Lepton ID/Reco/Trigger Efficiencies and SF for Period 11 High PT Lepton Data

Simona Rolli

Electrons ID

PerflDia

http://ncdf70.fnal.gov:8001/PerflDia/PerflDia.html

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- Documentation:
  - Web Page
  - CDF Note 8274, June 1st, 2006
  - CDF Note 8614, November 27, 2006
  - Joint Physics Meeting Blessing, November 17, 2006
- Code:
  - Instructions on how to run the code
- Results:
  - Period 9 data ( ): Runs 222529 to 228596 (MC sample zewkcd):
    - Mass distributions with comparisons between data and MC
    - Efficiencies and Scale Factors for data and MC (file not formatted!)
  - Post ShutDown data (June 2006 to September 2006): Runs 217990 to 222426 (MC sample zewkcd):
    - Mass distributions with comparisons between data and MC
    - Efficiencies and Scale Factors for data and MC (file not formatted!)
  - bhel0i Pre ShutDown data (September 2005 to June 2006): Runs 203819 to 212133: (MC sample zewkcd)
    - Mass distributions with comparisons between data and MC
    - Efficiencies and Scale Factors for data and MC (file not formatted!)
  - bhel0h (December 2004 to September 2005): Runs 190697 to 203799 (MC sample zewkcd)
    - Mass distributions with comparisons between data and MC
    - Efficiencies and Scale Factors for data and MC (file not formatted!)
  - bhel0d (2002 to August 2004) : Runs 138425 to 186598 (MC sample zewkcd)
    - Mass distributions with comparisons between data and MC
    - Efficiencies and Scale Factors for data and MC (file not formatted!)

How to run the electron efficiency code on TopNtuple
The code runs in two steps:

- A standalone executable runs on TopNtuple:
  - 1.) main_lepid: basically reads in the command line arguments and then runs ana_lepid

Electrons ID: Samples

Dataset bhelmj: Runs 233133 to 237795
MC sample : zewkee (dataset zemtee as of June 20 2007)
GRL :perliminary GRL for Period 11
(http://www-cdf.fnal.gov/internal/dqm/goodrun/good.html)

Looked at 32 files as from the lepton skim list:
http://www-cdf.fnal.gov/internal/physics/top/RunIITopProp/gen6/filelists/gen6/bhelmj1_lepton.rootlist

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.	≥ 3
COT St. Seg.	≥ 2
Conversion	$\neq 1$
Had/em	$\leq (0.055 + (0.00045 \times E))$
Isolation	≤ 0.1
LshrTrk	≤ 0.2
E/P	≤ 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	≤ 10.0

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	≤ 0.05	≤ 0.05
Pem3x3FitTow	$\neq 0$	$\neq 0$
Pem3x3Chisq	≤ 10	≤ 10
Pes5by9U	≥ 0.65	≥ 0.65
Pes5by9V	≥ 0.65	≥ 0.65
Isolation	≤ 0.1	≤ 0.1
ΔR	$\leq$ 3.0 cm	$\leq$ 3.0 cm
PhxMatch	TRUE	-
N_{hits}^{Si}	≥ 3	-
$\lvert z_0^{PHX} \rvert$	$\leq$ 60 cm	-

