Period 18 High PT Lepton Efficiencies and SF -preliminary results

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Tufts

Electrons ID: Samples

Dataset bhelmk: Runs 261119-264071 (P18)
MC sample : zektei (Feb 2008)
GRL :GRL for P18 v24

P18 SAM dataset : bhmumm, only 8715080 evts processed
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.

P18 numbers

	Period 17		Period 17	
	bhelmk(P16)	zektei	bhelmm(P18)	zektei
CEM Eff	0.781+\-0.005	0.795 +\-0.001	0.773+\-0.003	0.795 +\-0.001
CEM SF	0.982 +\-0.006	N/A	0.972 +\-0.004	N/A
nisoCEM Eff	0.815 +\-0.004	0.825 +\-0.001	0.806 +\-0.003	0.825 +\-0.001
nisoCEM SF	0.988 +\-0.006	N/A	0.977 +\-0.004	N/A
LooseCEM Eff	0.909 +/- 0.003	0.907 +\-0.001	0.903 +/- 0.002	0.907 +\-0.001
LooseCEM SF	1.002 +\-0.004	N/A	0.996 +\-0.003	N/A
nisolooseCEM Eff	0.945+\-0.0043	0.943 +\-0.001	0.945+\-0.002	0.943 +\-0.001
nisoloostCEM SF	1.003 +\-0.003	N/A	1.002 +\-0.002	N/A

	PHX		PHX	
Eff |Eta| < 2.0	0.688+\-0.007	0.744+\-0.002	0.661+\-0.005	0.744+\-0.002
SF |Eta| < 2.0	0.925+\-0.010	NA	0.888+\-0.007	NA
	PHX		PHX	
Eff |Eta| < 2.8	0.598+\-0.006	0.645+\-0.002	0.572+\-0.004	0.645+\-0.002
SF |Eta| < 2.8	0.934+\-0.009	NA	0.886+\-0.007	NA

CEM-PEM

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

P16

	PEM	
Eff |Eta| < 2.0	0.793+\-0.008	0.847+\-0.002
SF |Eta| < 2.0	0.937+\-0.010	NA

	PEM	
Eff |Eta| < 2.8	0.756+\-0.007	0.810+\-0.001
SF |Eta| < 2.8	0.934+\-0.009	NA

P17

	PEM	
Eff |Eta| < 2.0	0.784+\-0.006	0.847+\-0.002
SF |Eta| < 2.0	0.926+\-0.008	NA

	PEM	
Eff |Eta| < 2.8	0.742+\-0.006	0.810+\-0.001
SF |Eta| < 2.8	0.915+\-0.007	NA

P18

	PEM	
Eff |Eta| < 2.0	0.776+\-0.004	0.847+\-0.002
SF |Eta| < 2.0	0.916+\-0.005	NA

	PEM	
Eff |Eta| < 2.8	0.729+\-0.004	0.810+\-0.001
SF |Eta| < 2.8	0.900+\-0.005	NA

P18 numbers comments

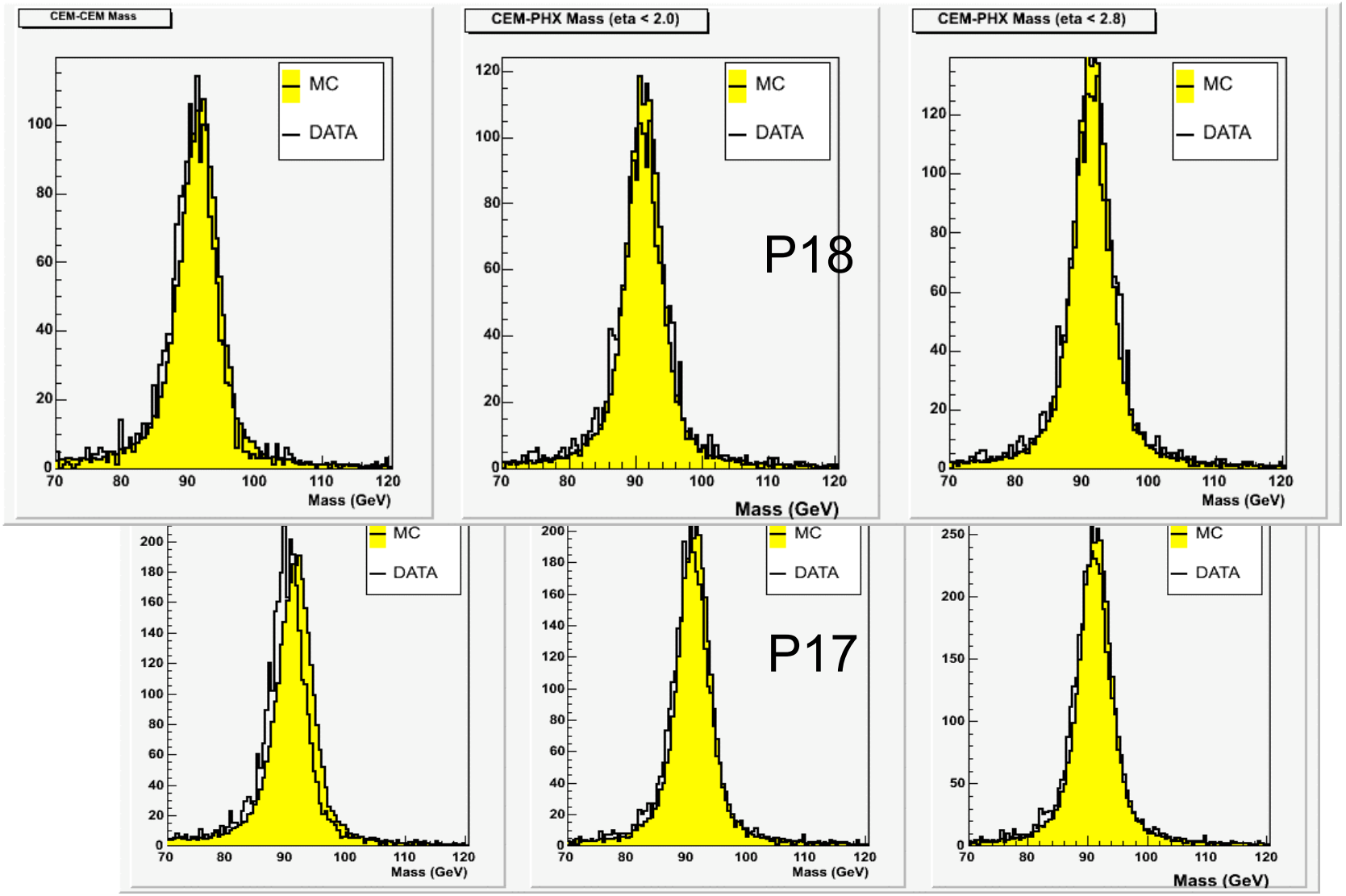
Some drop, which we will need to check while running on the entire dataset.
In P17 there was a drop due to the isolation cut, it seems to be there as well also now.

In P17 The Isolation N-1 efficiency dropped 1% since period 15. The raw CEM-CEM efficiency seems to show a similar 1% drop. There appears to be a small drop between period 15 and 16 which is hard to distinguish from statistics. However a 1% difference between period 15 and 17 looks significant.

Period 17 was the first dataset with statistics at luminosities > 250E30. These high luminosity electrons tend to have lower efficiencies as a result of the isolation cut.

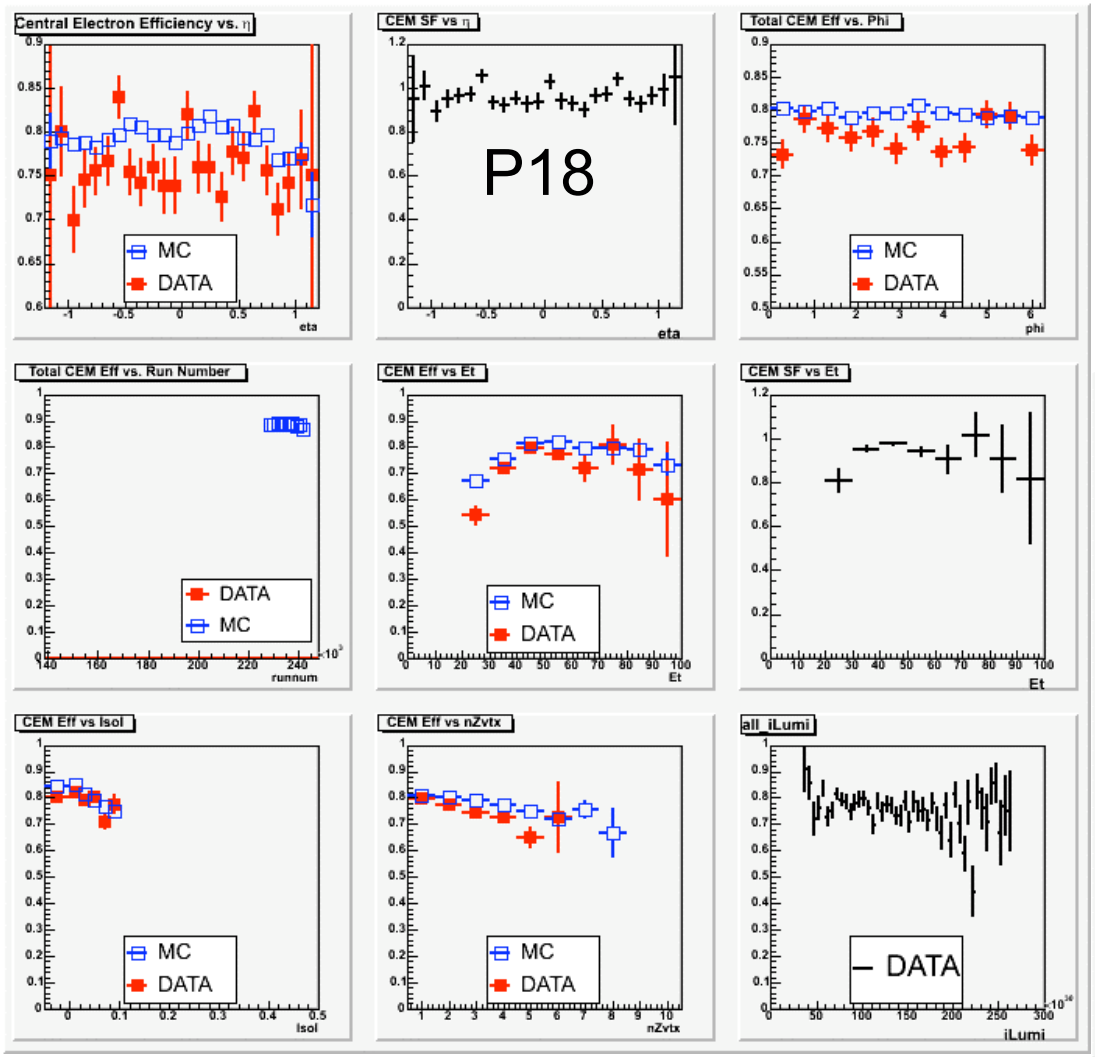
The other smoking gun here is the non-isolated efficiencies.
CEM-CEM and CEM-looseCEM efficiencies have dropped from their previous values.
However, the CEM-nisoCEM and CEM-nisoLooseCEM efficiencies remain the same as before.

