Period 15 High PT Lepton Efficiencies and SF -blessing

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Tufts

Electrons ID: Samples

Dataset bhelmk: Runs 254800-256824
MC sample : zektei (Feb 2008)
GRL :GRL for P15 v21

P15 SAM dataset
MC dataset zektei (P14 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 ΔZ	$\leq$ 3.0 cm
Signed CES ΔX	$-3.0 \leq q \times \Delta X \leq 1.5$
CES StripChi2	$\leq$ 10.0

$\mathbb{Z}$ 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
ΔR	$\leq$ 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 η-dependent, Phoenix charge fake rate, there is no opposite-sign requirement.

Period 15 vs P14

	Period 14		Period 15	
	bhelmk(P14)	zektei	bhelmk(P15)	zektei
CEM Eff	0.804+\-0.010	0.795+\-0.001	0.792+\-0.005	0.795 +\-0.001
CEM SF	1.011 +\-0.013	N/A	0.996 +\-0.006	N/A
nisoCEM Eff	0.832+\-0.009	0.825 +\-0.001	0.819 +\-0.005	0.825 +\-0.001
nisoCEM SF	1.010 +\-0.011	N/A	0.993 +\-0.006	N/A
LooseCEM Eff	0.923+\-0.007	0.907 +/- 0.001	0.917 +/- 0.003	0.907 +\-0.001
LooseCEM SF	1.018 +\-0.007	N/A	1.011 +\-0.004	N/A
nisolooseCEM Eff	0.954+\-0.005	0.943+\-0.001	0.946+\-0.003	0.943 +\-0.001
nisoloostCEM SF	1.012 +\-0.006	N/A	1.004 +\-0.003	N/A

	PHX		PHX	
Eff |Eta| < 2.0	0.717+\-0.016	0.744+\-0.002	0.711+\-0.007	0.744+\-0.002
SF |Eta| < 2.0	0.964+\-0.021	NA	0.956+\-0.010	NA
	PHX		PHX	
Eff |Eta| < 2.8	0.636+\-0.014	0.645+\-0.002	0.617+\-0.006	0.645+\-0.002
SF |Eta| < 2.8	0.986+\-0.022	NA	0.957+\-0.010	NA

Results for Period 15 (vs P12)

	Period 12		Period 15	
	Bhelmi(P12)	zewkeh	bhelmk(P15)	zektei
CEM Eff	0.7717+\-0.0052	0.8027 +\-0.0011	0.792+\-0.005	0.795 +\-0.001
CEM SF	0.9613 +\-0.007	N/A	0.996 +\-0.006	N/A
nisoCEM Eff	0.8051 +\-0.0049	0.8286 +\-0.0011	0.819 +\-0.005	0.825 +\-0.001
nisoCEM SF	0.9716 +\-0.006	N/A	0.993 +\-0.006	N/A
LooseCEM Eff	0.9018 +/- 0.0037	0.9136 +\-0.0011	0.917 +/- 0.003	0.907 +\-0.001
LooseCEM SF	0.9869 +\-0.004	N/A	1.011 +\-0.004	N/A
nisolooseCEM Eff	0.9401+\-0.0029	0.9452 +\-0.0011	0.946+\-0.003	0.943 +\-0.001
nisoloostCEM SF	0.9945 +\-0.0033	N/A	1.004 +\-0.003	N/A

	PHX		PHX	
Eff |Eta| < 2.0	0.7016+\-0.008	0.7460+\-0.0015	0.711+\-0.007	0.744+\-0.002
SF |Eta| < 2.0	0.9280+\- 0.0100	NA	0.956+\-0.010	NA
	PHX		PHX	
Eff |Eta| < 2.8	0.6155+\-0.0066	0.6589+\-0.0015	0.617+\-0.006	0.645+\-0.002
SF |Eta| < 2.8	0.9340+\- 0.0102	NA	0.957+\-0.010	NA

CEM-PEM

P12

	PEM	
Eff |Eta| < 2.0	0.8001 +\- 0.0065	0.8609 +\- 0.0012
SF |Eta| < 2.0	0.9294+\- 0.0077	NA

	PEM	
Eff |Eta| < 2.8	0.7632 +\- 0.0058	0.8297 +\- 0.011
SF |Eta| < 2.8	0.9198 +\- 0.007	NA

P13

	PEM	
Eff |Eta| < 2.0	0.800+\-0.005	0.861+\-0.001
SF |Eta| < 2.0	0.929+\- 0.006	NA

	PEM	
Eff |Eta| < 2.8	0.765+\-0.005	0.831+\-0.001
SF |Eta| < 2.8	0.921+\- 0.005	NA

P14

	PEM	
Eff |Eta| < 2.0	0.804+\-0.014	0.847+\-0.002
SF |Eta| < 2.0	0.949+\-0.016	NA

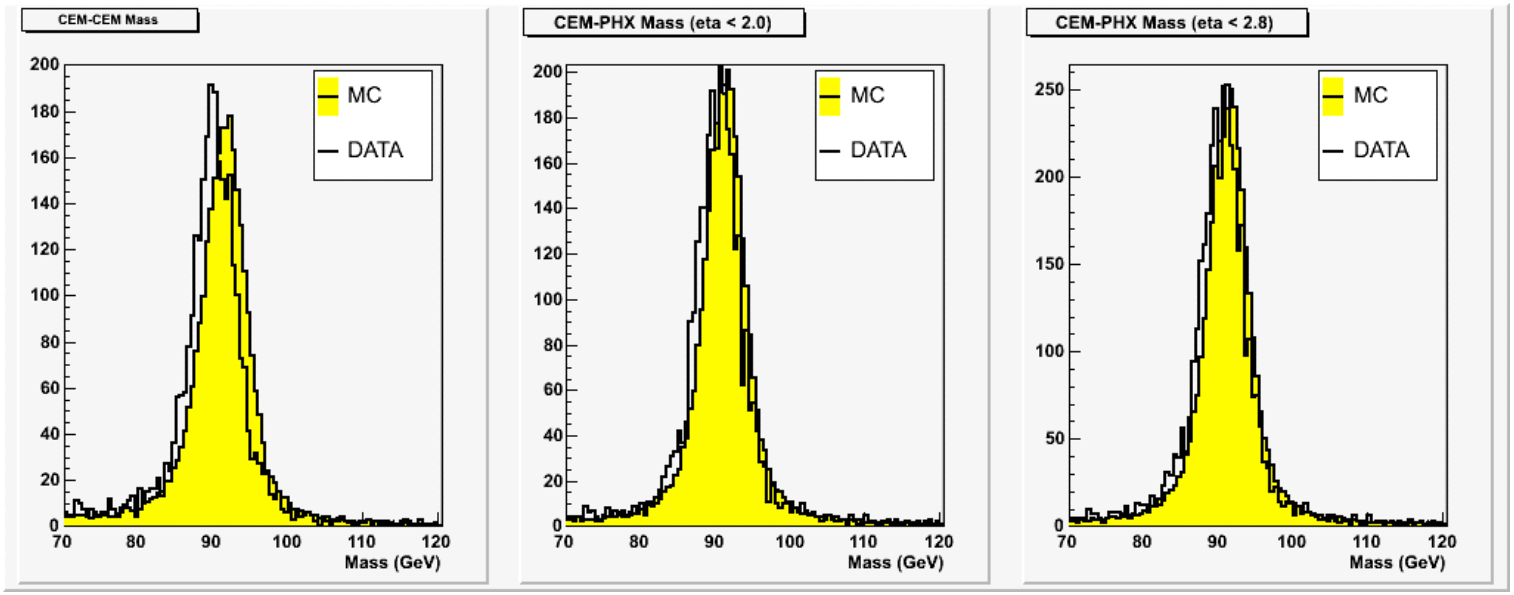
	PEM	
Eff |Eta| < 2.8	0.776+\-0.012	0.810+\-0.001
SF |Eta| < 2.8	0.958+\-0.015	NA

