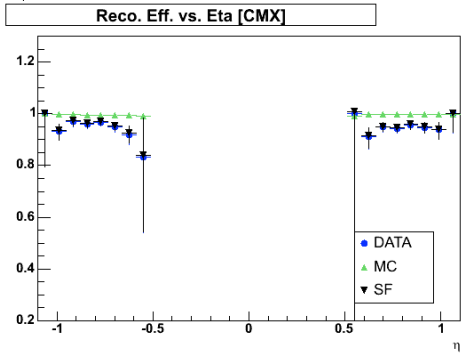
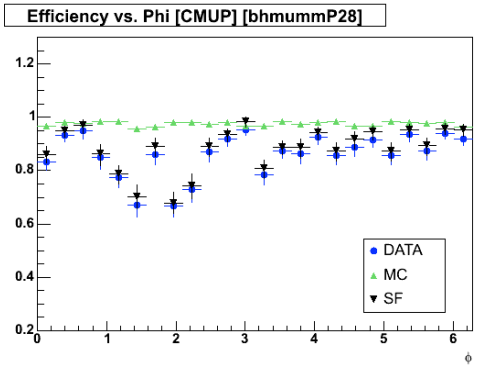


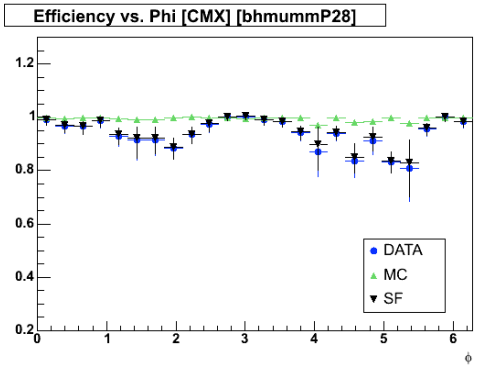




P28



# Trigger Efficiencies

**Use the two legs from the reconstructed Z** (both legs pass muon ID and fiducial cuts)

**Level 1:**

$\varepsilon^{L1}_{CMUP}$ is calculated from 2 independent samples, using CMUP-CMUP and CMUP-CMX samples:

$$\varepsilon^{L1(A)}_{CMUP} = \frac{\#\text{ of events with both legs triggered}}{\#\text{ of events with 1 CMX leg triggered}}$$

$$\varepsilon^{L1(B)}_{CMUP} = \frac{2R}{1+R}$$

$$R = \frac{\#\text{ of events with both legs triggered}}{\#\text{ of events with} \geq 1\text{ CMUP leg triggered}}$$

The final efficiency is an average of $\varepsilon^{L1(A)}_{CMUP}$ and $\varepsilon^{L1(B)}_{CMUP}$ weighted by the errors.

**Level 2:** (both leg pass L1)

$$\varepsilon^{L2}_{CMUP} = \frac{\#\text{ of events pass both L2 triggers}}{\#\text{ of events pass L2 CMX trigger}}$$

P22

**Level 3:** (both leg pass L2)

$$\varepsilon^{L3}_{CMUP} = \frac{\#\text{ of events pass both L3 triggers}}{\#\text{ of events pass L3 CMX trigger}}$$

CMX trigger efficiency is calculated in similar way.

# Efficiency calculation

$$\varepsilon(\text{CMUP})^{2D} = \frac{(\text{\# of events passing CMUP \& CMX})}{\text{\# of events passing CMUX}}$$

$$\varepsilon(\text{CMUP})^{3D} = \frac{(\text{\# of events passing 2D-CMUP \& 2D-CMX \& 3-D CMUP})}{(\text{\# of events passing 2D-CMUP \&\& 2D-CMX})} \times \text{2D-CMUP eff}$$

$$\varepsilon(\text{CMX})^{2D} = \frac{(\text{\# of events passing CMUP \& CMX})}{\text{\# of events passing CMUP}}$$

These ones increases for the bad runs

$$\varepsilon(\text{CMX})^{3D} = \frac{(\text{\# of events passing 2D-CMUP \& 2D-CMX \& 3-D CMX})}{(\text{\# of events passing 2D-CMUP \&\& 2D-CMX})} \times \text{2D-CMX eff}$$