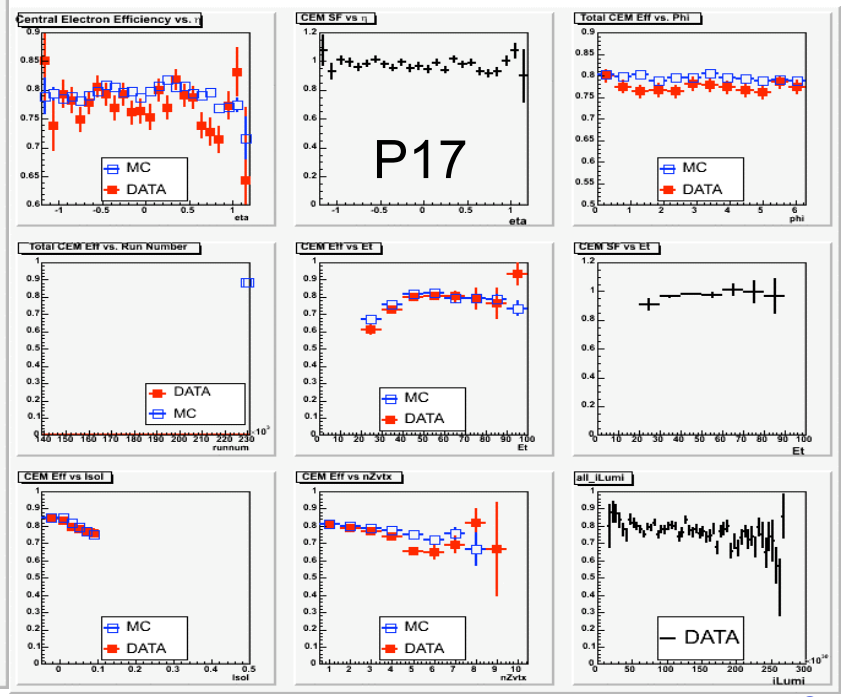
EleID Plots


CEM-CEM Mass
CEM-PHX Mass (eta < 2.0)
CEM-PHX Mass (eta < 2.8)
MC
DATA
P18
P17
Mass (GeV)