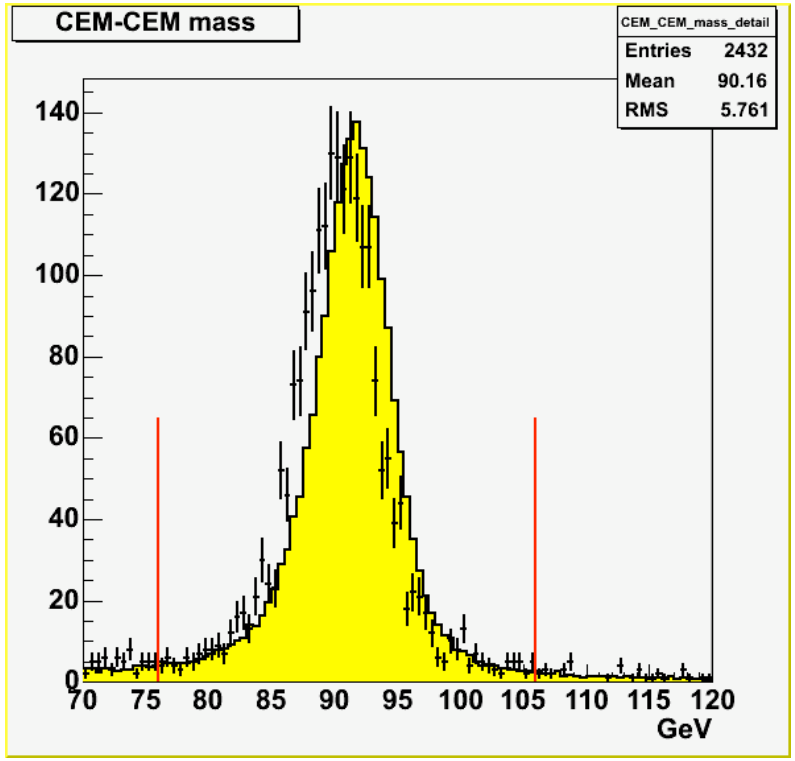
Electron ID: Results

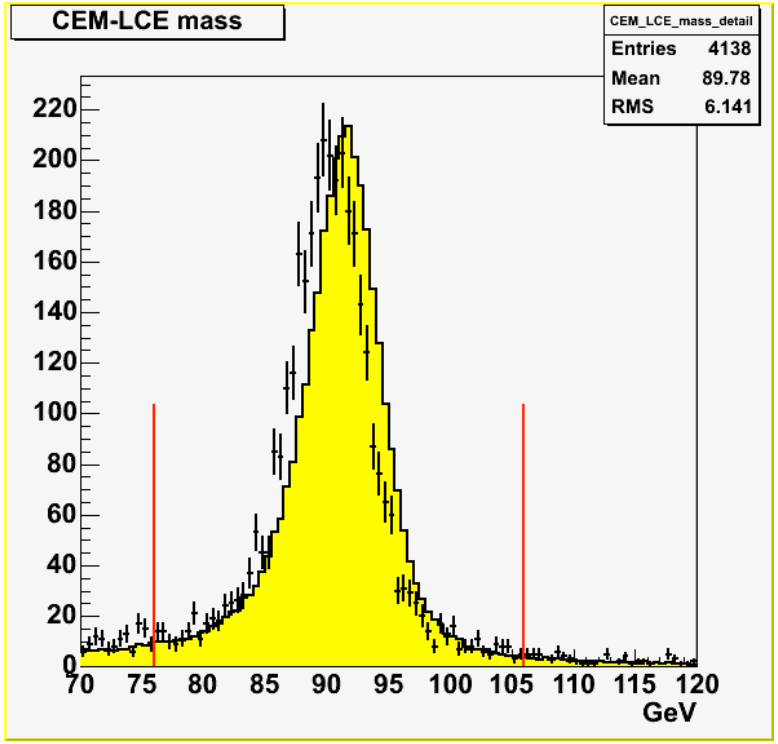
CEM	All errors are statistical only			
	0i Post SD	Per 9	**bhelmi (Per 10)**	MC (Zemted)
CEM Eff	0.788 +/- 0.005	0.789 +/- 0.005	0.787 +/- 0.004	0.805 +/- 0.001
CEM SF	0.977 +/- 0.006	0.978 +/- 0.006	0.978 +/- 0.005	N/A
nisoCEM Eff	0.816 +/- 0.004	0.818 +/- 0.005	0.816 +/- 0.004	0.830 +/- 0.001
nisoCEM SF	0.986 +/- 0.005	0.984 +/- 0.006	0.984 +/- 0.004	N/A
looseCEM Eff	0.915 +/- 0.003	0.914 +/- 0.003	0.914 +/- 0.003	0.917 +/- 0.001
looseCEM SF	0.996 +/- 0.004	0.996 +/- 0.004	0.996 +/- 0.003	N/A
nisolooseCEM Eff	0.945 +/- 0.003	0.945 +/- 0.003	0.946 +/- 0.002	0.947 +/- 0.001
nisolooseCEM SF	1.000 +/- 0.003	0.999 +/- 0.003	0.999 +/- 0.002	N/A
PHX				
Eff |Eta| < 2.0	0.708 +/- 0.007	0.700 +/- 0.008	0.702 +/- 0.006	0.758 +/- 0.00
SF |Eta| < 2.0	0.926 +/- 0.009	0.921 +/- 0.010	0.926 +/- 0.008	N/A
Eff |Eta| < 2.8	0.623 +/- 0.006	0.621 +/- 0.006	0.614 +/- 0.005	0.661 +/- 0.001
SF |Eta| < 2.8	0.929 +/- 0.009	0.936 +/- 0.010	0.929 +/- 0.008	N/A