# Raw efficiencies vs P24 through P27

| Category | Efficiency (%) |
|---|---|
| CMUP | $93.02^{+0.62}_{-0.70}$ |
| CMX | $76.58^{+1.26}_{-1.27}$ |
| ARCH | $80.94^{+1.36}_{-1.33}$ |
| MK | $66.74^{+2.94}_{-3.37}$ |
| $CMUP_S$ | $87.76^{+0.92}_{-1.02}$ |
| $CMX_S$ | $72.34^{+1.34}_{-1.41}$ |
| $ARCH_S$ | $76.66^{+1.40}_{-1.59}$ |
| $MK_S$ | $62.09^{+3.08}_{-3.54}$ |

bhmummP25_SAM: Muon combined trigger efficiencies

| Category | Efficiency (%) |
|---|---|
| CMUP | $90.68^{+0.80}_{-0.98}$ |
| CMX | $80.29^{+1.24}_{-1.35}$ |
| ARCH | $84.04^{+1.33}_{-1.38}$ |
| MK | $69.57^{+3.10}_{-3.49}$ |
| $CMUP_S$ | $85.02^{+1.13}_{-1.34}$ |
| $CMX_S$ | $76.03^{+1.33}_{-1.45}$ |
| $ARCH_S$ | $79.49^{+1.55}_{-1.54}$ |
| $MK_S$ | $66.29^{+3.39}_{-3.72}$ |

bhmummP26: Muon combined trigger efficiencies

| Category | Efficiency (%) |
|---|---|
| CMUP | $91.12^{+0.56}_{-0.62}$ |
| CMX | $79.51^{+0.88}_{-0.92}$ |
| CMX A | $84.88^{+0.92}_{-1.01}$ |
| CMX MK | $66.98^{+2.36}_{-2.48}$ |
| CMUP SLAM | $86.65^{+0.79}_{-0.82}$ |
| CMX SLAM | $74.76^{+1.00}_{-1.07}$ |
| CMX SLAM A | $79.43^{+1.07}_{-1.11}$ |
| CMX SLAM MK | $64.64^{+2.44}_{-2.57}$ |

bhmummP27-1: Muon combined trigger efficiencies

| Category | Efficiency (%) |
|---|---|
| CMUP | $90.68^{+0.66}_{-0.73}$ |
| CMX | $78.17^{+1.04}_{-1.11}$ |
| ARCH | $84.10^{+1.11}_{-1.18}$ |
| MK | $66.92^{+2.64}_{-3.00}$ |
| $CMUP_S$ | $84.67^{+0.94}_{-1.04}$ |
| $CMX_S$ | $73.15^{+1.15}_{-1.20}$ |
| $ARCH_S$ | $78.82^{+1.28}_{-1.35}$ |
| $MK_S$ | $62.11^{+2.87}_{-3.19}$ |

bhmummP28: Muon combined trigger efficiencies

# Comparison with previous periods

Combined (L1+L2+L3) CMUP 2-D Trigger efficiencies

| Period | Measured (SR) | Livetime Corr. | Corr. Efficiency |
|---|---|---|---|
| 12 | 0.9241(78) | 1.0 | 0.9241(78) |
| 13 | 0.9090(61) | 1.0 | 0.9090(61) |
| 14 | 0.9197(2.22) | 1.0 | 0.9197 (2.22) |
| 15 | 0.9163( 77) | 1.0 | 0.9163 ( 77) |
| 16 | 0.9172(116) | 1.0 | 0.9172(116) |
| 17 | 0.9203(76) | 1.0 | 0.9203(76) |
| 18 | 0.9210(56) | 1.0 | 0.9210(56) |
| 19 | 0.9177 (75) | 1.0 | 0.9177 (75) |
| 20 | 0.9074 (75) | 1.0 | 0.9074 (75) |
| 21 | 0.9134 (65) | 1.0 | 0.9134 (65) |
| 22 | 0.9022 (73) | 1.0 | 0.9022 (73) |
| 23 | 0.9034 (81) | 1.0 | 0.9034 (81) |
| 24 | 0.9068 (85) | 1.0 | 0.9058 (85) |
| 25 | 0.9302 (66) | 1.0 | 0.9302 (66) |
| 26 | 0.9068 (89) | 1.0 | 0.9068 (89) |
| 27 | 0.9112 (58) | 1.0 | 0.9112(58) |
| 28 | 0.9068 (70) | 1.0 | 0.9068 (70) |