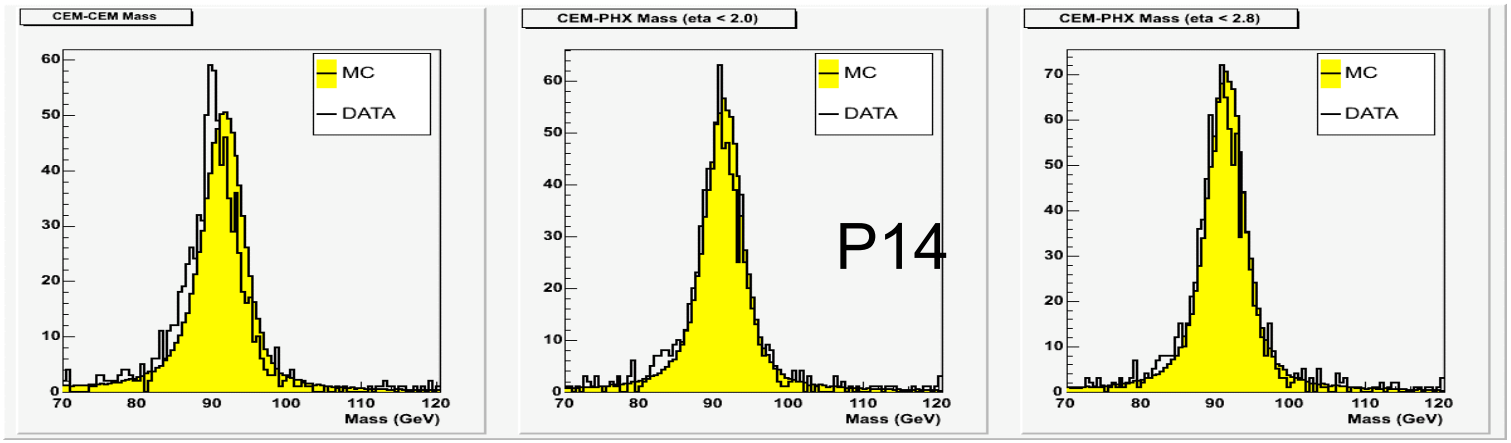
P15

	PEM	
Eff |Eta| < 2.0	0.802+\-0.006	0.847+\-0.002
SF |Eta| < 2.0	0.947+\-0.008	NA

	PEM	
Eff |Eta| < 2.8	0.765+\-0.006	0.810+\-0.001
SF |Eta| < 2.8	0.944+\-0.007	NA

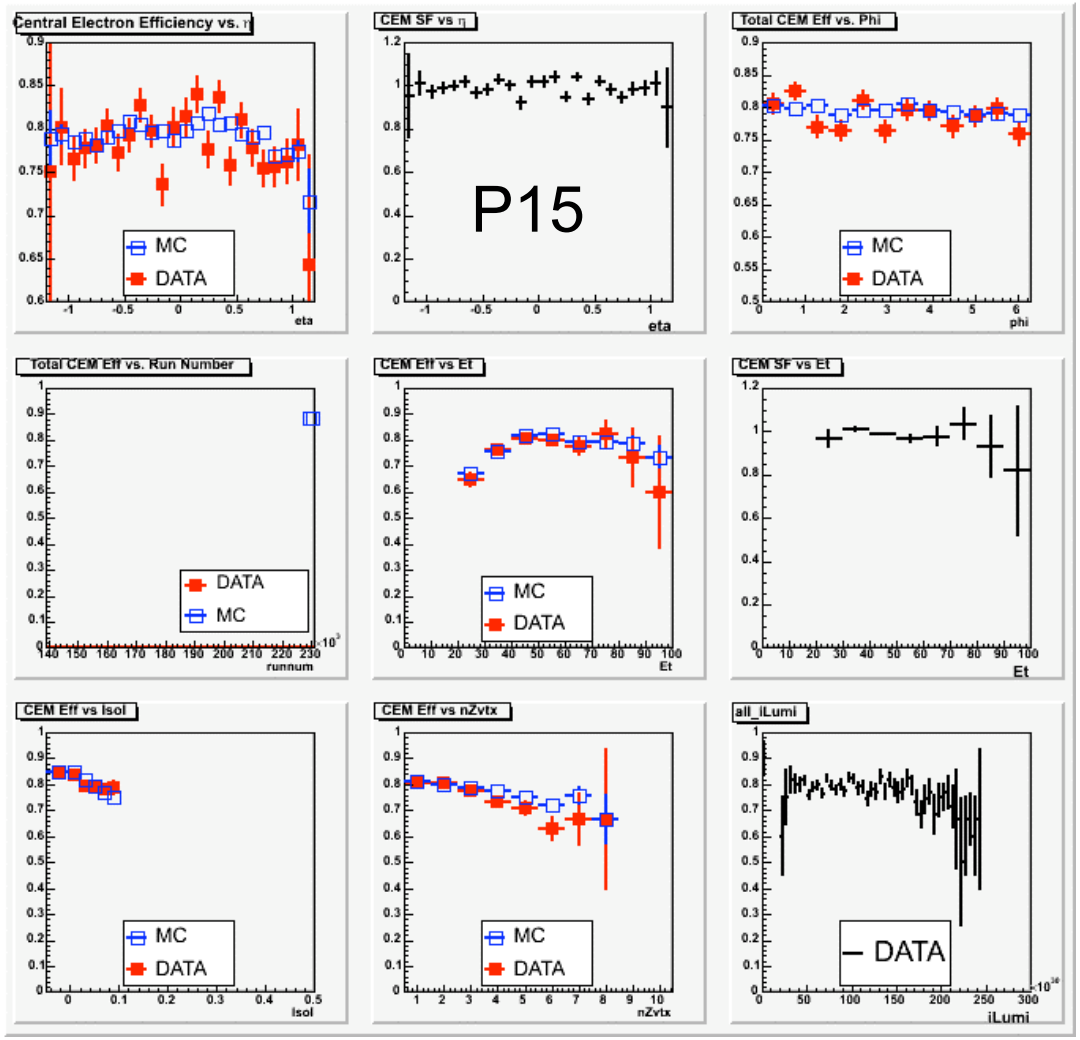
EleID Plots

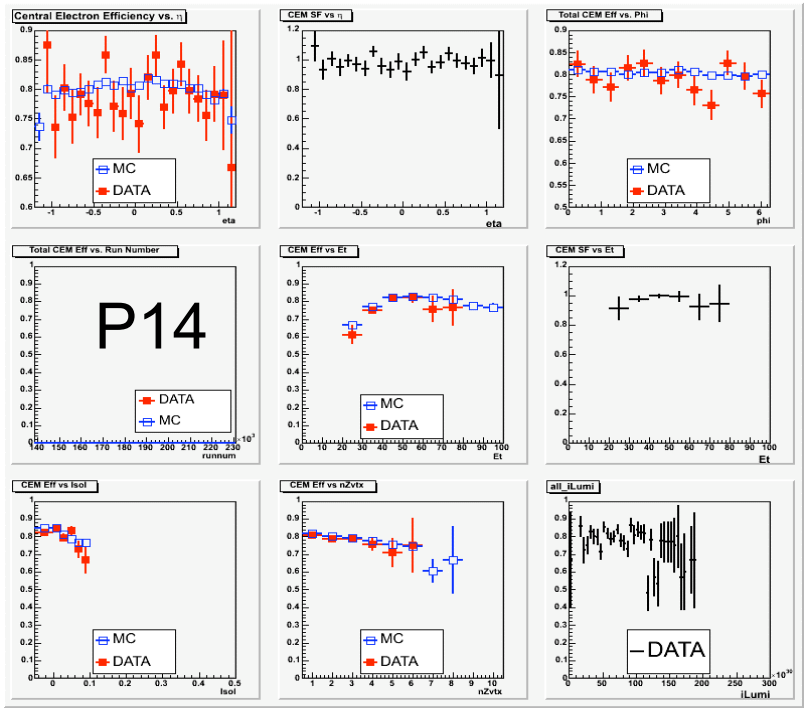

CEM-CEM Mass
CEM-PHX Mass (eta < 2.0)
CEM-PHX Mass (eta < 2.8)
MC
DATA
Mass (GeV)


CEM-CEM Mass
CEM-PHX Mass (eta < 2.0)
CEM-PHX Mass (eta < 2.8)
MC
DATA
P14
Mass (GeV)