EleID Plots 1

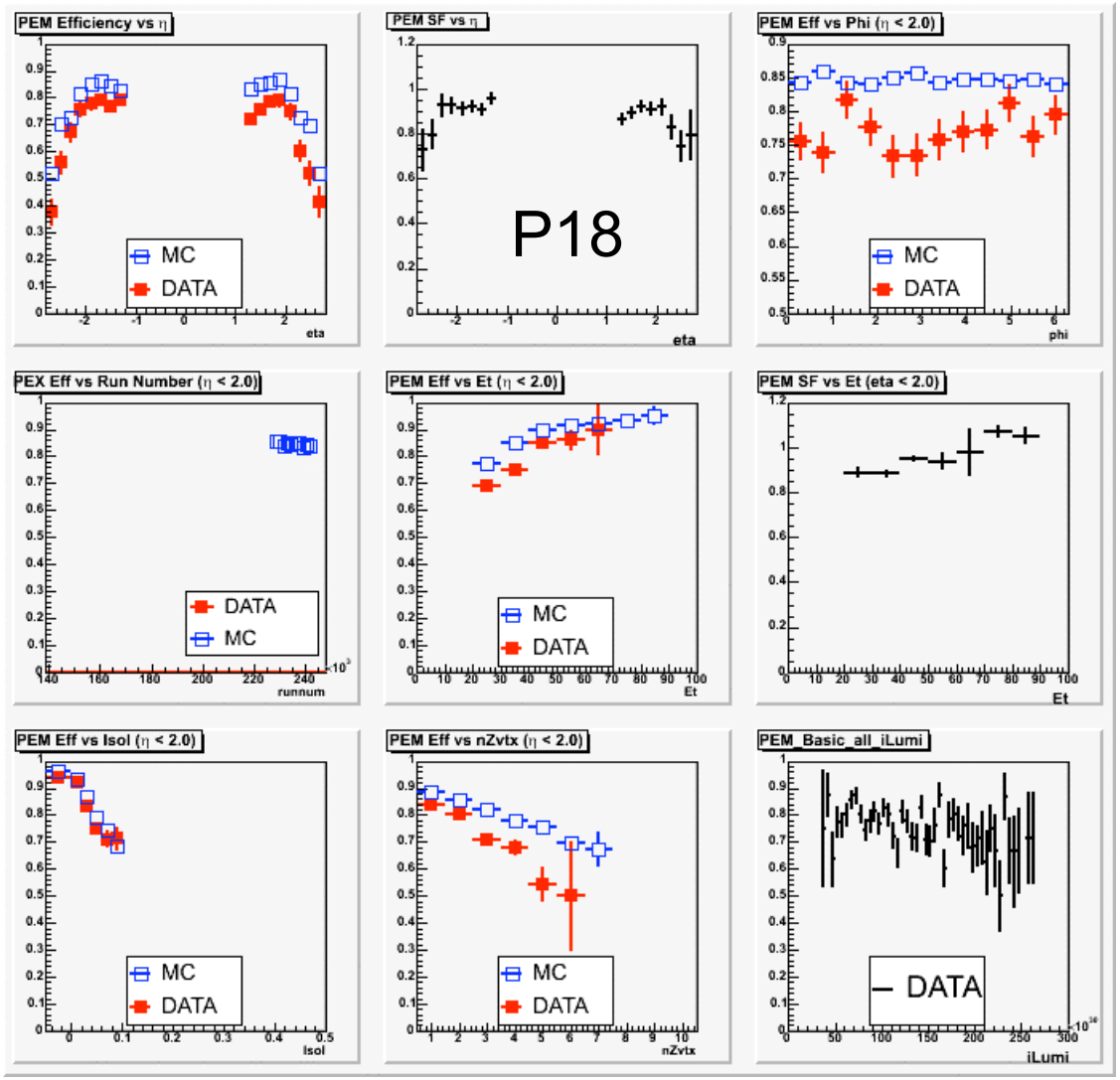
CEM Efficiencies

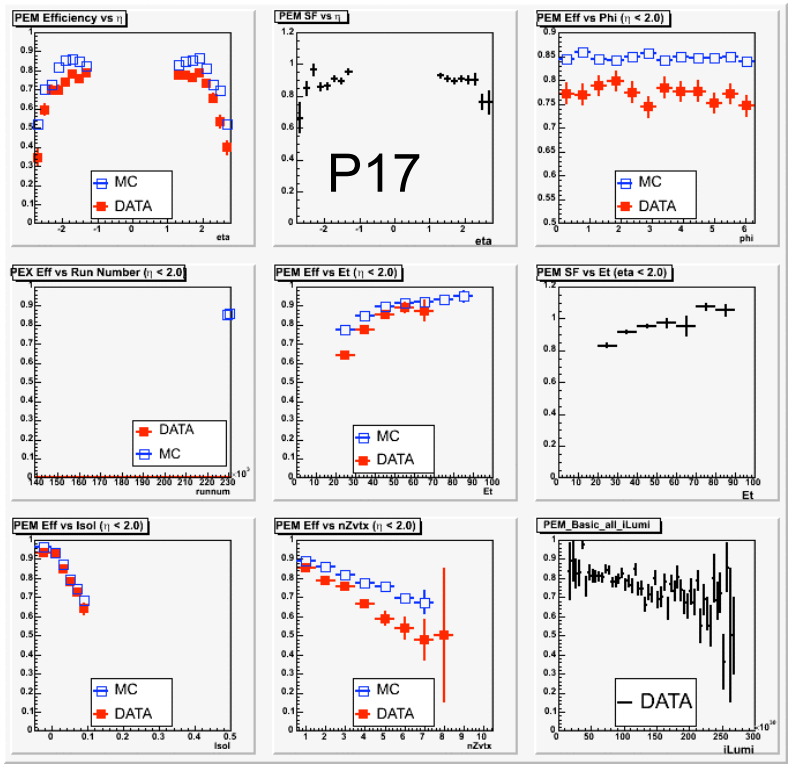




EleID Plots 2

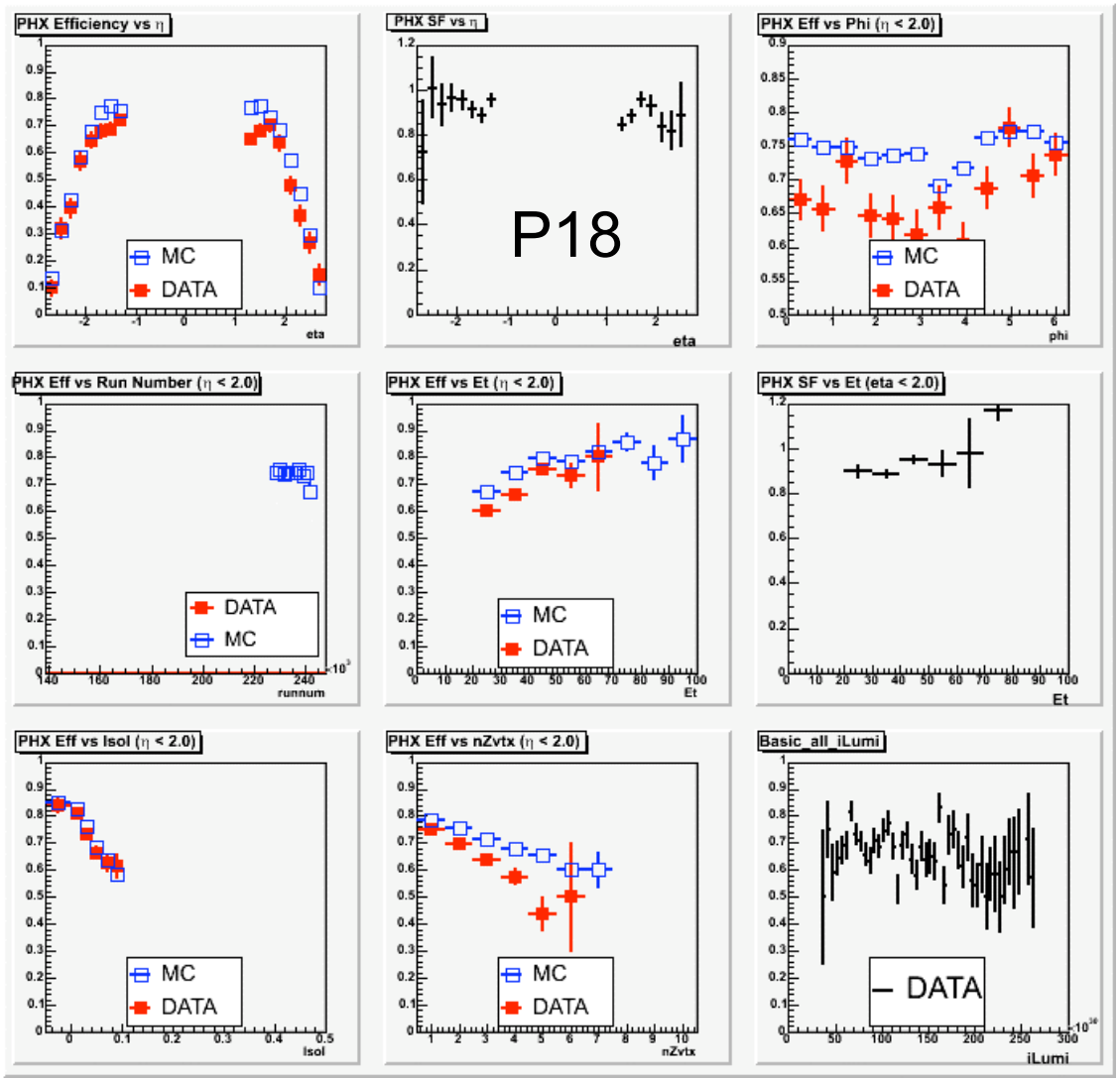
PEM Efficiencies

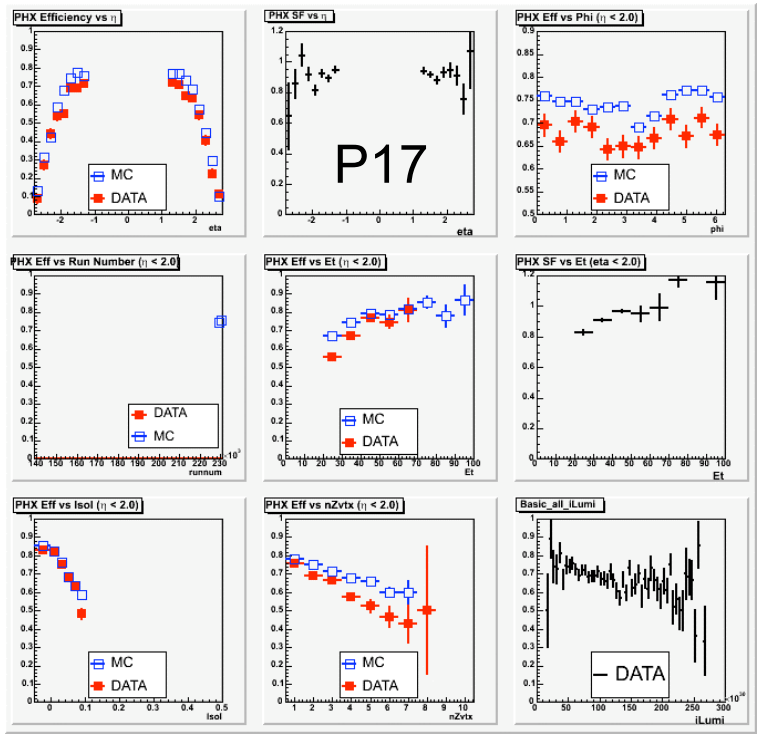




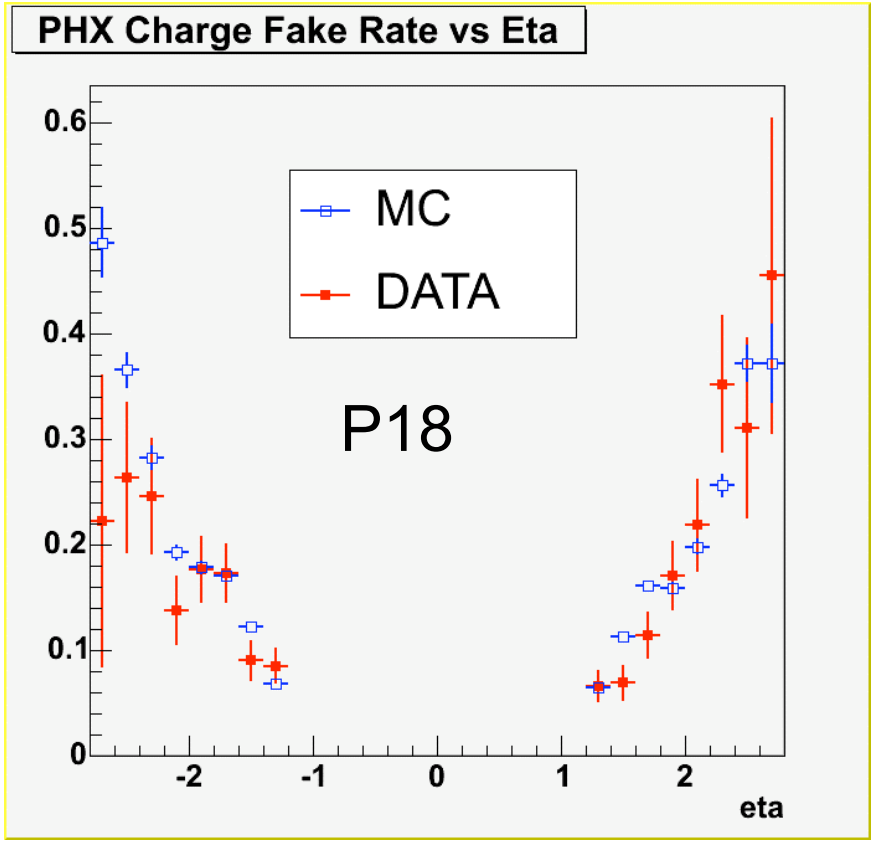
EleID Plots 3

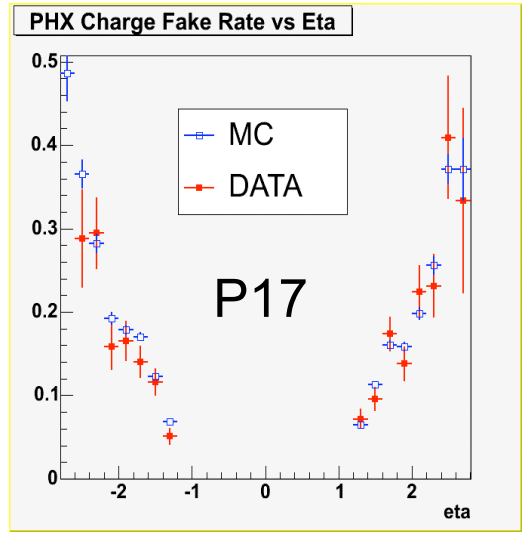
PHX Efficiencies





PHX Fake Charge Rate

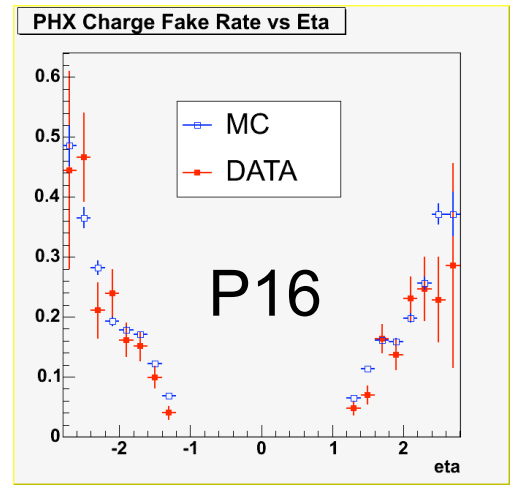




Eta > 2.0
Phoenix charge fake rate =
0.1112 +/- 0.0058

Eta < 2.8
Phoenix charge fake rate =
0.1361 +/- 0.0057

$\eta < 2$
Phoenix charge fake rate =
0.0984 +/- 0.0072



$\eta < 2.8$
Phoenix charge fake rate =
0.1317 +/- 0.0074

Phoenix charge fake rate

$\eta < 2$ 0.1088 +/- 0.0078

$\eta < 2.8$ 0.1342 +/- 0.0076

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

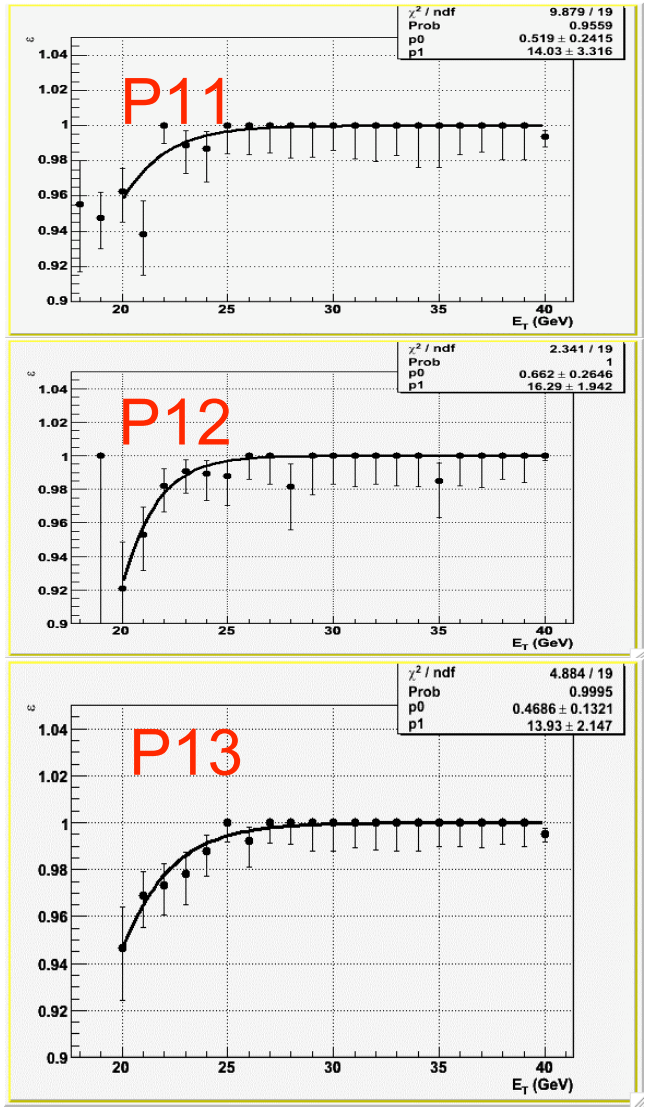
Trigger	Period 9	Period 10A	Period 10B
L1_XFT_PT8	0.9651(6)	0.9673(7)	0.9650(29)
L2_XFT_PT8	0.9992(1)	0.9993(1)	0.9992(5)
L3 tracking	0.9954(2)	0.9932(3)	0.9968(9)
Total Tracking	0.9598(7)	0.9600(8)	0.9611(31)

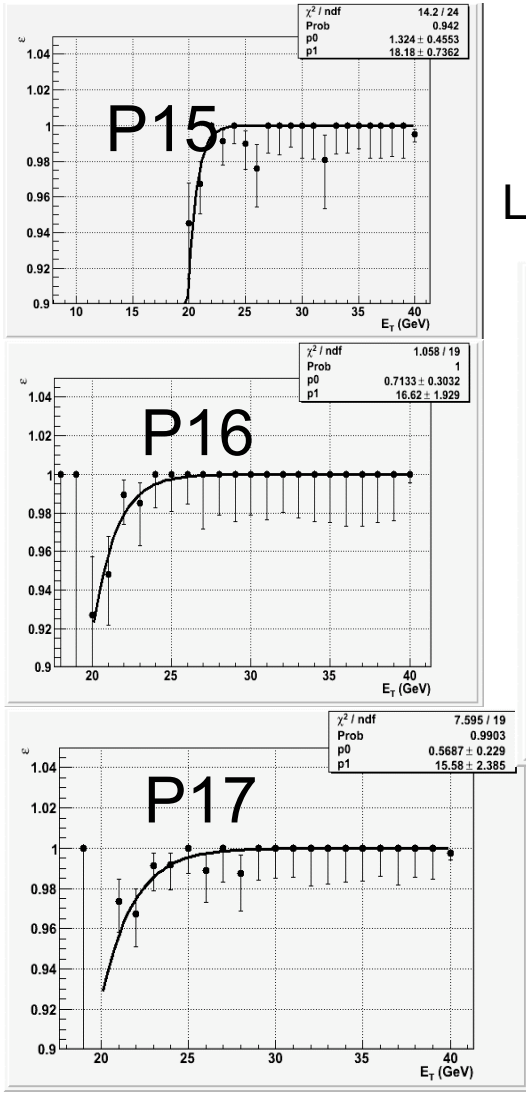
NofflW	203217
NcemL1	197064
NcemL2	196972
NcemL3	195396