CMUP

# CMUP 3-D

Combined (L1+L2+L3) CMUP 3-D Trigger efficiencies

| Period | 2-D Efficiency | 2-D+3-D/2-D (SR) | 3-D Efficiency |
|---|---|---|---|
| 12 | 0.9241(78) | 0.9108(105) | 0.8417(120) |
| 13 | 0.9090(61) | | 0.8284 (91) |
| 14 | 0.9197(2.22) | | 0.8943 (2.22) |
| 15 | 0.9163(77) | | 0.8790 (100) |
| 16 | 0.9172(116) | | 0.8939(137) |
| 17 | 0.9203 (76) | | 0.8885 (97) |
| 18 | 0.9210(56) | | 0.8864(75) |
| 19 | 0.9177(75) | | 0.8866 (95) |
| 20 | 0.9074(75) | | 0.8852 (90) |
| 21 | 0.9134 (65) | | 0.8802 (82) |
| 22 | 0.9022 (73) | | 0.8484 (100) |
| 23 | 0.9034 (83) | | 0.8606 (83) |
| 24 | 0.9068 (85) | | 0.8504 (107) |
| 25 | 0.9302 (66) | | 0.8776 (96) |
| 26 | 0.9068 (89) | | 0.8502 (123) |
| 27 | 0.9112(58) | | 0.8665 (80) |
| 28 | 0.9068(70) | | 0.8410 (114) |

# Comparison with previous periods

Combined (L1+L2+L3) CMX 2-D Trigger efficiencies

Arches-only:

| Period | Measured (SR) | Livetime Corr. | Corr. Efficiency |
|---|---|---|---|
| 13 | 0.8915 (85) | 0.9601 | 0.9285 (85) |
| 14 | 0.9123 (239) | 0.99 | 0.9215 (239) |
| 15 | 0.9013 (117) | 0.95 | 0.9487 (117) |
| 16 | 0.8439 (204) | 0.915 | 0.9223 (223) |
| 17 | 0.8532 (127) | 0.9128 | 0.9345 (127) |
| 18 | 0.8522(96) | 0.9031 | 0.9437 (96) |
| 19 | 0.8174 | 0.871 | 0.9384 |
| 20 | 0.8336 | 0.9030 | 0.9231 |
| 21 | 0.8351 | 0.858 | 0.9733 |
| 22 | 0.8362 | 0.9077 | 0.9212 |
| 23 | 0.8337 | 0.8739 | 0.9539 |
| 24 | 0.8335 | 0.8849 | 0.9419 …… |
| 25 | 0.8094 (130) | 0.8765 | 0.9234 |
| 26 | 0.8404 (135) | 0.9431 | 0.8911 |
| 27 | 0.8488 (100) | 0.9241 | 0.9185 |
| 28 | 0.8410 (100) | 0.9028 | 0.9315 |