EleID Plots 1

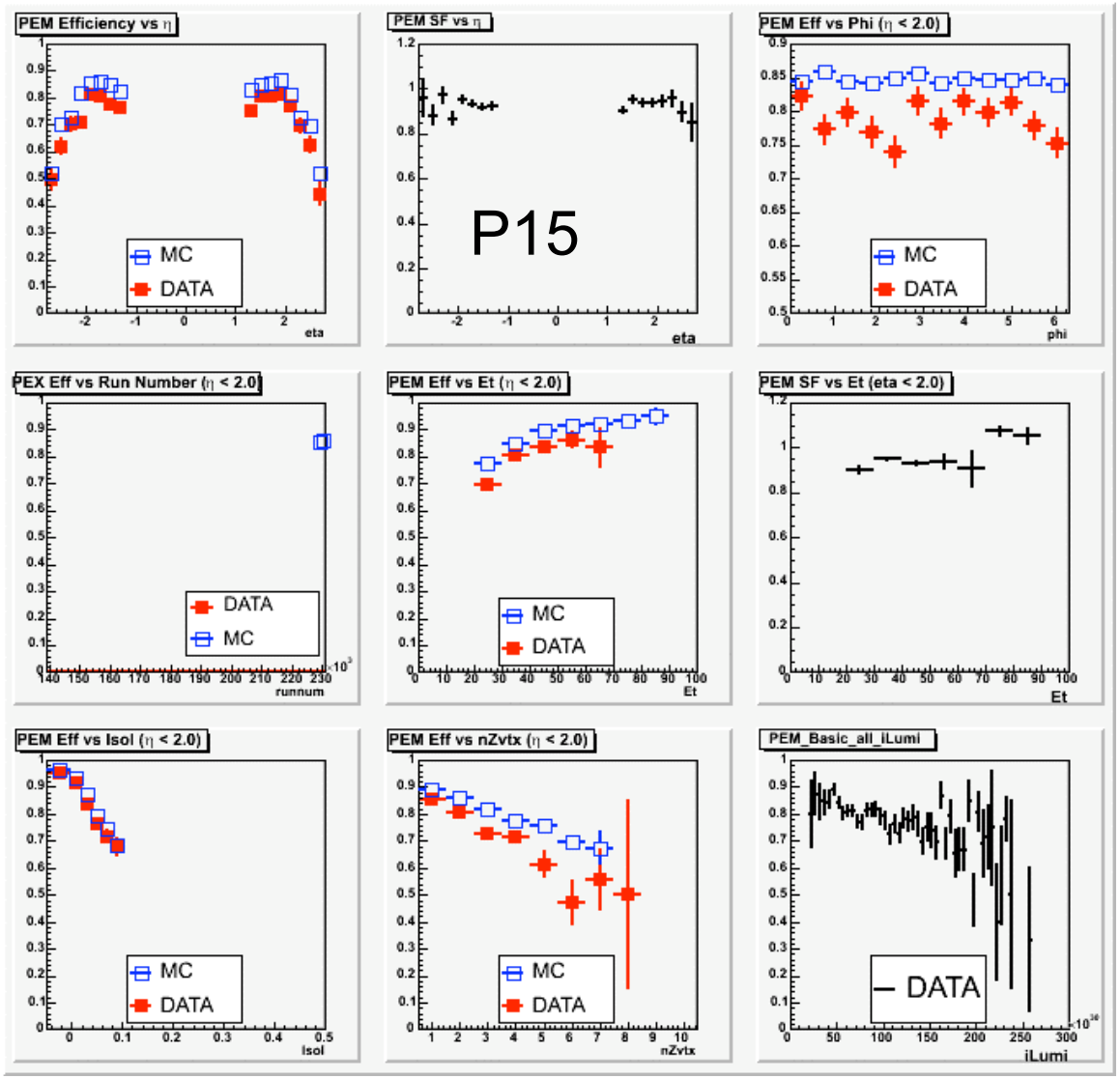
CEM Efficiencies

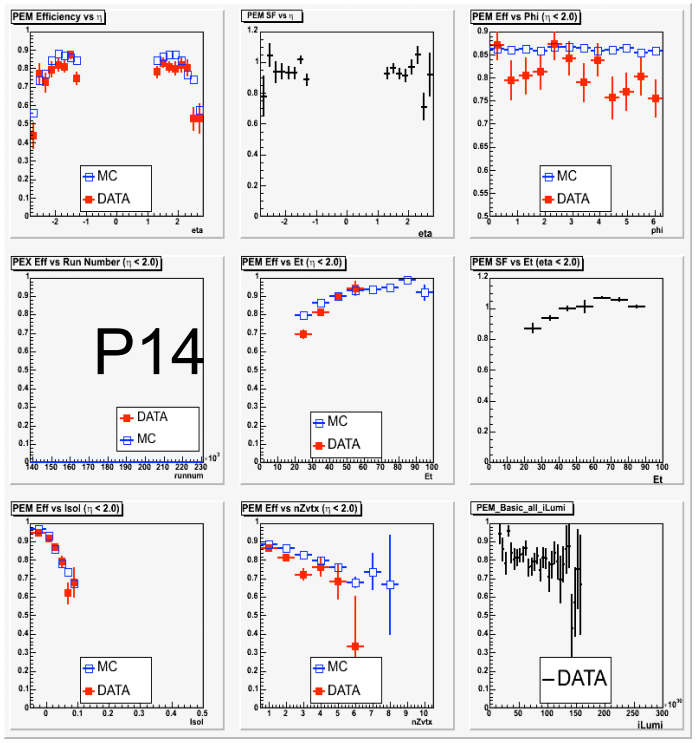




EleID Plots 2

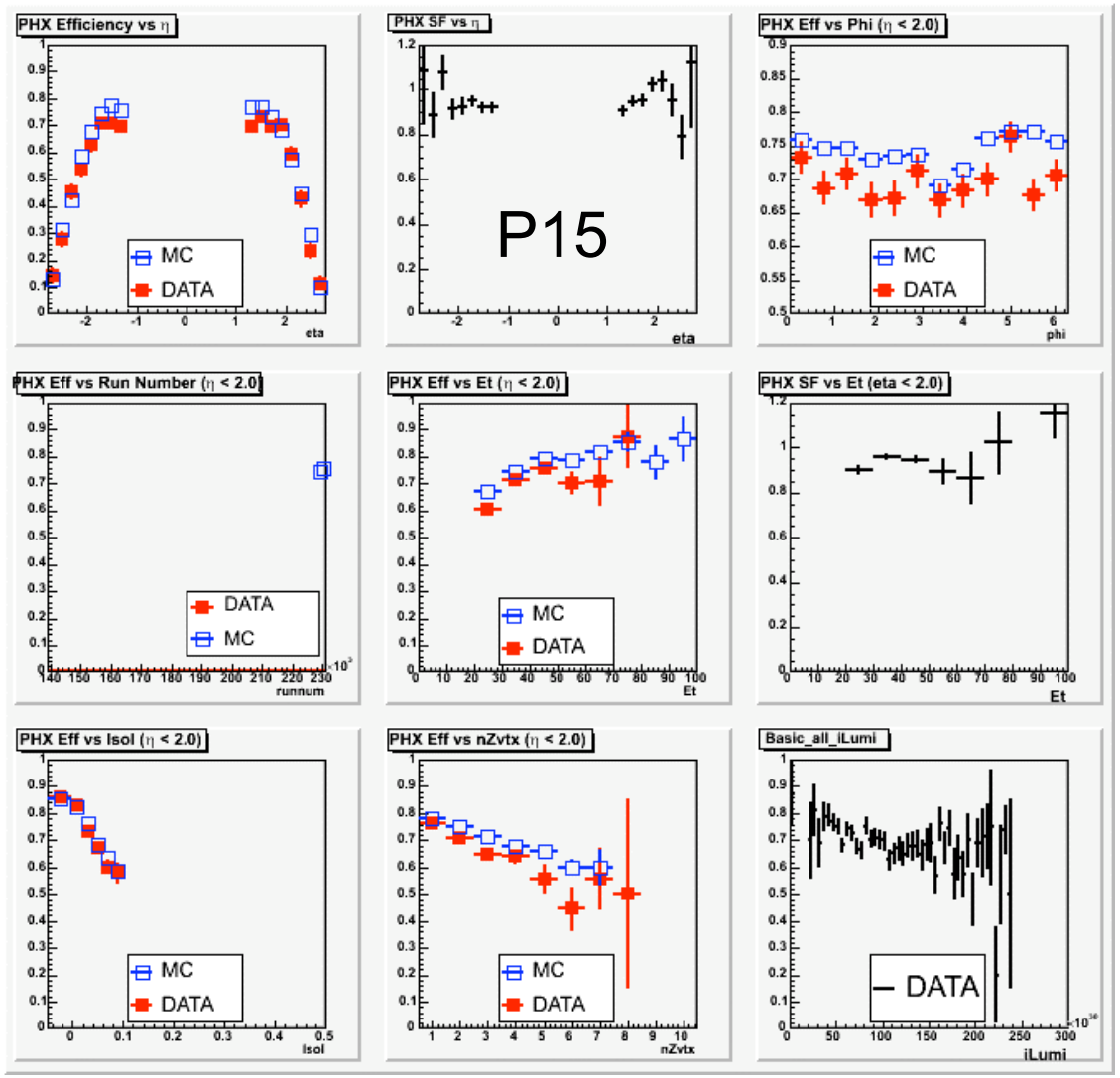
PEM Efficiencies

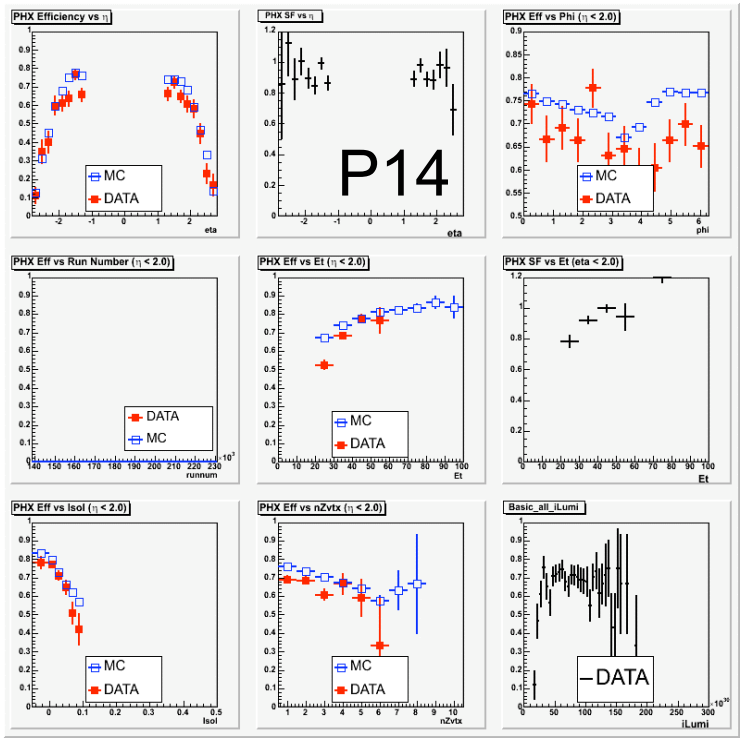




EleID Plots 3

PHX Efficiencies





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	≥ 3
N_{SL}^{stereo} with 5 hits	≥ 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
χ^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

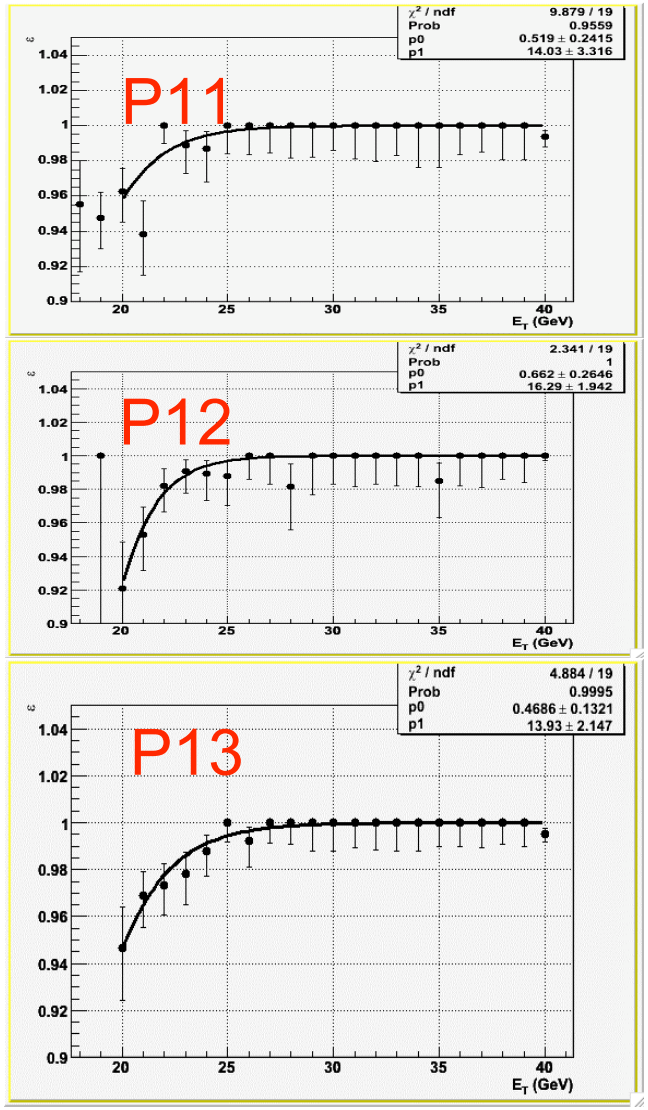
Analyzed all data

NofflW	85776
NcemL1	83166
NcemL2	83118
NcemL3	82627

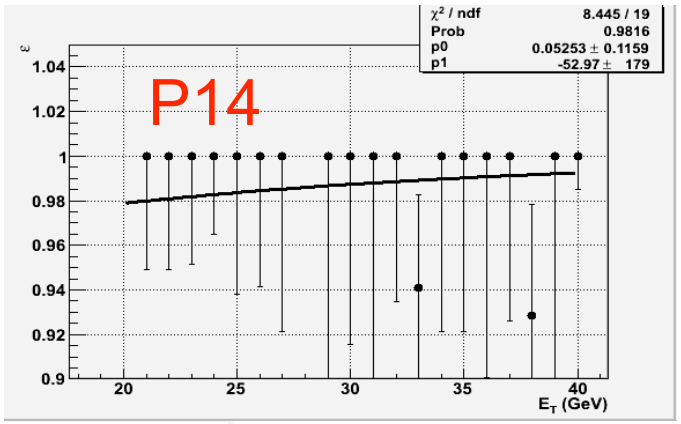
Trigger	Period 9	Period 10A	Period 10B	Period 11	Period 12
L1_XFT_PT8	0.9651(6)	0.9673(7)	0.9650(29)	0.9688(4)	0.96857 ± 0.003
L2_XFT_PT8	0.9992(1)	0.9993(1)	0.9992(5)	0.9988(4)	0.9990 ± 0.003