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

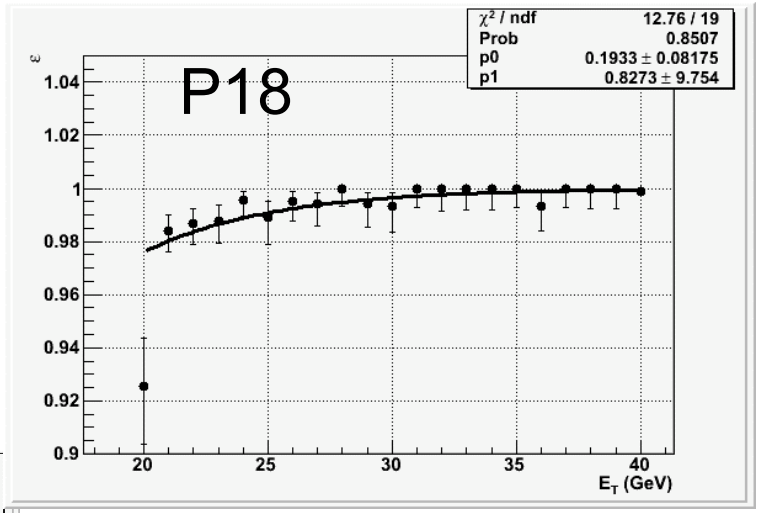
Electron Trigger : Results





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

L2_CEM16 calorimeter efficiency



Muons

Dataset bhmumk: Runs 261119-264071
MC sample : zektim (Feb 2008)
GRL : GRL for P18 v24

Data: P18 Data on SAM : bhmumm
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

P17

Cut	Count	Efficiency (%)
No cut	2643	
E_{EM} cut	2561	$96.90^{+0.34}_{-0.39}$
E_{HAD} cut	2603	$98.49^{+0.23}_{-0.28}$
COT hits cut	2643	$100.00^{+0.00}_{-0.07}$
d_0 cut	2634	$99.66^{+0.11}_{-0.15}$
Isolation cut	2542	$96.18^{+0.38}_{-0.40}$
Δx_{CMU} cut	2635	$99.70^{+0.10}_{-0.16}$
Δx_{CMP} cut	2594	$98.15^{+0.27}_{-0.32}$
All above cuts	2372	$89.75^{+0.63}_{-0.64}$
All cuts excl. isol.	2460	$93.08^{+0.50}_{-0.52}$
Sliding isol. cut	2570	$97.24^{+0.30}_{-0.34}$
All cuts (sliding isol.)	2395	$90.62^{+0.55}_{-0.63}$
χ^2 cut	2643	$100.00^{+0.00}_{-0.07}$
All cuts (χ^2)	2372	$89.75^{+0.63}_{-0.64}$
All track cuts	2422	$91.64^{+0.50}_{-0.57}$
All trk cuts excl. isol.	2513	$95.08^{+0.40}_{-0.48}$

TABLE I: Dataset bhmumkP17: Muon ID efficiencies for CM

P18

Cut	Count	Efficiency (%)
No cut	4418	
E_{EM} cut	4297	$97.26^{+0.24}_{-0.28}$
E_{HAD} cut	4335	$98.12^{+0.21}_{-0.23}$
COT hits cut	4415	$99.93^{+0.03}_{-0.06}$
d_0 cut	4387	$99.30^{+0.13}_{-0.14}$
Isolation cut	4214	$95.38^{+0.30}_{-0.34}$
Δx_{CMU} cut	4399	$99.57^{+0.09}_{-0.13}$
Δx_{CMP} cut	4323	$97.85^{+0.21}_{-0.23}$
All above cuts	3918	$88.68^{+0.50}_{-0.47}$
All cuts excl. isol.	4086	$92.49^{+0.41}_{-0.42}$
Sliding isol. cut	4287	$97.03^{+0.26}_{-0.28}$
All cuts (sliding isol.)	3981	$90.11^{+0.44}_{-0.48}$
χ^2 cut	4418	$100.00^{+0.00}_{-0.04}$
All cuts (χ^2)	3918	$88.68^{+0.50}_{-0.47}$
All track cuts	4017	$90.92^{+0.46}_{-0.47}$
All trk cuts excl. isol.	4190	$94.84^{+0.35}_{-0.33}$

TABLE I: Dataset bhmummP18: Muon ID efficiencies for CMUP

CMUP ID SF

P17

Cut	Scale Factor
No cut	
E_{EM} cut	$1.0067^{+0.0036}_{-0.0041}$
E_{HAD} cut	$1.0015^{+0.0024}_{-0.0029}$
COT hits cut	$1.0001^{+0.0000}_{-0.0007}$
d_0 cut	$0.9995^{+0.0012}_{-0.0015}$
Isolation cut	$0.9941^{+0.0039}_{-0.0042}$
Δx_{CMU} cut	$0.9971^{+0.0010}_{-0.0016}$
Δx_{CMP} cut	$0.9867^{+0.0027}_{-0.0032}$
All above cuts	$0.9863^{+0.0070}_{-0.0070}$
All cuts excl. isol.	$0.9914^{+0.0054}_{-0.0056}$
Sliding isol. cut	$0.9964^{+0.0031}_{-0.0035}$
All cuts (sliding isol.)	$0.9877^{+0.0060}_{-0.0069}$
χ^2 cut	$1.0000^{+0.0000}_{-0.0007}$
All cuts (χ^2)	$0.9863^{+0.0070}_{-0.0070}$
All track cuts	$1.0018^{+0.0055}_{-0.0063}$
All trk cuts excl. isol.	$1.0074^{+0.0043}_{-0.0051}$

TABLE I: Dataset bhmumkP17_zektimP14: Muon ID Scal

P18

Cut	Scale Factor
No cut	
E_{EM} cut	$1.0110^{+0.0025}_{-0.0029}$
E_{HAD} cut	$0.9977^{+0.0021}_{-0.0024}$
COT hits cut	$0.9995^{+0.0003}_{-0.0006}$
d_0 cut	$0.9957^{+0.0013}_{-0.0014}$
Isolation cut	$0.9869^{+0.0031}_{-0.0035}$
Δx_{CMU} cut	$0.9958^{+0.0009}_{-0.0013}$
Δx_{CMP} cut	$0.9838^{+0.0021}_{-0.0023}$
All above cuts	$0.9759^{+0.0056}_{-0.0053}$
All cuts excl. isol.	$0.9855^{+0.0044}_{-0.0045}$
Sliding isol. cut	$0.9947^{+0.0026}_{-0.0029}$
All cuts (sliding isol.)	$0.9828^{+0.0049}_{-0.0053}$
χ^2 cut	$1.0000^{+0.0000}_{-0.0004}$
All cuts (χ^2)	$0.9759^{+0.0056}_{-0.0053}$
All track cuts	$0.9952^{+0.0051}_{-0.0052}$
All trk cuts excl. isol.	$1.0051^{+0.0038}_{-0.0036}$

TABLE I: Dataset bhmummP18_zektim: Muon ID Scale Factors for CMUP

CMX ID Efficiencies

P17

Cut	Count	Efficiency (%)
No cut	1700	
E_{EM} cut	1635	$96.18^{+0.48}_{-0.55}$
E_{HAD} cut	1664	$97.88^{+0.34}_{-0.40}$
COT hits cut	1698	$99.88^{+0.07}_{-0.16}$
d_0 cut	1695	$99.71^{+0.14}_{-0.21}$
Isolation cut	1613	$94.88^{+0.58}_{-0.60}$
Δx_{CMX} cut	1695	$99.71^{+0.14}_{-0.21}$
All above cuts	1512	$88.94^{+0.76}_{-0.81}$
All cuts excl. isol.	1589	$93.47^{+0.62}_{-0.65}$
Sliding isol. cut	1645	$96.76^{+0.43}_{-0.50}$
All cuts (sliding isol.)	1540	$90.59^{+0.67}_{-0.79}$
χ^2 cut	1700	$100.00^{+0.00}_{-0.11}$
All cuts (χ^2)	1512	$88.94^{+0.76}_{-0.81}$
All track cuts	1515	$89.12^{+0.77}_{-0.79}$
All trk cuts excl. isol.	1593	$93.71^{+0.58}_{-0.69}$

P18

Cut	Count	Efficiency (%)
No cut	2747	
E_{EM} cut	2659	$96.80^{+0.35}_{-0.39}$
E_{HAD} cut	2696	$98.14^{+0.27}_{-0.32}$
COT hits cut	2745	$99.93^{+0.05}_{-0.10}$
d_0 cut	2740	$99.75^{+0.09}_{-0.14}$
Isolation cut	2628	$95.67^{+0.40}_{-0.43}$
Δx_{CMX} cut	2732	$99.45^{+0.14}_{-0.17}$
All above cuts	2484	$90.43^{+0.54}_{-0.63}$
All cuts excl. isol.	2587	$94.18^{+0.43}_{-0.50}$
Sliding isol. cut	2657	$96.72^{+0.32}_{-0.36}$
All cuts (sliding isol.)	2511	$91.41^{+0.53}_{-0.56}$
χ^2 cut	2747	$100.00^{+0.00}_{-0.07}$
All cuts (χ^2)	2484	$90.43^{+0.54}_{-0.63}$
All track cuts	2499	$90.97^{+0.58}_{-0.59}$
All trk cuts excl. isol.	2602	$94.72^{+0.42}_{-0.46}$

TABLE II: Dataset bhmummP18: Muon ID efficiencies for CMX

CMX ID SF

P17

Cut	Scale Factor
No cut	
E_{EM} cut	$0.9990^{+0.0050}_{-0.0057}$
E_{HAD} cut	$1.0004^{+0.0035}_{-0.0041}$
COT hits cut	$0.9989^{+0.0007}_{-0.0016}$
d_0 cut	$0.9995^{+0.0014}_{-0.0021}$
Isolation cut	$0.9784^{+0.0060}_{-0.0062}$
Δx_{CMX} cut	$0.9986^{+0.0014}_{-0.0021}$
All above cuts	$0.9755^{+0.0084}_{-0.0089}$
All cuts excl. isol.	$0.9962^{+0.0067}_{-0.0070}$
Sliding isol. cut	$0.9899^{+0.0044}_{-0.0051}$
All cuts (sliding isol.)	$0.9860^{+0.0074}_{-0.0087}$
χ^2 cut	$1.0000^{+0.0000}_{-0.0011}$
All cuts (χ^2)	$0.9755^{+0.0084}_{-0.0089}$
All track cuts	$0.9760^{+0.0085}_{-0.0087}$
All trk cuts excl. isol.	$0.9971^{+0.0062}_{-0.0074}$

P18

Cut	Scale Factor
No cut	
E_{EM} cut	$1.0060^{+0.0036}_{-0.0040}$
E_{HAD} cut	$1.0031^{+0.0028}_{-0.0033}$
COT hits cut	$0.9994^{+0.0005}_{-0.0010}$
d_0 cut	$0.9996^{+0.0009}_{-0.0014}$
Isolation cut	$0.9874^{+0.0042}_{-0.0044}$
Δx_{CMX} cut	$0.9961^{+0.0014}_{-0.0017}$
All above cuts	$0.9931^{+0.0060}_{-0.0070}$
All cuts excl. isol.	$1.0041^{+0.0046}_{-0.0054}$
Sliding isol. cut	$0.9896^{+0.0033}_{-0.0037}$
All cuts (sliding isol.)	$0.9955^{+0.0059}_{-0.0062}$
χ^2 cut	$1.0000^{+0.0000}_{-0.0007}$
All cuts (χ^2)	$0.9931^{+0.0060}_{-0.0070}$
All track cuts	$0.9975^{+0.0064}_{-0.0065}$
All trk cuts excl. isol.	$1.0083^{+0.0045}_{-0.0049}$

TABLE II: Dataset bhmummP18_zektim: 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.