CMX

# CMX 3-D

Combined (L1+L2+L3) CMX 3-D Trigger efficiencies

Arches-only

| Period | 2-D Efficiency | 3-D Efficiency |
|---|---|---|
| 13 | 0.8915/0.9601=0.93 (85) | 0.8569 / 0.9601 = 0.8926 (9) |
| 14 | 0.9123/0.99= 0.9215 (2.39) | 0.8815/0.99 = 0.8904 (2.7) |
| 15 | 0.9013/0.95= 0.9487 (117) | 0.8765/0.95 = 0.9226 (128) |
| 16 | 0.8439/0.915= 0.9223 (223) | 0.8183/0.915 = 0.8943 (235) |
| 17 | 0.8532/0.913= 0.9345 (127) | 0.8195/0.913 = 0.8975 (142) |
| 18 | 0.8522/0.9031=0.9437 (96) | 0.8192/0.903 = 0.9072 (112) |
| 19 | 0.8174/0.871=0.9384 (129) | 0.7874/0.871 = 0.9040 (140) |
| 20 | 0.8336/0.9030=0.9231 (129) | 0.8143/0.9030 = 0.9018 (120) |
| 21 | 0.8351/0.858 = 0.9733 | 0.8009/0.858 = 0.9334 |
| 22 | 0.8362/0.9077 = 0.9212 | 0.8085/0.9077 = 0.8907 |
| 23 | 0.8337/0.8739 = 0.9539 | 0.7853/0.8739 = 0.8986 |
| 24 | 0.8355/0.9704 = 0.85 | 0.7853/0.8849 = 0.8874 |
| 25 | 0.8094/0.8765 = 0.92 | 0.7666/0.8765 = 0.8746 |
| 26 | 0.8404/0.9431 = 0.89 | 0.7949/0.9431 = 0.8428 (130) |
| 27 | 0.8488/0.9242 = 0.92 | 0.7943/0.9242 = 0.8594 (109) |
| 28 | 0.8410/0.9028 = 0.93 | 0.7882/0.9028 = 0.8730 (100) |

# COT Efficiencies

Events are selected with Z_NOTRACK trigger
Z→ee events are selected using:
Calorimeter cuts only to select electrons

- Et > 25 GeV
- Fiduciality →fiducial_track or fiducial_smx
- Had/Em < 0.055 + 0.00045 x E
- IsoRatio < 0.1
- $\chi^2_{strip} < 10$
- $L_{shr} < 0.2$