L3 tracking	0.9954(2)	0.9932(3)	0.9968(9)	0.9935(4)	0.9940 ± 0.003
Total Tracking	0.9598(7)	0.9600(8)	0.9611(31)	0.9614(4)	0.9600 ± 0.003

Trigger	Period 13	Period 14	Period 15
L1_XFT_PT8	0.963922 ± 0.003	0.964755 ± 0.03	0.9695 ± 0.005
L2_XFT_PT8	0.998003 ± 0.003	0.999569 ± 0.03	0.9994 ± 0.005
L3 tracking	0.994608 ± 0.003	0.996055 ± 0.03	0.9940 ± 0.005
Total Tracking	0.95681 ± 0.003	0.960535 ± 0.03	0.9633 ± 0.005

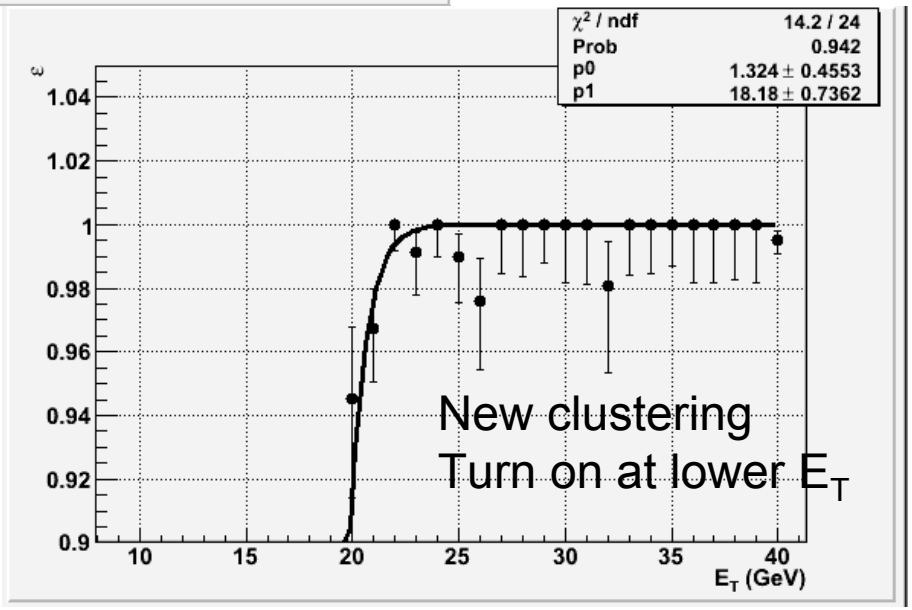
Electron Trigger : Results



L2_CEM16 calorimeter efficiency



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



Muons

Dataset bhmumk: Runs 254800-256824
MC sample : zektim (Feb 2008)
GRL : GRL for P15 v21

Data: P15 Data on SAM
MC: dataset zektim 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:

ρ_{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 ϕ 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