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	$89.47^{+1.64}_{-1.88}$

P16

Category	Fiducial	w/ Stub	Efficiency (%)
CMUP	1513	1351	$89.29^{+0.80}_{-0.87}$
CMX	831	789	$94.95^{+0.81}_{-0.85}$
CMX Arches	655	633	$96.64^{+0.67}_{-0.89}$
CMX Miniskirt	149	130	$87.25^{+2.79}_{-3.46}$
CMX Keystone	27	26	$96.30^{+3.12}_{-7.82}$
CMU-only	361	330	$91.41^{+1.46}_{-1.67}$
CMP-only	428	373	$87.15^{+1.62}_{-1.90}$
CMX MiniKey	176	156	$88.64^{+2.57}_{-2.89}$

P17

Category	Fiducial	w/ Stub	Efficiency (%)
CMUP	2893	2574	$88.97^{+0.63}_{-0.64}$
CMX	1727	1643	$95.14^{+0.52}_{-0.56}$
CMX Arches	1355	1305	$96.31^{+0.52}_{-0.56}$
CMX Miniskirt	305	278	$91.15^{+1.72}_{-1.99}$
CMX Keystone	67	60	$89.55^{+3.61}_{-4.98}$
CMU-only	741	656	$88.53^{+1.22}_{-1.32}$
CMP-only	777	688	$88.55^{+1.20}_{-1.34}$
CMX MiniKey	372	338	$90.86^{+1.42}_{-1.70}$

P18

Category	Fiducial	w/ Stub	Efficiency (%)
CMUP	4834	4307	$89.10^{+0.43}_{-0.45}$
CMX	2820	2673	$94.79^{+0.40}_{-0.48}$
CMX Arches	2242	2163	$96.48^{+0.37}_{-0.46}$
CMX Miniskirt	450	396	$88.00^{+1.55}_{-1.77}$
CMX Keystone	128	114	$89.06^{+2.93}_{-3.32}$
CMU-only	1171	1030	$87.96^{+0.96}_{-1.00}$
CMP-only	1377	1233	$89.54^{+0.84}_{-0.92}$
CMX MiniKey	578	510	$88.24^{+1.32}_{-1.42}$

Reconstruction SF

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	$0.8747^{+0.0177}_{-0.0177}$

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	$0.9041^{+0.0166}_{-0.0166}$

P16

Category	Scale Factor
CMUP	$0.9167^{+0.0082}_{-0.0089}$
CMX	$0.9532^{+0.0081}_{-0.0086}$
CMX Arches	$0.9683^{+0.0067}_{-0.0089}$
CMX Miniskirt	$0.8812^{+0.0282}_{-0.0349}$
CMX Keystone	$0.9749^{+0.0316}_{-0.0792}$
CMU-only	$0.9370^{+0.0150}_{-0.0171}$
CMP-only	$0.8871^{+0.0165}_{-0.0193}$
CMX MiniKey	$0.8956^{+0.0260}_{-0.0260}$

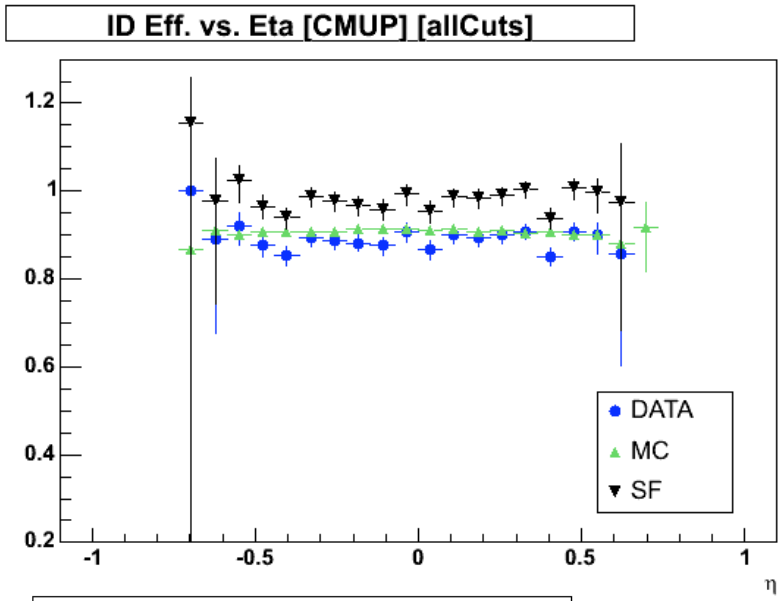
P17

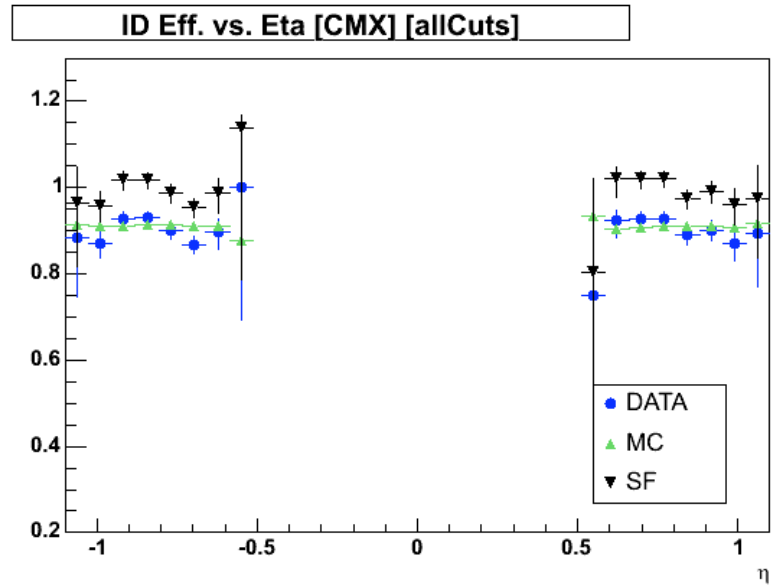
Category	Scale Factor
CMUP	$0.9134^{+0.0064}_{-0.0066}$
CMX	$0.9551^{+0.0052}_{-0.0056}$
CMX Arches	$0.9650^{+0.0052}_{-0.0056}$
CMX Miniskirt	$0.9206^{+0.0174}_{-0.0201}$
CMX Keystone	$0.9066^{+0.0366}_{-0.0505}$
CMU-only	$0.9074^{+0.0125}_{-0.0136}$
CMP-only	$0.9013^{+0.0122}_{-0.0136}$
CMX MiniKey	$0.9181^{+0.0144}_{-0.0144}$

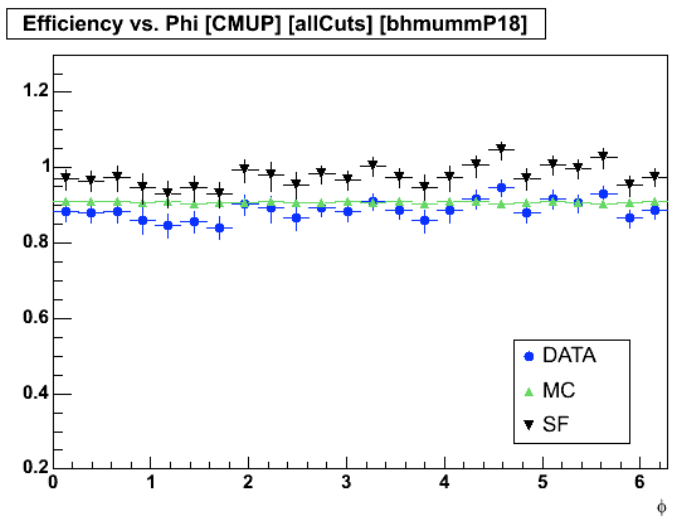
P18

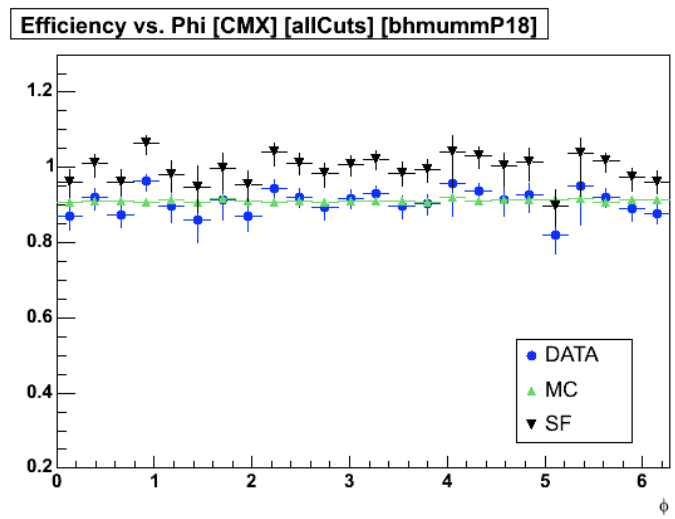
Category	Scale Factor
CMUP	$0.9144^{+0.0044}_{-0.0046}$
CMX	$0.9516^{+0.0041}_{-0.0048}$
CMX Arches	$0.9668^{+0.0038}_{-0.0046}$
CMX Miniskirt	$0.8883^{+0.0157}_{-0.0179}$
CMX Keystone	$0.9020^{+0.0297}_{-0.0337}$
CMU-only	$0.9015^{+0.0098}_{-0.0102}$
CMP-only	$0.9112^{+0.0085}_{-0.0094}$
CMX MiniKey	$0.8912^{+0.0133}_{-0.0133}$