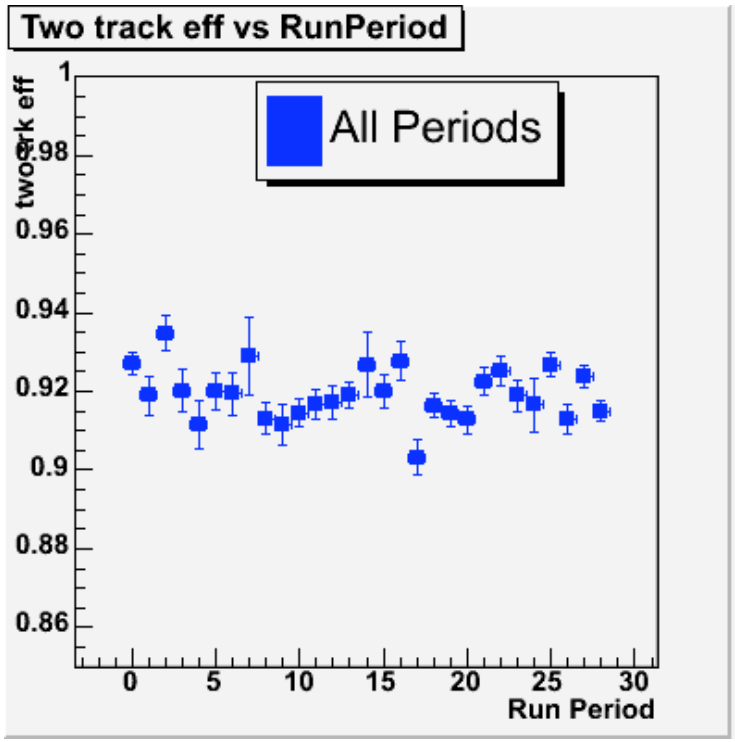
Calorimeter + tracking cuts

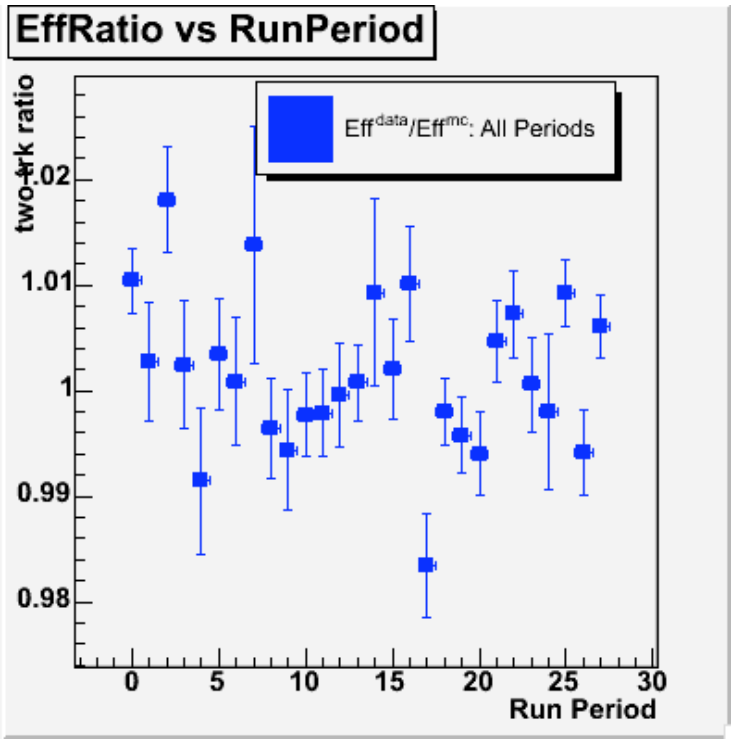
- trkPt > 10 GeV

$$e_{2trk} = \frac{\#\ Z(cc) \text{ with } TrkP_T > 10 \text{ GeV on both electrons}}{\#\ Z(cc) \text{ with two electrons}}$$

- 2 central electrons
- 82 < M(ee) < 102 GeV/$c^2$

# COT Efficiencies: Run Number




$$e_{2trk}^{DATA} = 0.9188 \quad 0.0007$$

0.9191 ± 0.0008 up to P27

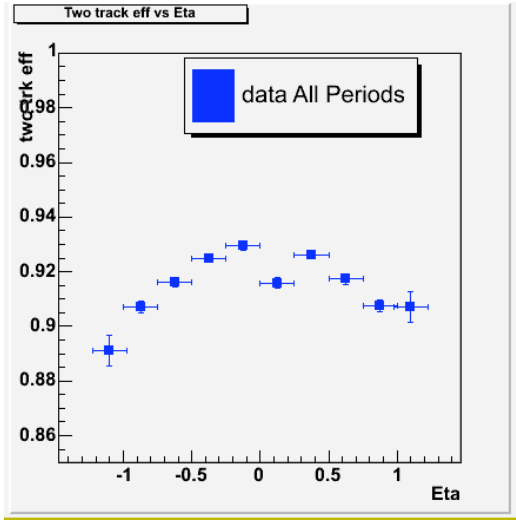
# COT Efficiencies vs Periods

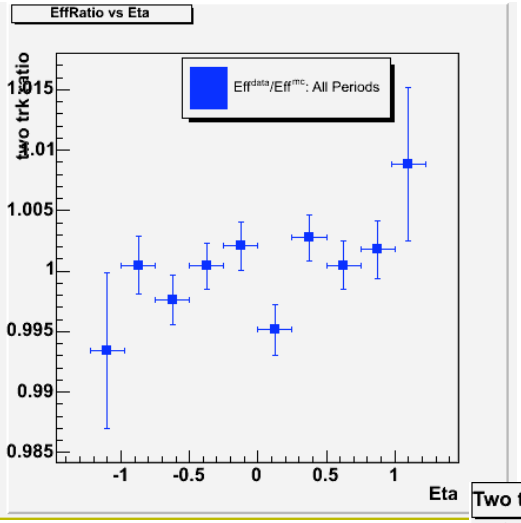
| Period | Ncc | Ncc + 2trk | Efficiency | Error |
|---|---|---|---|---|
| 0 | 9117 | 8452 | 0.927059 | 0.00272341 |
| 1 | 3013 | 2769 | 0.919018 | 0.00497001 |
| 2 | 3112 | 2909 | 0.934769 | 0.0044265 |
| 3 | 2492 | 2293 | 0.920144 | 0.00543008 |
| 4 | 2094 | 1909 | 0.911652 | 0.00620189 |
| 5 | 3351 | 3083 | 0.920024 | 0.00468589 |
| 6 | 2547 | 2342 | 0.919513 | 0.00539047 |
| 7 | 661 | 614 | 0.928896 | 0.00999611 |
| 8 | 4514 | 4122 | 0.913159 | 0.00419136 |
| 9 | 3089 | 2816 | 0.911622 | 0.00510706 |
| 10 | 6321 | 5781 | 0.91457 | 0.00351576 |
| 11 | 5566 | 5103 | 0.916816 | 0.00370159 |
| 12 | 3922 | 3597 | 0.917134 | 0.004402 |
| 13 | 6930 | 6368 | 0.918903 | 0.00327921 |
| 14 | 1025 | 950 | 0.926829 | 0.00813405 |
| 15 | 3908 | 3596 | 0.920164 | 0.00433566 |
| 16 | 2777 | 2576 | 0.92762 | 0.00491708 |
| 17 | 4284 | 3869 | 0.903128 | 0.00451907 |
| 18 | 9172 | 8406 | 0.916485 | 0.00288877 |
| 19 | 7199 | 6583 | 0.914433 | 0.00329681 |
| 20 | 6254 | 5709 | 0.912856 | 0.00356649 |
| 21 | 5836 | 5384 | 0.92255 | 0.00349904 |
| 22 | 4906 | 4538 | 0.92499 | 0.00376067 |
| 23 | 4535 | 4167 | 0.918853 | 0.0040548 |
| 24 | 1665 | 1526 | 0.916517 | 0.00677896 |
| 25 | 7909 | 7330 | 0.926792 | 0.00292893 |
| 26 | 5884 | 5372 | 0.912984 | 0.00367446 |
| 27 | 9352 | 8640 | 0.923867 | 0.00274246 |
| 28 | 11387 | 10419 | 0.914991 | 0.00261359 |