P14

Cut	Count	Efficiency (%)
No cut	753	
E_{EM} cut	732	$97.21^{+0.59}_{-0.78}$
E_{HAD} cut	738	$98.01^{+0.48}_{-0.69}$
COT hits cut	753	$100.00^{+0.00}_{-0.24}$
d_0 cut	752	$99.87^{+0.12}_{-0.29}$
Isolation cut	725	$96.28^{+0.64}_{-0.82}$
Δx_{CMU} cut	750	$99.60^{+0.22}_{-0.40}$
Δx_{CMP} cut	735	$97.61^{+0.58}_{-0.69}$
All above cuts	671	$89.11^{+1.22}_{-1.32}$
All cuts excl. isol.	696	$92.43^{+0.98}_{-1.07}$
Sliding isol. cut	726	$96.41^{+0.70}_{-0.86}$
All cuts (sliding isol.)	672	$89.24^{+1.09}_{-1.25}$
χ^2 cut	753	$100.00^{+0.00}_{-0.24}$
All cuts (χ^2)	671	$89.11^{+1.22}_{-1.32}$
All track cuts	690	$91.63^{+0.99}_{-1.15}$
All trk cuts excl. isol.	716	$95.09^{+0.76}_{-0.90}$

TABLE I: Dataset bhmumj_SAMP14: Muon ID efficiencies for CMUP

P15

Cut	Count	Efficiency (%)
No cut	2326	
E_{EM} cut	2261	$97.21^{+0.33}_{-0.40}$
E_{HAD} cut	2278	$97.94^{+0.28}_{-0.35}$
COT hits cut	2325	$99.96^{+0.03}_{-0.10}$
d_0 cut	2314	$99.48^{+0.14}_{-0.20}$
Isolation cut	2220	$95.44^{+0.43}_{-0.50}$
Δx_{CMU} cut	2311	$99.36^{+0.17}_{-0.22}$
Δx_{CMP} cut	2284	$98.19^{+0.27}_{-0.32}$
All above cuts	2072	$89.08^{+0.62}_{-0.65}$
All cuts excl. isol.	2155	$92.65^{+0.56}_{-0.61}$
Sliding isol. cut	2261	$97.21^{+0.33}_{-0.40}$
All cuts (sliding isol.)	2107	$90.58^{+0.58}_{-0.69}$
χ^2 cut	2326	$100.00^{+0.00}_{-0.08}$
All cuts (χ^2)	2072	$89.08^{+0.62}_{-0.65}$
All track cuts	2120	$91.14^{+0.60}_{-0.67}$
All trk cuts excl. isol.	2205	$94.80^{+0.44}_{-0.49}$

TABLE I: Dataset bhmumkP15_GRLv21: Muon ID efficiencies for CMUP

CMUP ID SF

P14

Cut	Scale Factor
No cut	
E_{EM} cut	$1.0110^{+0.0062}_{-0.0081}$
E_{HAD} cut	$0.9961^{+0.0049}_{-0.0071}$
COT hits cut	$1.0001^{+0.0000}_{-0.0024}$
d_0 cut	$0.9999^{+0.0012}_{-0.0030}$
Isolation cut	$0.9904^{+0.0066}_{-0.0085}$
Δx_{CMU} cut	$0.9962^{+0.0022}_{-0.0040}$
Δx_{CMP} cut	$0.9812^{+0.0059}_{-0.0069}$
All above cuts	$0.9731^{+0.0134}_{-0.0144}$
All cuts excl. isol.	$0.9833^{+0.0104}_{-0.0114}$
Sliding isol. cut	$0.9865^{+0.0072}_{-0.0088}$
All cuts (sliding isol.)	$0.9697^{+0.0119}_{-0.0137}$
χ^2 cut	$1.0000^{+0.0000}_{-0.0024}$
All cuts (χ^2)	$0.9731^{+0.0134}_{-0.0144}$
All track cuts	$0.9955^{+0.0108}_{-0.0126}$
All trk cuts excl. isol.	$1.0063^{+0.0081}_{-0.0095}$

P15

Cut	Scale Factor
No cut	
E_{EM} cut	$1.0099^{+0.0035}_{-0.0042}$
E_{HAD} cut	$0.9959^{+0.0029}_{-0.0036}$
COT hits cut	$0.9997^{+0.0003}_{-0.0010}$
d_0 cut	$0.9977^{+0.0014}_{-0.0021}$
Isolation cut	$0.9865^{+0.0045}_{-0.0052}$
Δx_{CMU} cut	$0.9936^{+0.0017}_{-0.0022}$
Δx_{CMP} cut	$0.9872^{+0.0027}_{-0.0032}$
All above cuts	$0.9790^{+0.0068}_{-0.0072}$
All cuts excl. isol.	$0.9869^{+0.0060}_{-0.0065}$
Sliding isol. cut	$0.9961^{+0.0034}_{-0.0042}$
All cuts (sliding isol.)	$0.9873^{+0.0063}_{-0.0076}$
χ^2 cut	$1.0000^{+0.0000}_{-0.0008}$
All cuts (χ^2)	$0.9790^{+0.0068}_{-0.0072}$
All track cuts	$0.9964^{+0.0067}_{-0.0073}$
All trk cuts excl. isol.	$1.0044^{+0.0047}_{-0.0052}$

TABLE I: Dataset bhmumkP15_GRLv21_zektimP14: Muon ID Scale Factors for CMUP

CMX ID Efficiencies

P14

Cut	Count	Efficiency (%)
No cut	489	
E_{EM} cut	470	$96.11^{+0.91}_{-1.05}$
E_{HAD} cut	484	$98.98^{+0.46}_{-0.66}$
COT hits cut	489	$100.00^{+0.00}_{-0.38}$
d_0 cut	487	$99.59^{+0.29}_{-0.54}$
Isolation cut	476	$97.34^{+0.75}_{-0.91}$
Δx_{CMX} cut	487	$99.59^{+0.29}_{-0.54}$
All above cuts	450	$92.02^{+1.24}_{-1.50}$
All cuts excl. isol.	463	$94.68^{+0.97}_{-1.18}$
Sliding isol. cut	480	$98.16^{+0.62}_{-0.85}$
All cuts (sliding isol.)	454	$92.84^{+1.20}_{-1.34}$
χ^2 cut	489	$100.00^{+0.00}_{-0.38}$
All cuts (χ^2)	450	$92.02^{+1.24}_{-1.50}$
All track cuts	451	$92.23^{+1.23}_{-1.31}$
All trk cuts excl. isol.	464	$94.89^{+0.96}_{-1.19}$

TABLE II: Dataset bhmumj_SAMP14: Muon ID efficiencies for CMX

P15

Cut	Count	Efficiency (%)
No cut	1521	
E_{EM} cut	1471	$96.71^{+0.48}_{-0.55}$
E_{HAD} cut	1493	$98.16^{+0.35}_{-0.43}$
COT hits cut	1520	$99.93^{+0.06}_{-0.15}$
d_0 cut	1515	$99.61^{+0.16}_{-0.23}$
Isolation cut	1471	$96.71^{+0.48}_{-0.55}$
Δx_{CMX} cut	1516	$99.67^{+0.15}_{-0.22}$
All above cuts	1389	$91.32^{+0.72}_{-0.75}$
All cuts excl. isol.	1435	$94.35^{+0.62}_{-0.64}$
Sliding isol. cut	1484	$97.57^{+0.41}_{-0.47}$
All cuts (sliding isol.)	1402	$92.18^{+0.65}_{-0.72}$
χ^2 cut	1521	$100.00^{+0.00}_{-0.12}$
All cuts (χ^2)	1389	$91.32^{+0.72}_{-0.75}$
All track cuts	1394	$91.65^{+0.68}_{-0.78}$
All trk cuts excl. isol.	1440	$94.67^{+0.59}_{-0.68}$

TABLE II: Dataset bhmumkP15_GRLv21: Muon ID efficiencies for CMX

CMX ID SF

P14

Cut	Scale Factor
No cut	
E_{EM} cut	$0.9980^{+0.0095}_{-0.0109}$
E_{HAD} cut	$1.0120^{+0.0047}_{-0.0068}$
COT hits cut	$1.0001^{+0.0000}_{-0.0038}$
d_0 cut	$0.9968^{+0.0029}_{-0.0054}$
Isolation cut	$1.0002^{+0.0078}_{-0.0093}$
Δx_{CMX} cut	$0.9976^{+0.0029}_{-0.0054}$
All above cuts	$1.0049^{+0.0136}_{-0.0164}$
All cuts excl. isol.	$1.0079^{+0.0104}_{-0.0126}$
Sliding isol. cut	$1.0030^{+0.0064}_{-0.0087}$
All cuts (sliding isol.)	$1.0084^{+0.0131}_{-0.0146}$
χ^2 cut	$1.0000^{+0.0000}_{-0.0038}$
All cuts (χ^2)	$1.0049^{+0.0136}_{-0.0164}$
All track cuts	$1.0052^{+0.0134}_{-0.0143}$
All trk cuts excl. isol.	$1.0082^{+0.0103}_{-0.0126}$