Reco and ID Plots

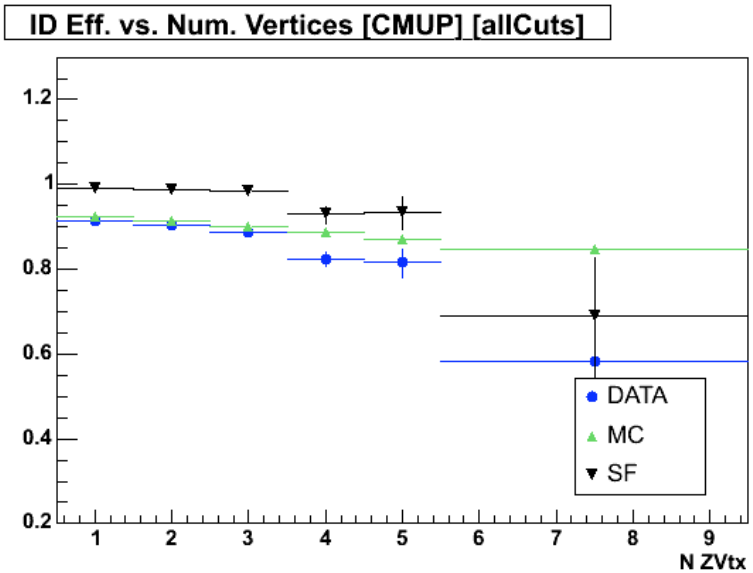


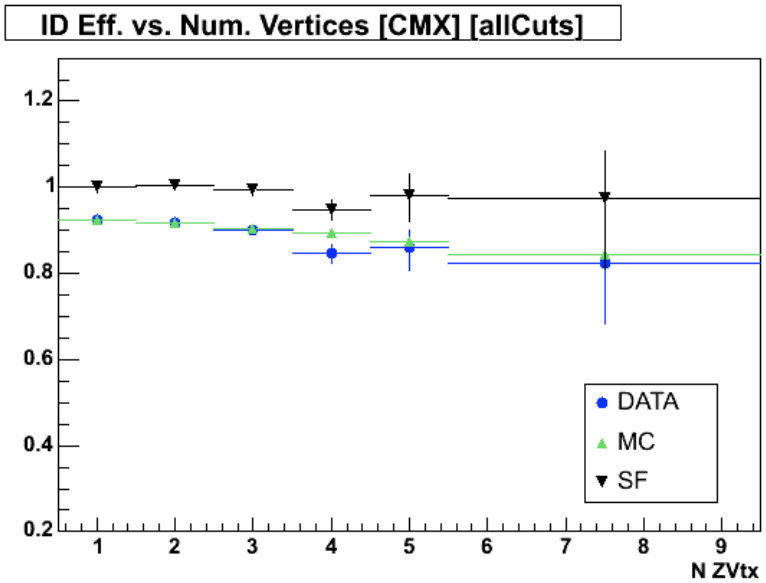


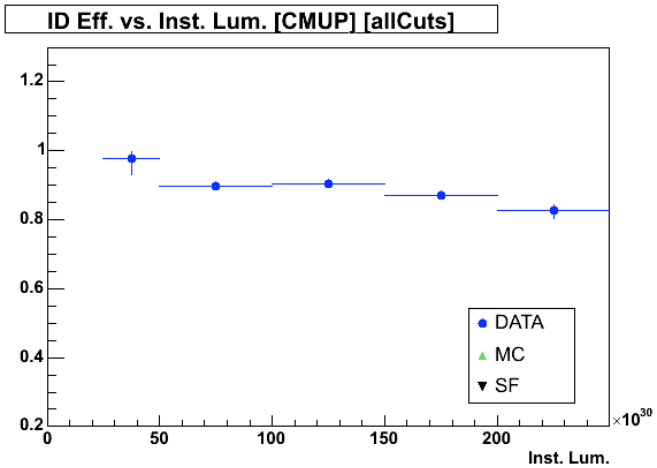


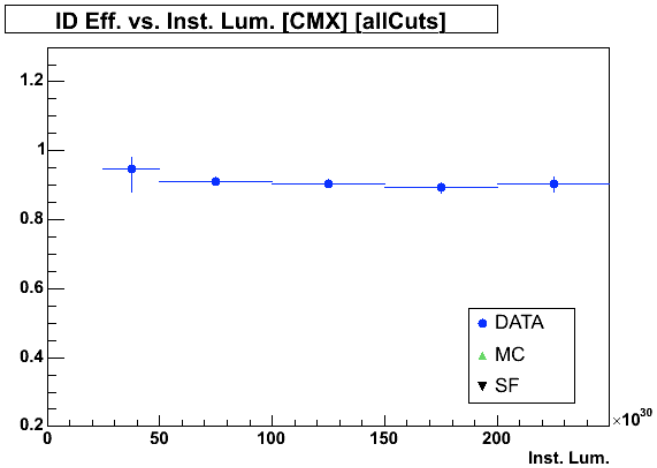


Reco and ID Plots

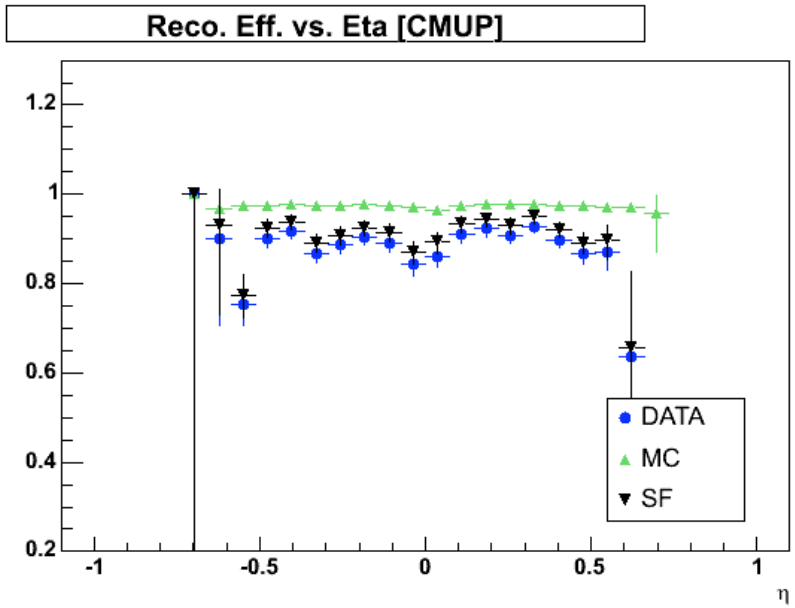


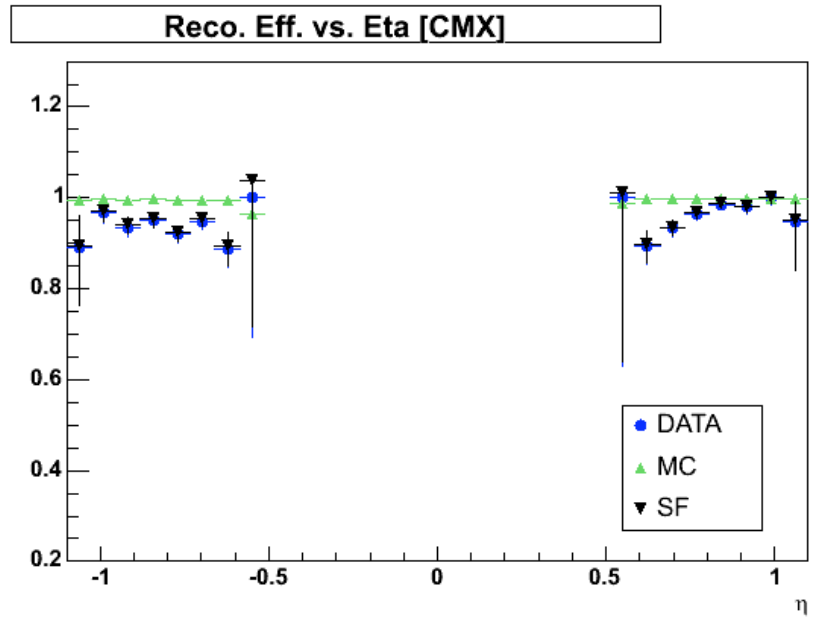


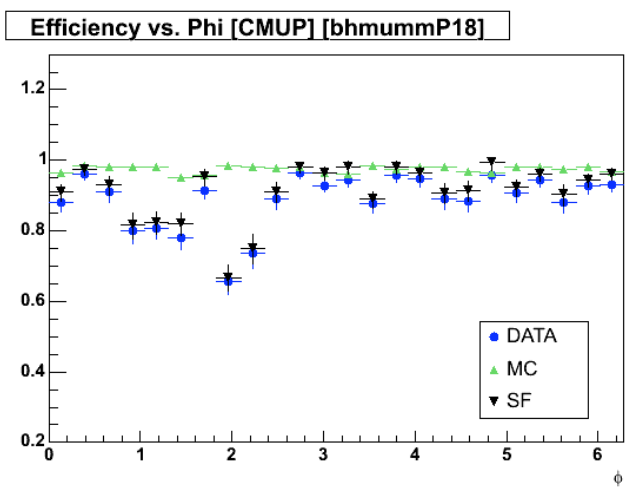


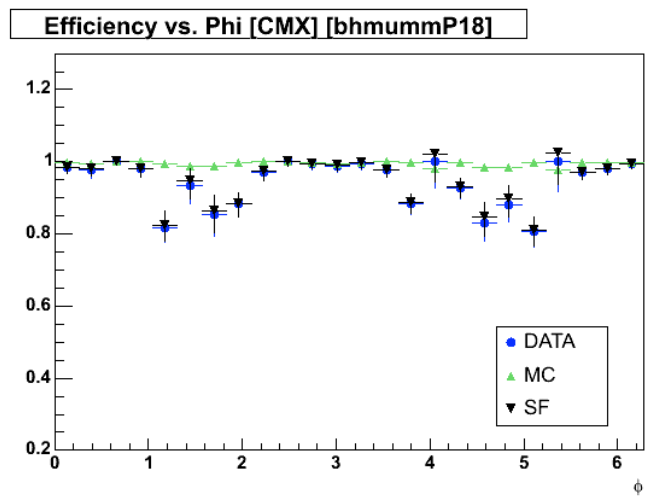


Reco and ID Plots









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

L1

1st leg	2nd leg	1st passes	both pass	Efficiency (%)
CMUP	CMUP	877	775	-
CMX	CMUP	1022	970	$94.27^{+0.52}_{-0.46}$
CMUP	CMX	1087	970	-
CMX	CMX	373	287	$88.57^{+0.84}_{-0.79}$
CMUP	ARCH	859	823	-
CMUP	MK	228	147	-
ARCH	ARCH	257	227	-
ARCH	MK	80	40	-
MK	ARCH	40	40	$95.46^{+0.64}_{-0.55}$
MK	MK	36	20	$73.47^{+2.56}_{-2.45}$

1st leg	2nd leg	1st passes	both pass	Efficiency (%)
CMUP	CMUP	1450	1276	-
CMX	CMUP	1736	1638	$93.91^{+0.41}_{-0.35}$
CMUP	CMX	1824	1638	-
CMX	CMX	579	461	$89.42^{+0.64}_{-0.58}$
CMUP	ARCH	1467	1389	-
CMUP	MK	357	249	-
ARCH	ARCH	412	366	-
ARCH	MK	124	73	-
MK	ARCH	76	73	$94.56^{+0.55}_{-0.50}$
MK	MK	40	22	$77.09^{+1.99}_{-1.97}$

L2

Category	Events Passing	Efficiency (%)
Pass L1	970	-
CMUP	869	$98.00^{+0.49}_{-0.61}$
CMX	799	$90.10^{+1.06}_{-1.09}$
CMUP-CMX	783	-
CMUP-A	734	-
CMUP-MK	135	-
CMUP-CMX-A	658	$89.65^{+1.08}_{-1.27}$
CMUP-CMX-MK	125	$92.59^{+2.13}_{-2.94}$

Category	Events Passing	Efficiency (%)
Pass L1	1638	-
CMUP	1353	$98.39^{+0.36}_{-0.42}$
CMX	1244	$90.47^{+0.79}_{-0.87}$
CMUP-CMX	1224	-
CMUP-A	1145	-
CMUP-MK	208	-
CMUP-CMX-A	1033	$90.22^{+0.85}_{-0.91}$
CMUP-CMX-MK	191	$91.83^{+1.83}$