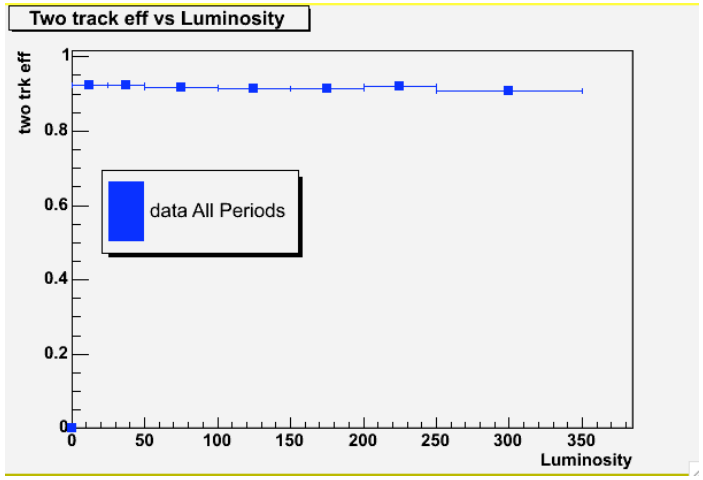
# Conclusions

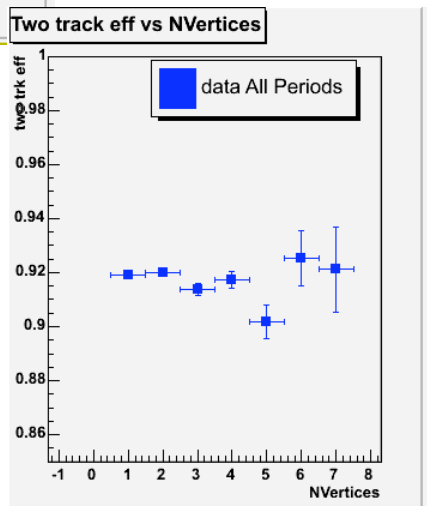
- P28 high PT electrons and muons analyzed:
  - Electron ID - ok
  - Ele Trigger  - in agreement with previous periods
  - Muon ID and Reco : ok
  - Muon Trigger: ok
  - MET_PEM trigger ok
  - COT Eff : ok