P15

Cut	Scale Factor
No cut	
E_{EM} cut	$1.0046^{+0.0050}_{-0.0057}$
E_{HAD} cut	$1.0032^{+0.0036}_{-0.0044}$
COT hits cut	$0.9994^{+0.0006}_{-0.0015}$
d_0 cut	$0.9985^{+0.0016}_{-0.0023}$
Isolation cut	$0.9973^{+0.0050}_{-0.0057}$
Δx_{CMX} cut	$0.9983^{+0.0015}_{-0.0022}$
All above cuts	$1.0016^{+0.0080}_{-0.0082}$
All cuts excl. isol.	$1.0055^{+0.0067}_{-0.0069}$
Sliding isol. cut	$0.9981^{+0.0042}_{-0.0049}$
All cuts (sliding isol.)	$1.0033^{+0.0071}_{-0.0079}$
χ^2 cut	$1.0000^{+0.0000}_{-0.0012}$
All cuts (χ^2)	$1.0016^{+0.0080}_{-0.0082}$
All track cuts	$1.0037^{+0.0075}_{-0.0086}$
All trk cuts excl. isol.	$1.0074^{+0.0063}_{-0.0073}$

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.

P12

Category	Fiducial	w/ Stub	Efficiency (%)
CMUP	2534	2311	$91.20^{+0.55}_{-0.62}$
CMX	1524	1455	$95.47^{+0.57}_{-0.60}$
CMX Arches	1165	1144	$98.20^{+0.41}_{-0.47}$
CMX Miniskirt	283	238	$84.10^{+2.13}_{-2.56}$
CMX Keystone	76	73	$96.05^{+2.19}_{-3.67}$
CMU-only	651	567	$87.10^{+1.28}_{-1.45}$
CMP-only	606	558	$92.08^{+1.18}_{-1.16}$
CMX MiniKey	359	311	$86.63^{+1.75}_{-1.96}$

P13

Category	Fiducial	w/ Stub	Efficiency (%)
CMUP	4644	4240	$91.30^{+0.42}_{-0.46}$
CMX	2711	2587	$95.43^{+0.40}_{-0.43}$
CMX Arches	2163	2113	$97.69^{+0.33}_{-0.35}$
CMX Miniskirt	450	382	$84.89^{+1.73}_{-1.98}$
CMX Keystone	98	92	$93.88^{+2.41}_{-3.45}$
CMU-only	1128	1002	$88.83^{+0.97}_{-0.99}$
CMP-only	1284	1184	$92.21^{+0.71}_{-0.85}$
CMX MiniKey	548	474	$86.50^{+1.49}_{-1.63}$

P14

Category	Fiducial	w/ Stub	Efficiency (%)
CMUP	815	732	$89.82^{+1.05}_{-1.19}$
CMX	487	471	$96.71^{+0.80}_{-1.06}$
CMX Arches	373	367	$98.39^{+0.68}_{-0.98}$
CMX Miniskirt	91	82	$90.11^{+3.05}_{-4.37}$
CMX Keystone	23	22	$95.65^{+3.96}_{-9.13}$
CMU-only	200	179	$89.50^{+2.10}_{-2.68}$
CMP-only	216	199	$92.13^{+1.91}_{-2.19}$
CMX MiniKey	114	104	$91.23^{+2.72}_{-3.53}$

P15

Category	Fiducial	w/ Stub	Efficiency (%)
CMUP	2534	2261	$89.23^{+0.67}_{-0.60}$
CMX	1540	1466	$95.19^{+0.56}_{-0.61}$
CMX Arches	1198	1160	$96.83^{+0.49}_{-0.61}$
CMX Miniskirt	261	230	$88.12^{+2.01}_{-2.28}$
CMX Keystone	81	76	$93.83^{+2.46}_{-3.79}$
CMU-only	658	580	$88.15^{+1.21}_{-1.33}$
CMP-only	689	612	$88.82^{+1.12}_{-1.42}$
CMX MiniKey	342	306	$89.47^{+1.64}_{-1.88}$

Reconstruction SF

P11

Category	Scale Factor
CMUP	$0.9276^{+0.0048}_{-0.0053}$
CMX	$0.9557^{+0.0043}_{-0.0050}$
CMX Arches	$0.9840^{+0.0032}_{-0.0037}$
CMX Miniskirt	$0.8277^{+0.0192}_{-0.0203}$
CMX Keystone	$0.9736^{+0.0193}_{-0.0351}$
CMU-only	$0.8991^{+0.0107}_{-0.0114}$
CMP-only	$0.9224^{+0.0085}_{-0.0095}$
CMX MiniKey	$0.8515^{+0.0173}_{-0.0173}$

P12

Category	Scale Factor
CMUP	$0.9345^{+0.0056}_{-0.0064}$
CMX	$0.9584^{+0.0058}_{-0.0060}$
CMX Arches	$0.9840^{+0.0041}_{-0.0047}$
CMX Miniskirt	$0.8490^{+0.0215}_{-0.0258}$
CMX Keystone	$0.9706^{+0.0222}_{-0.0372}$
CMU-only	$0.8921^{+0.0132}_{-0.0149}$
CMP-only	$0.9372^{+0.0121}_{-0.0118}$
CMX MiniKey	$0.8747^{+0.0177}_{-0.0177}$

P13

Category	Scale Factor
CMUP	$0.9371^{+0.0044}_{-0.0047}$
CMX	$0.9577^{+0.0040}_{-0.0043}$
CMX Arches	$0.9785^{+0.0034}_{-0.0035}$
CMX Miniskirt	$0.8567^{+0.0175}_{-0.0200}$
CMX Keystone	$0.9499^{+0.0245}_{-0.0350}$
CMU-only	$0.9100^{+0.0099}_{-0.0102}$
CMP-only	$0.9379^{+0.0072}_{-0.0087}$
CMX MiniKey	$0.8733^{+0.0151}_{-0.0151}$

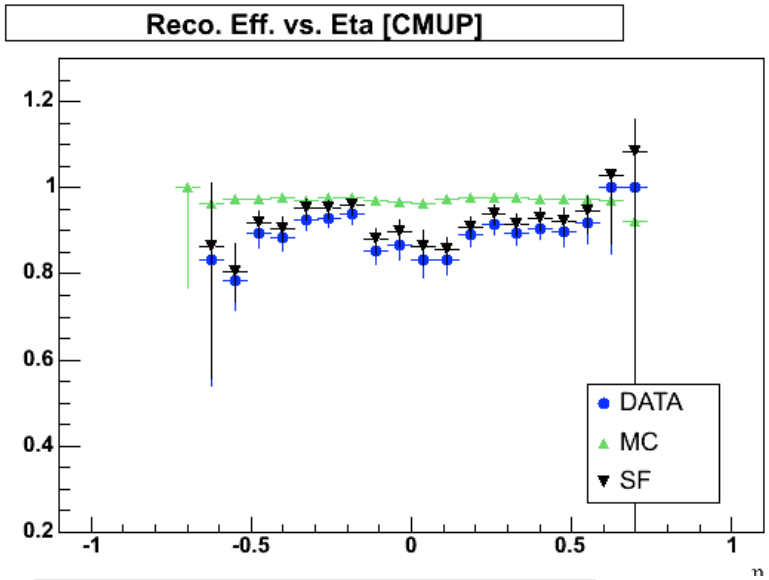
P14

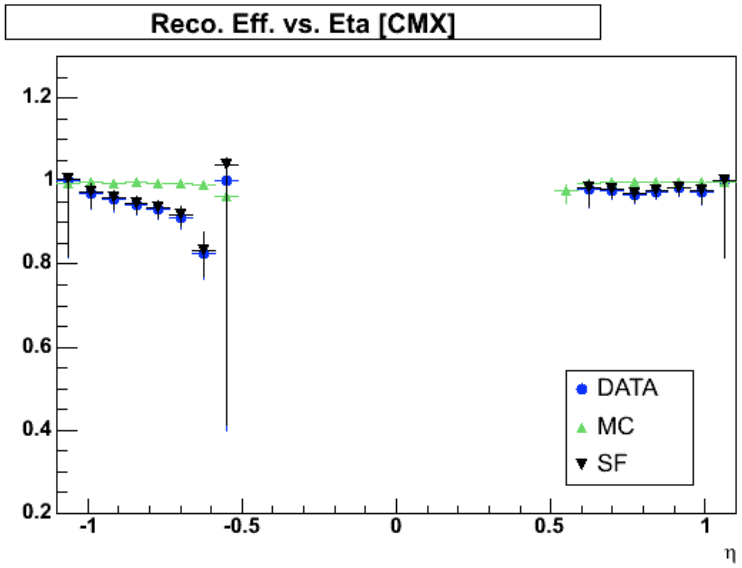
Category	Scale Factor
CMUP	$0.9218^{+0.0108}_{-0.0123}$
CMX	$0.9706^{+0.0080}_{-0.0106}$
CMX Arches	$0.9856^{+0.0068}_{-0.0098}$
CMX Miniskirt	$0.9093^{+0.0308}_{-0.0441}$
CMX Keystone	$0.9678^{+0.0401}_{-0.0924}$
CMU-only	$0.9169^{+0.0216}_{-0.0275}$
CMP-only	$0.9371^{+0.0195}_{-0.0223}$
CMX MiniKey	$0.9211^{+0.0274}_{-0.0274}$