P17

Category	Events Passing	Efficiency (%)
Pass L1	970	-
CMUP-CMUP$_S$	832	-
CMX-CMX$_S$	772	-
CMUP-CMX-CMUP$_S$	756	$94.62^{+0.84}_{-0.92}$
CMUP-CMX-CMX$_S$	756	$87.00^{+1.19}_{-1.16}$
CMUP-CMX-CMX$_S$-A	632	$86.10^{+1.30}_{-1.44}$
CMUP-CMX-CMX$_S$-MK	124	$91.85^{+2.48}_{-2.98}$

P18

Category	Events Passing	Efficiency (%)
Pass L1	1638	-
CMUP-CMUP$_S$	1288	-
CMX-CMX$_S$	1196	-
CMUP-CMX-CMUP$_S$	1178	$94.69^{+0.67}_{-0.70}$
CMUP-CMX-CMX$_S$	1178	$87.07^{+0.87}_{-0.98}$
CMUP-CMX-CMX$_S$-A	993	$86.72^{+1.02}_{-1.13}$
CMUP-CMX-CMX$_S$-MK	185	$88.94^{+2.27}_{-2.71}$

Trigger Eff

L3

Category	Events Passing	Efficiency (%)
Pass L2	783	-
CMUP	780	$99.62^{+0.20}_{-0.36}$
CMX	781	$99.74^{+0.17}_{-0.34}$
CMUP-CMX	778	-
CMUPA	655	-
CMUPMK	125	-
CMUPARCH	653	$99.69^{+0.20}_{-0.39}$
CMUP-MK	125	$100.00^{+0.00}_{-1.46}$

Combined

Category	Efficiency (%)
CMUP	$92.03^{+0.71}_{-0.80}$
CMX	$79.60^{+1.21}_{-1.23}$
CMX A	$85.32^{+1.18}_{-1.35}$
CMX MK	$68.03^{+2.84}_{-3.29}$
CMUP SLAM	$88.85^{+0.95}_{-1.02}$
CMX SLAM	$76.85^{+1.29}_{-1.26}$
CMX SLAM A	$81.95^{+1.36}_{-1.48}$
CMX SLAM MK	$67.48^{+2.98}_{-3.29}$

P17

Category	Events Passing	Efficiency (%)
Pass L2	1224	-
CMUP	1220	$99.67^{+0.17}_{-0.25}$
CMX	1223	$99.92^{+0.06}_{-0.19}$
CMUP-CMX	1219	-
CMUPA	1030	-
CMUPMK	190	-
CMUPARCH	1029	$99.90^{+0.08}_{-0.23}$
CMUP-MK	190	$100.00^{+0.00}_{-0.96}$

Category	Efficiency (%)
CMUP	$92.10^{+0.55}_{-0.57}$
CMX	$80.82^{+0.92}_{-0.95}$
CMX A	$85.22^{+0.94}_{-0.99}$
CMX MK	$70.79^{+2.30}_{-2.61}$
CMUP SLAM	$88.64^{+0.75}_{-0.76}$
CMX SLAM	$77.79^{+0.96}_{-1.02}$
CMX SLAM A	$81.92^{+1.08}_{-1.17}$
CMX SLAM MK	$68.57^{+2.49}_{-2.80}$

P18

Comparison with previous periods

CMUP

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

Period	Measured (SR)	Livetime Corr.	Corr. Efficiency
10	0.9196(56)	1.0	0.9196(56)
11	0.9198(61)	1.0	0.9198(61)
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)

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)
16	0.9172(116)		0.8939(137)
17	0.9203 (76)		0.8885 (97)
18	0.9210(56)		0.8864(75)

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)
16	0.8439 (204)	0.915	0.9223 (223)
17	0.8532 (127)	0.9128	0.9345 (127)
18	0.8522(96)	0.9539	0.8933 (96)

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 = 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	0.8522/0.9539=0.8933 (96)	0.8192/0.954 = 0.8587 (112)

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
- $\chi^2_{strip} < 10$
- $L_{shr} < 0.2$