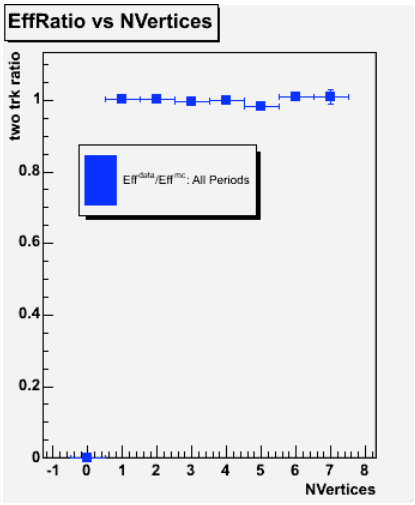
# More plots


Two track eff vs Eta
two trk eff
data All Periods
Eta


EffRatio vs Eta
two trk ratio
Eff^data/Eff^mc: All Periods
Eta


Two track eff vs Luminosity
two trk eff
data All Periods
Luminosity


Two track eff vs NVertices
two trk eff
data All Periods
NVertices

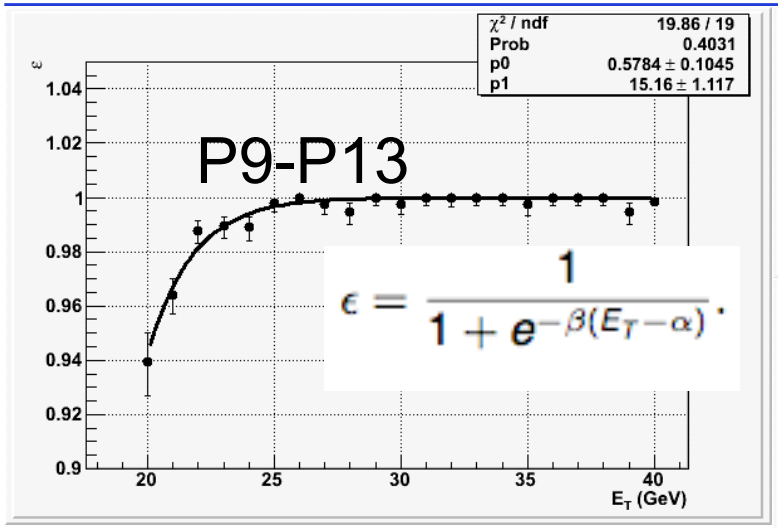
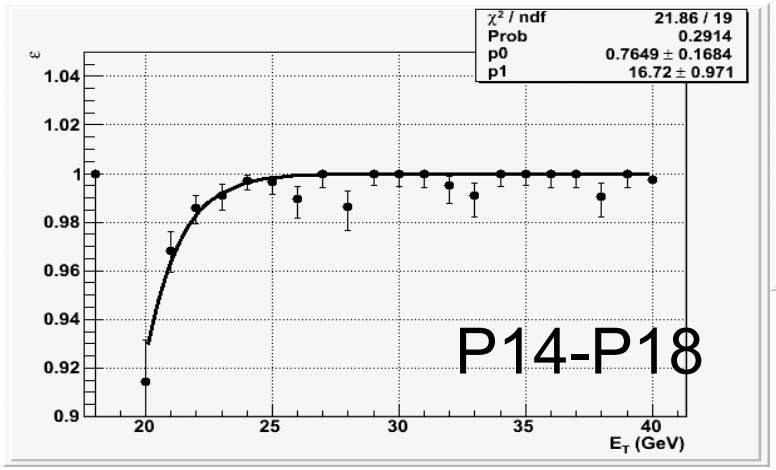
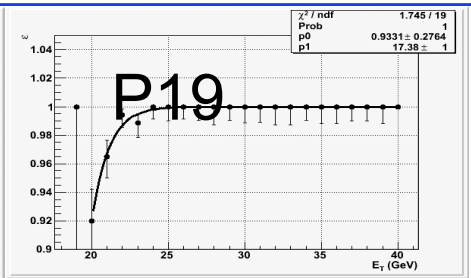
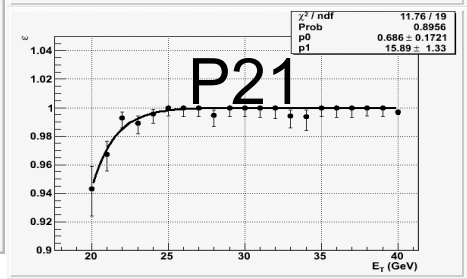
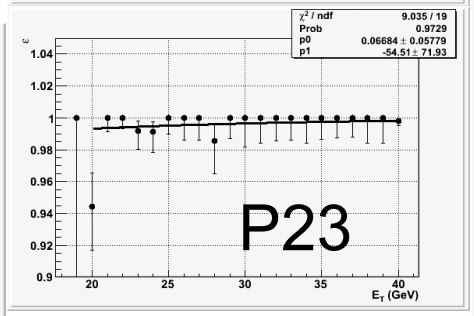
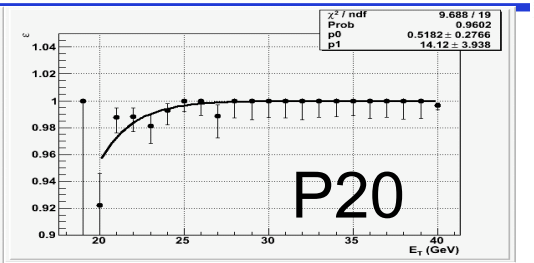
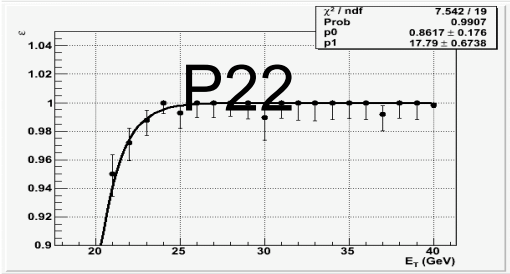
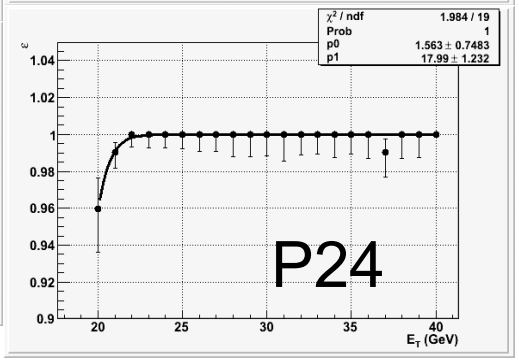