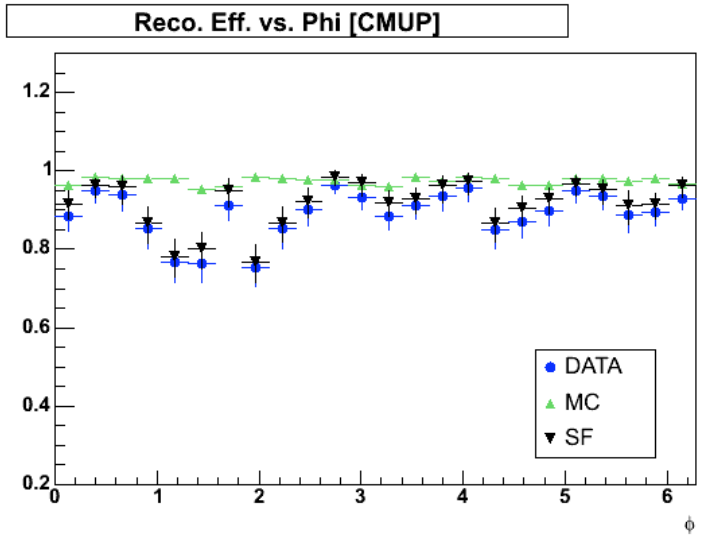
P15

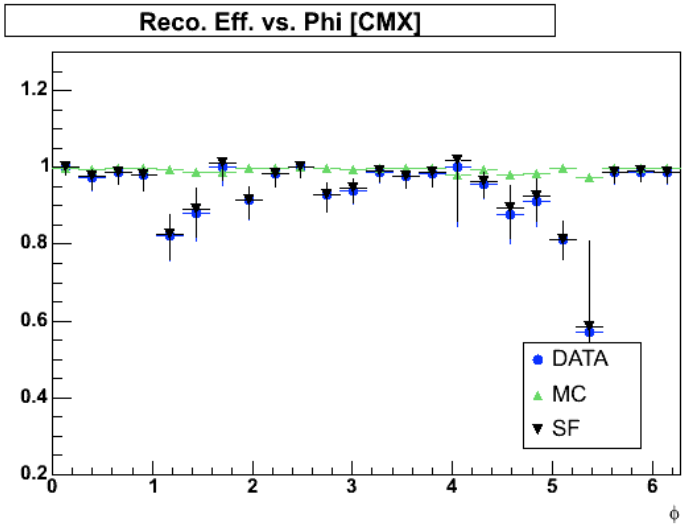
Category	Scale Factor
CMUP	$0.9160^{+0.0068}_{-0.0062}$
CMX	$0.9557^{+0.0056}_{-0.0062}$
CMX Arches	$0.9702^{+0.0049}_{-0.0061}$
CMX Miniskirt	$0.8901^{+0.0204}_{-0.0231}$
CMX Keystone	$0.9499^{+0.0250}_{-0.0384}$
CMU-only	$0.9035^{+0.0124}_{-0.0136}$
CMP-only	$0.9041^{+0.0114}_{-0.0145}$
CMX MiniKey	$0.9041^{+0.0166}_{-0.0166}$

Reco and ID Plots

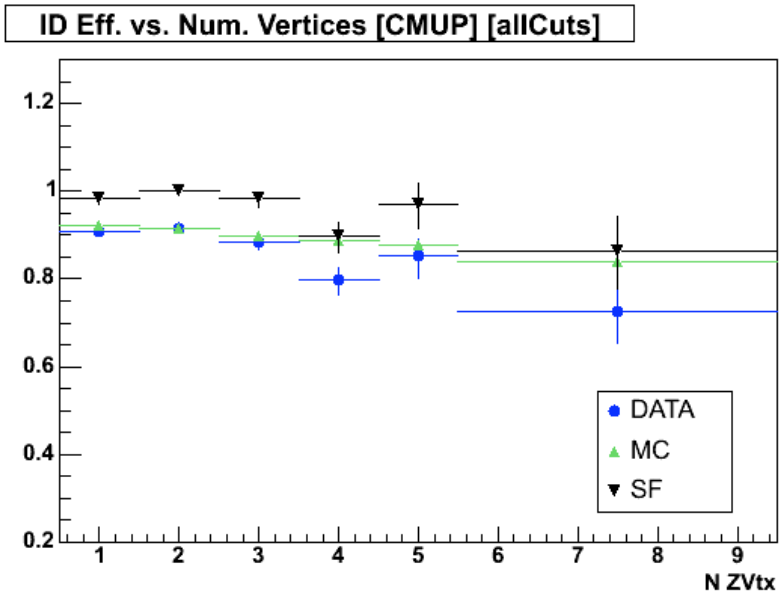


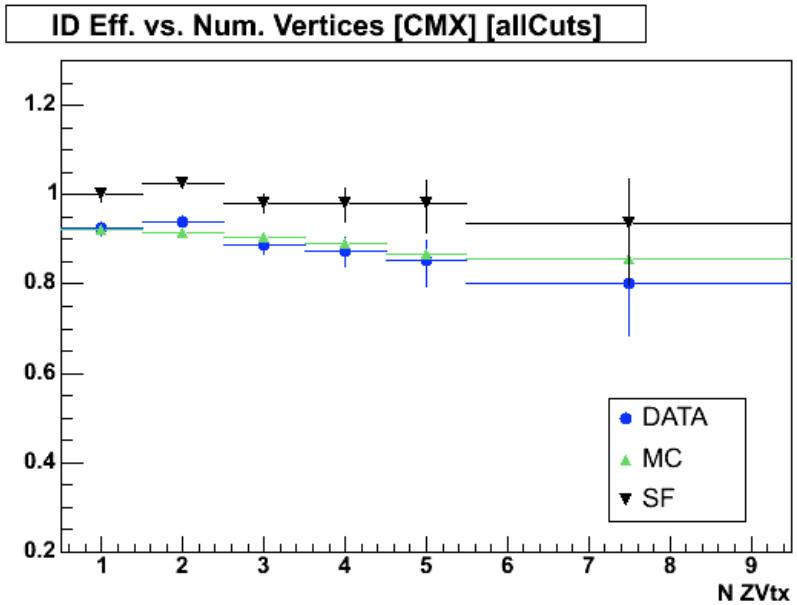






Reco and ID Plots





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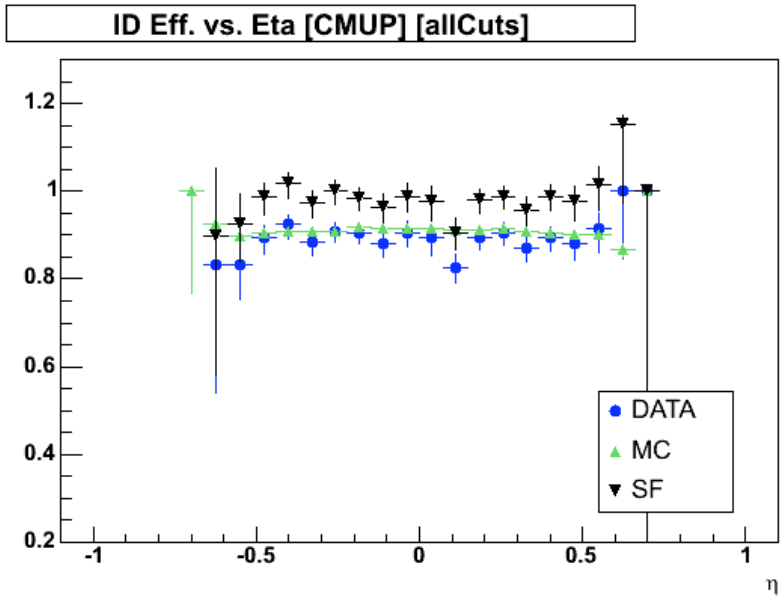