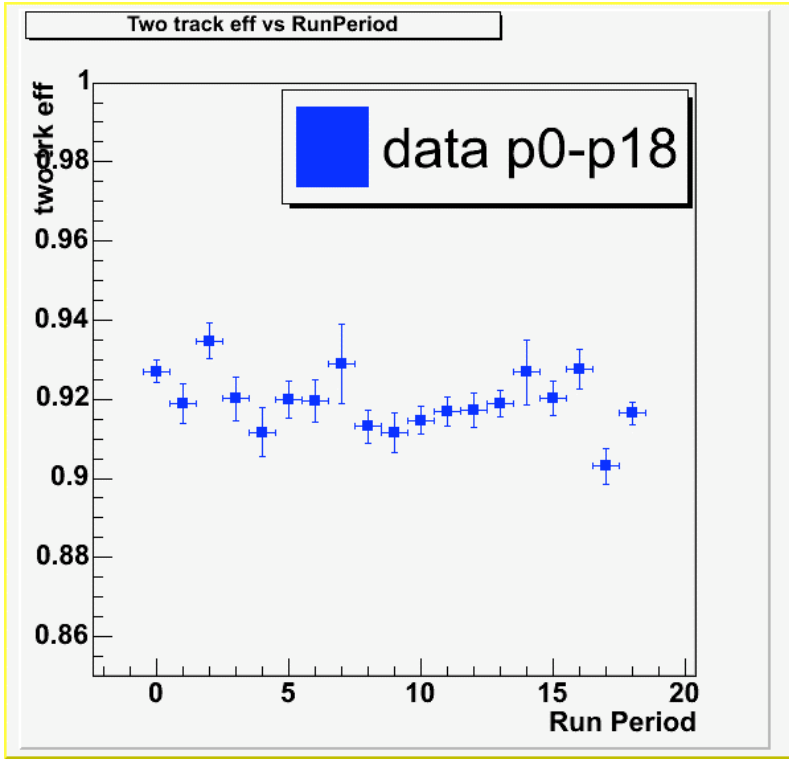
Calorimeter + tracking cuts

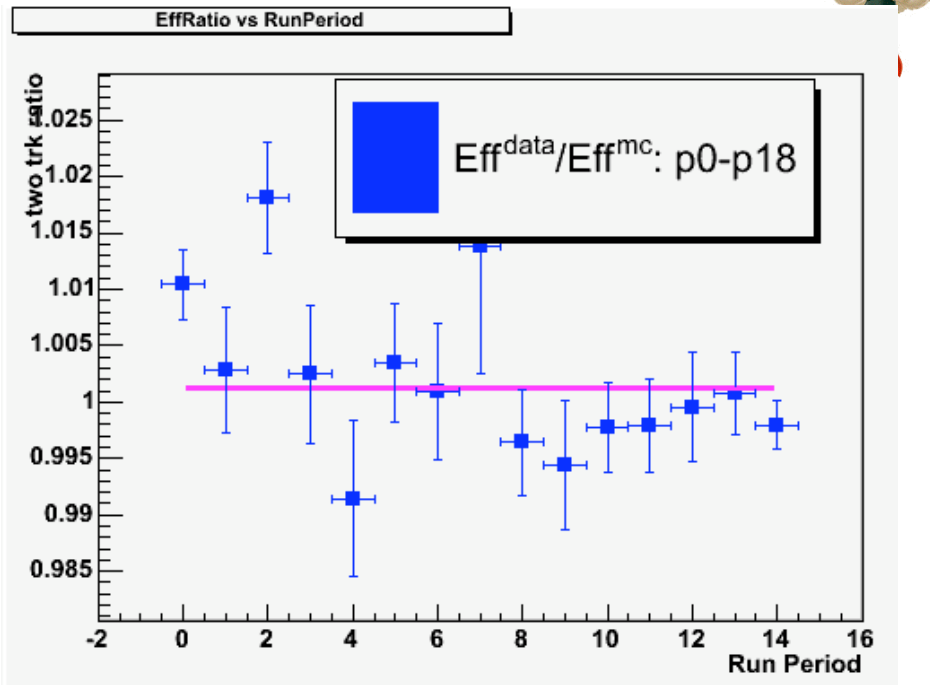
- trkPt > 10 GeV

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

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

COT Efficiencies: Run Number





EXT PARAMETER			
NO.	NAME	VALUE	ERROR
1	p0	1.00126e+00	1.09512e-03

$$e_{2trk}^{DATA} = 0.9186 \pm 0.0010$$

$$e_{2trk}^{MC} = 0.9178 \pm 0.0002$$

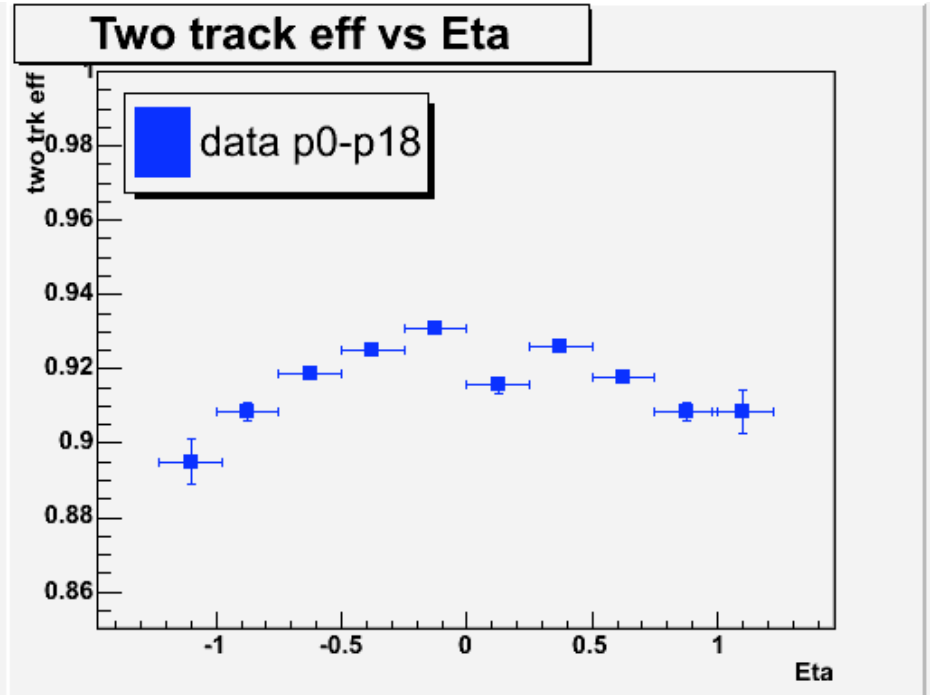
$$e_{2trk}^{DATA} = 0.9189 \pm 0.0010$$

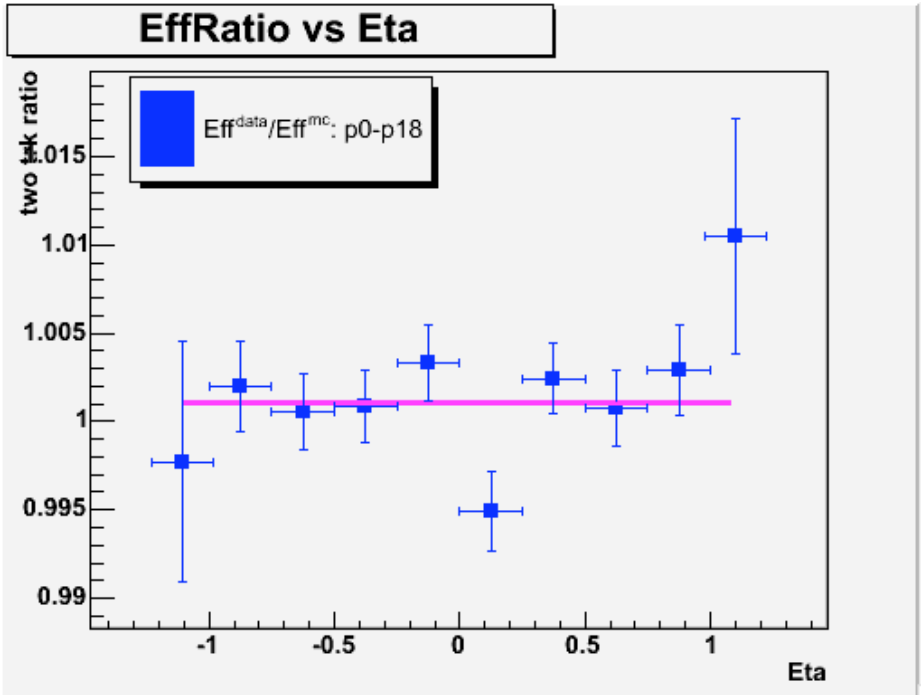
up to P17

COT Efficiencies vs Periods

Period	Ncc	Ncc + 2trk	Efficiency	Error
0	9117	8452	0.9270	0.0027
1	3013	2769	0.9190	0.0050
2	3112	2909	0.9348	0.0044
3	2492	2293	0.9201	0.0054
4	2094	1909	0.9116	0.0062
5	3351	3083	0.9200	0.0047
6	2547	2342	0.9195	0.0054
7	661	614	0.9289	0.0099
8	4514	4122	0.9132	0.0042
9	3089	2816	0.9116	0.0051
10	6321	5781	0.9145	0.0035
11	5566	5103	0.9168	0.0037
12	3922	3597	0.9171	0.0044
13	6930	6368	0.9189	0.00328
14	1025	950	0.9268	0.00813
15	3908	3596	0.9202	0.00433
16	2777	2576	0.9276	0.00492
17	4284	3869	0.9031	0.00452
18	9172	8406	0.9164	0.00289

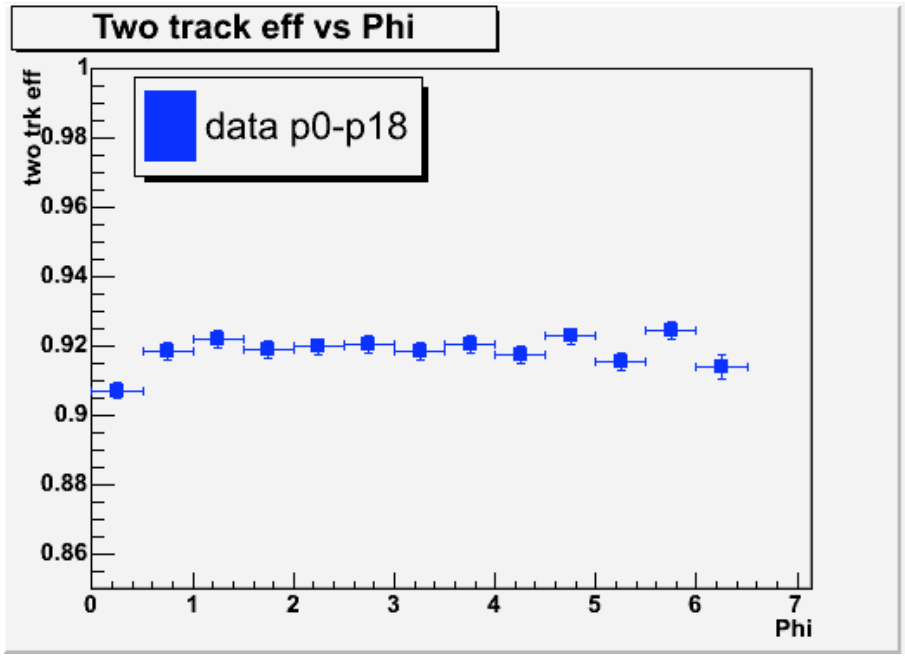
COT Efficiencies:Eta

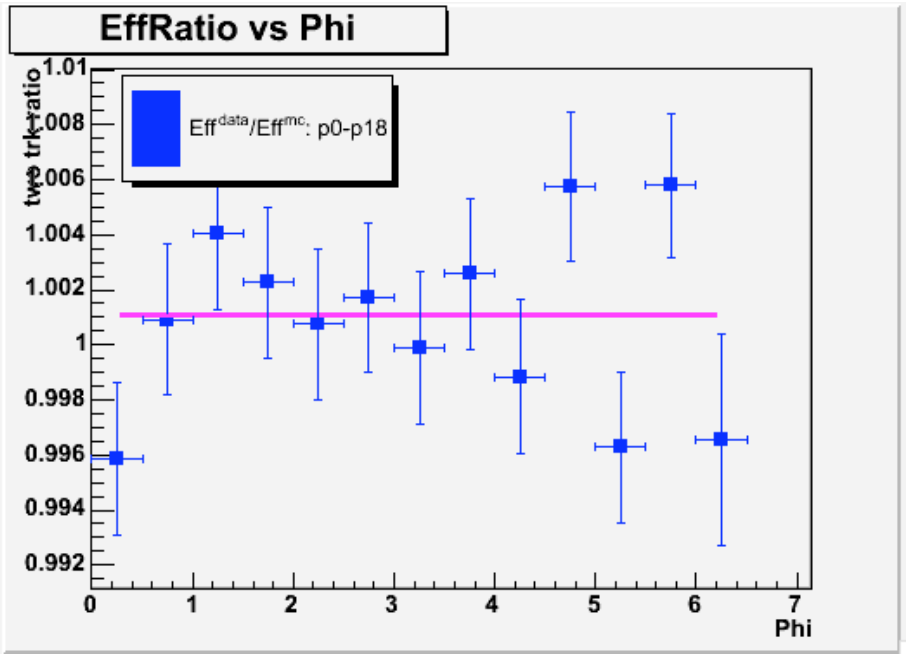




NO.	NAME	VALUE	ERROR
1	p0	1.00103e+00	7.71490e-04

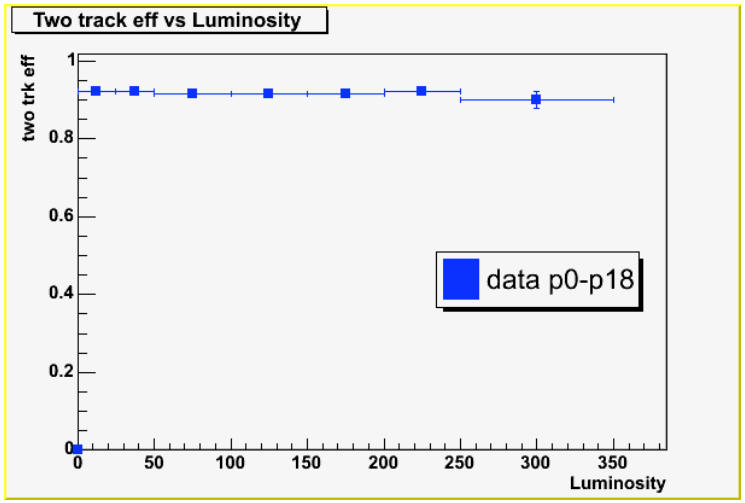
COT Efficiencies:Phi

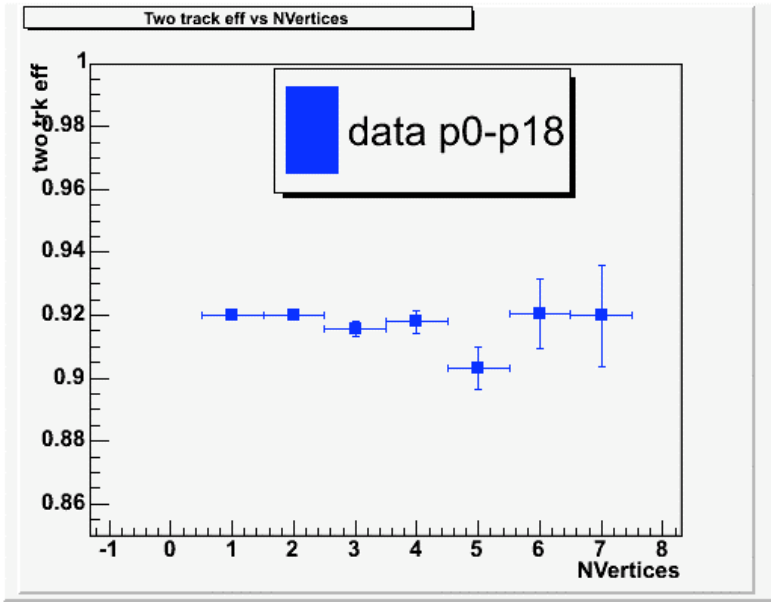


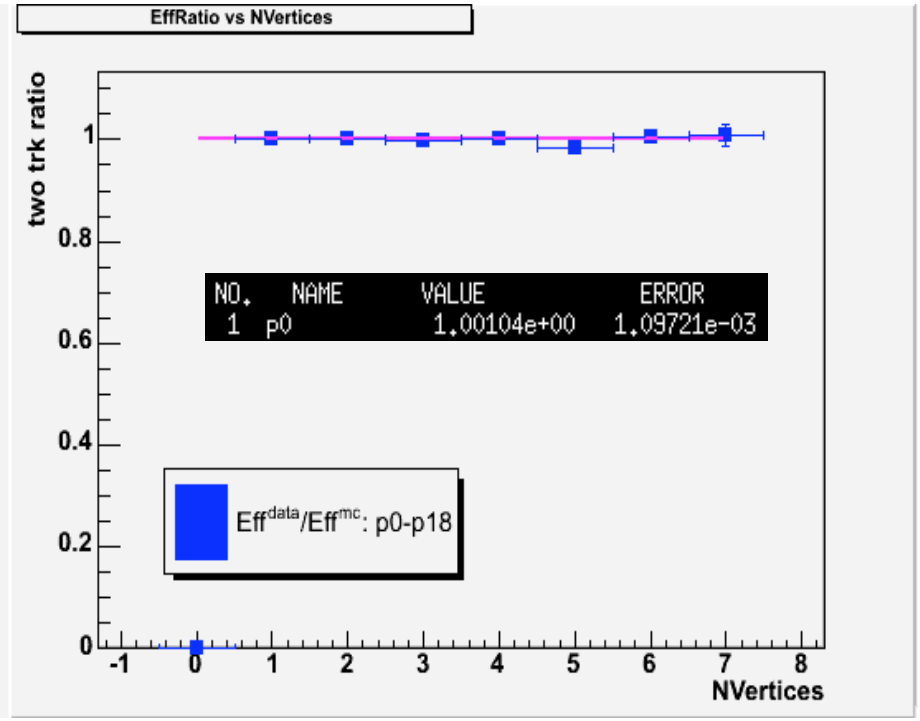


NO.	NAME	VALUE	ERROR
1	p0	1.00109e+00	7.74437e-04

COT Efficiencies: Lumi and NVertexes







Conclusions

- P18 high PT electrons and muons analyzed:
  - Electron ID
    - General drop in efficiency, same iso-ID as in P17 due to high lumi runs - waiting for expert comment
    - Ele Trigger - ok
  - Muon ID and Reco ok
  - Muon Trigger ok - cross check dps accounting
  - MET_PEM trigger - next time…
  - COT Eff - in good agreement with previous numbers