EffRatio vs NVertices
two trk ratio
Eff^data/Eff^mc: All Periods
NVertices

# Electron Trigger: Results Past Periods

Analyzed all data

| Trigger | Period 9 | Period 10A | Period 10B |
|---|---|---|---|
| L1_XFT_PT8 | 0.9651(6) | 0.9673(7) | 0.9650(29) |
| L2_XFT_PT8 | 0.9992(1) | 0.9993(1) | 0.9992(5) |
| L3 tracking | 0.9954(2) | 0.9932(3) | 0.9968(9) |
| Total Tracking | 0.9598(7) | 0.9600(8) | 0.9611(31) |

| Trigger | Period 11 | Period 12 | Period 13 | Period 14 |
|---|---|---|---|---|
| L1_XFT_PT8 | 0.9688(4) | 0.96857 ± 0.003 | 0.963922 ± 0.003 | 0.964755 ± 0.03 |
| L2_XFT_PT8 | 0.9988(4) | 0.9990 ± 0.003 | 0.998003 ± 0.003 | 0.999569 ± 0.03 |
| L3 tracking | 0.9935(4) | 0.9940 ± 0.003 | 0.994608 ± 0.003 | 0.996055 ± 0.03 |
| Total Tracking | 0.9614(4) | 0.9600 ± 0.003 | 0.95681 ± 0.003 | 0.960535 ± 0.03 |

| Trigger | Period 15 | Period 16 | Period 17 | Period 18 |
|---|---|---|---|---|
| L1_XFT_PT8 | 0.9695 ± 0.005 | 0.9684 ± 0.005 | 0.9694 ± 0.003 | 0.9697 ± 0.003 |
| L2_XFT_PT8 | 0.9994 ± 0.005 | 0.9994 ± 0.005 | 0.9995 ± 0.003 | 0.9995 ± 0.003 |
| L3 tracking | 0.9940 ± 0.005 | 0.9927 ± 0.005 | 0.9929 ± 0.003 | 0.9919 ± 0.003 |
| Total Tracking | 0.9633 ± 0.005 | 0.9609 ± 0.005 | 0.9622 ± 0.003 | 0.9615 ± 0.003 |

# L2 Calo Eff: past periods