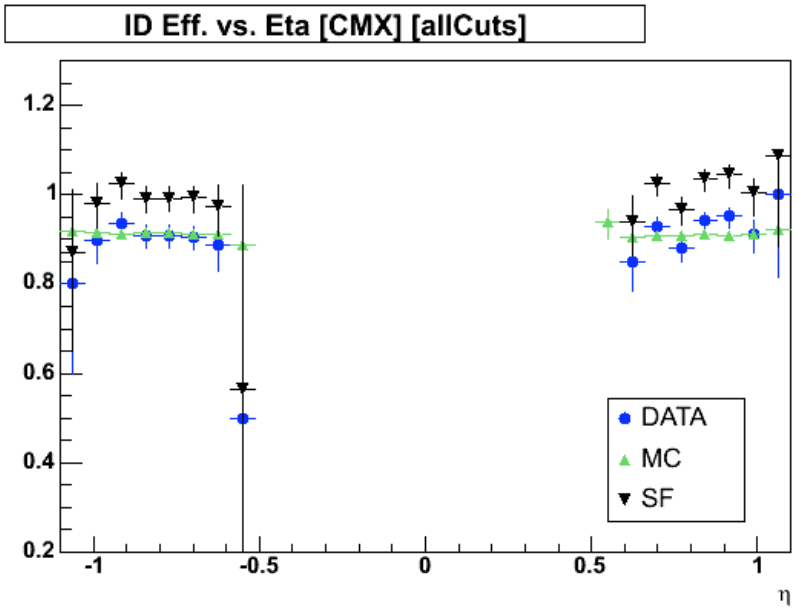

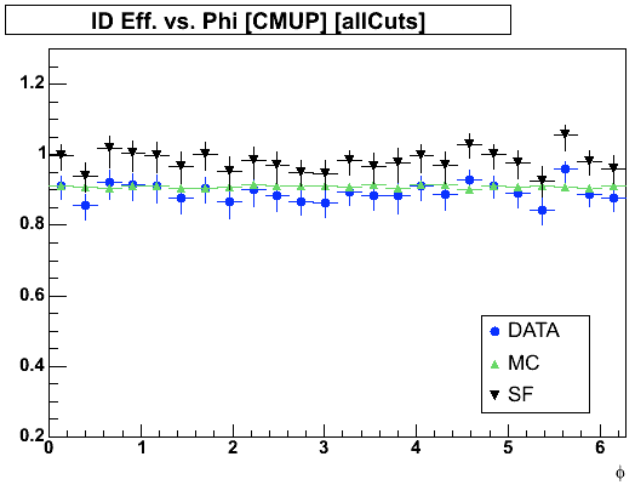

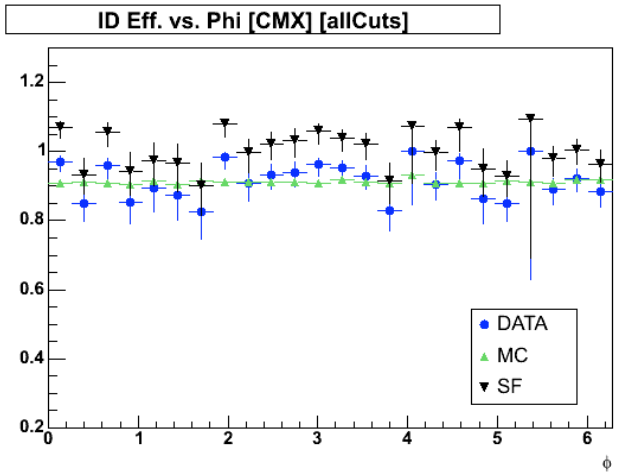

Trigger Efficiencies

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

Level 1:

ε^{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)

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

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.

Efficiencies not corrected for livetimes

1st leg	2nd leg	1st passes	both pass	Efficiency (%)
CMUP	CMUP	763	660	-
CMX	CMUP	928	874	$93.44^{+0.60}_{-0.54}$
CMUP	CMX	966	874	-
CMX	CMX	349	292	$90.71^{+0.85}_{-0.75}$
CMUP	ARCH	751	716	-
CMUP	MK	215	158	-
ARCH	ARCH	243	227	-
ARCH	MK	81	48	-
MK	ARCH	51	48	$95.83^{+0.67}_{-0.58}$
MK	MK	22	17	$81.30^{+2.41}_{-2.22}$

TABLE I: Dataset bhmumkP15-1: Muon L1 trigger efficiencies

Category	Events Passing	Efficiency (%)
Pass L1	874	-
CMUP	805	$98.45^{+0.45}_{-0.57}$
CMX	774	$94.66^{+0.80}_{-0.96}$
CMUP-CMX	762	-
CMUP-A	656	-
CMUP-MK	149	-
CMUP-CMX-A	618	$94.21^{+0.96}_{-1.09}$
CMUP-CMX-MK	144	$96.64^{+1.50}_{-2.21}$

TABLE II: Dataset bhmumkP15-1: Muon L2 trigger efficiencies

Category	Events Passing	Efficiency (%)
Pass L1	874	-
CMUP-CMUP$_S$	769	-
CMX-CMX$_S$	752	-
CMUP-CMX-CMUP$_S$	731	$94.44^{+0.82}_{-0.94}$
CMUP-CMX-CMX$_S$	740	$91.93^{+0.99}_{-1.06}$
CMUP-CMX-CMX$_S$-A	601	$91.62^{+1.06}_{-1.28}$
CMUP-CMX-CMX$_S$-MK	139	$93.29^{+2.22}_{-2.76}$

TABLE III: Dataset bhmumkP15-1: Muon L2 SLAM trigger efficiencies

Trigger Eff

Category	Events Passing	Efficiency (%)
Pass L2	762	-
CMUP	759	$99.61^{+0.21}_{-0.37}$
CMX	761	$99.87^{+0.12}_{-0.30}$
CMUP-CMX	758	-
CMUPA	615	-
CMUPMK	144	-
CMUPARCH	614	$99.84^{+0.13}_{-0.36}$
CMUP-MK	144	$100.00^{+0.00}_{-1.27}$

TABLE IV: Dataset bhmumkP15-1: Muon L3 trigger efficiencies

Livetimes and correction factors
CMUP 2-D Livetime .953585
CMUP 3-D Livetime 1.000309
CMX 2-D Livetime .947956
CMX 3-D Livetime .956760

CMUP 2-D correction 1
CMX 2-D correction .954453

Category	Efficiency (%)
CMUP	$91.63^{+0.75}_{-0.83}$
CMX	$85.76^{+1.08}_{-1.15}$
CMX A	$90.13^{+1.12}_{-1.22}$
CMX MK	$78.58^{+2.63}_{-2.97}$
CMUP SLAM	$87.90^{+0.97}_{-1.06}$
CMX SLAM	$83.28^{+1.19}_{-1.21}$
CMX SLAM A	$87.65^{+1.19}_{-1.37}$
CMX SLAM MK	$75.85^{+2.88}_{-3.21}$

TABLE V: Dataset bhmumkP15-1: Muon combined trigger efficiencies

CMX = 85.76 / 0.95 = 90.27 (1.10)
CMX SLAM = 83.28 / 0.95 = 87.66 (1.20)
CMX A = 90.13 / 0.95 = 94.87 (1.17))
CMX SLAM A = 87.65 / 0.95= 92.26 (1.27)

Comparison with previous periods

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

Period	Measured (SR)	Livetime Corr.	Corr. Efficiency
8	0.9130(67)	1.000	0.9130(67)
9	0.9270(67)	1.000	0.9270(67)
10	0.9196(56)	1.000	0.9196(56)
11	0.9198(61)	1.000	0.9198(61)
12	0.9241(78)	1.000	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)

CMUP

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

Period	2-D Efficiency	2-D+3-D/2-D (SR)	3-D Efficiency
10	0.9196(56)	0.9265(78)	0.8520(89)
11	0.9198(61)	0.9375(88)	0.8623(98)
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)

Comparison with previous periods

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

Arches-only:

Period	Measured (SR)	Livetime Corr.	Corr. Efficiency
12	0.8923 (118)	0.945	0.944 (125)
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)

CMX

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

Arches-only

Period	2-D Efficiency	3-D Efficiency
12	0.8923/0.945= 0.94(125)	0.9002 (140)
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 = .8904 (2.7)
15	0.9013/0.95=0.9487 (117)	0.8765/0.95 = 0.9226 (128)

Conclusions

- P15 high PT electrons and muons analyzed:
  - ID, Muon ID/Reco efficiencies look reasonable
  - Trigger Eff ok