CEM	
Bhelmi(P11)	**zewkee**
0.7770+\-0.0042	0.7983 +\-0.0009
0.97331 +\-0.00545	N/A
0.8116 +\-0.0040	0.8267 +\-0.0009
0.9817 +\-0.0049	N/A
0.9091 +/- 0.0029	0.9090 +\-0.0009
1.00015 +\-0.003	N/A
0.9423+\-0.0024	0.9433 +\-0.0009
0.9988 +\-0.0027	N/A

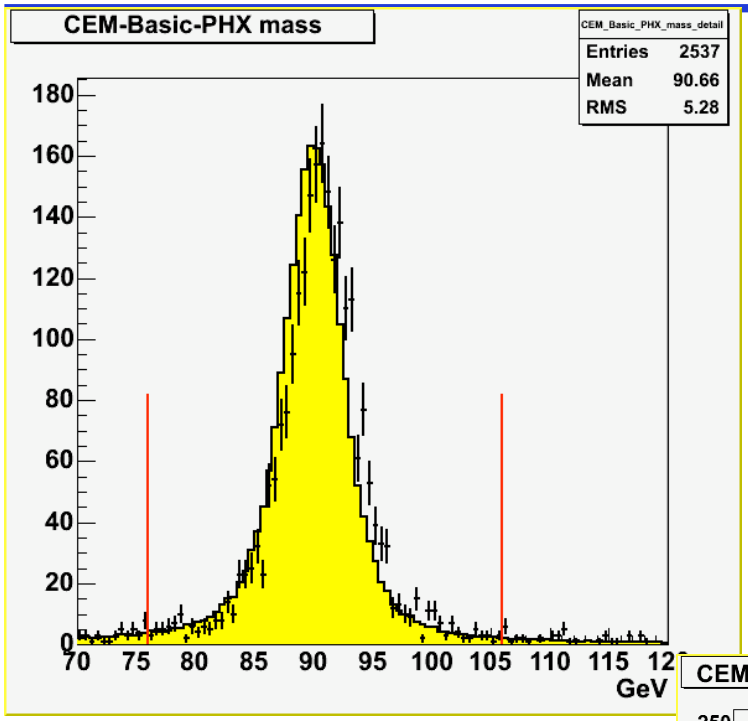
PHX	
0.6904+\-0.0063	0.7472+\-0.0012
0.9239+\- 0.0085	NA
In progress	In progress
In progress	N/A

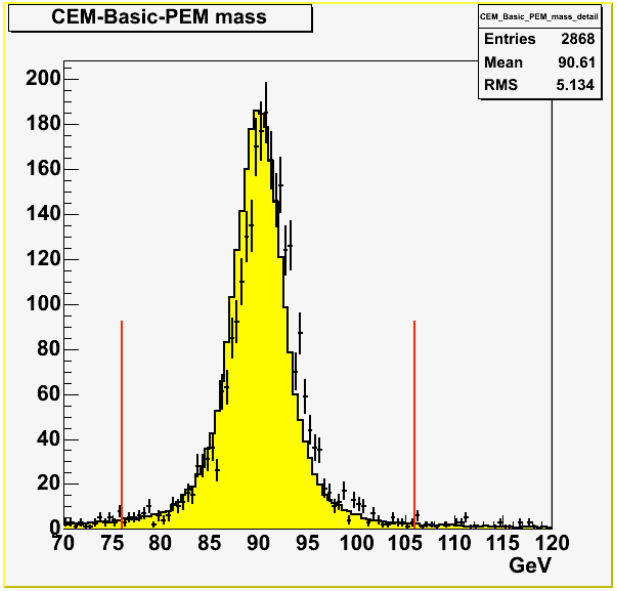
Electron ID Z candidates

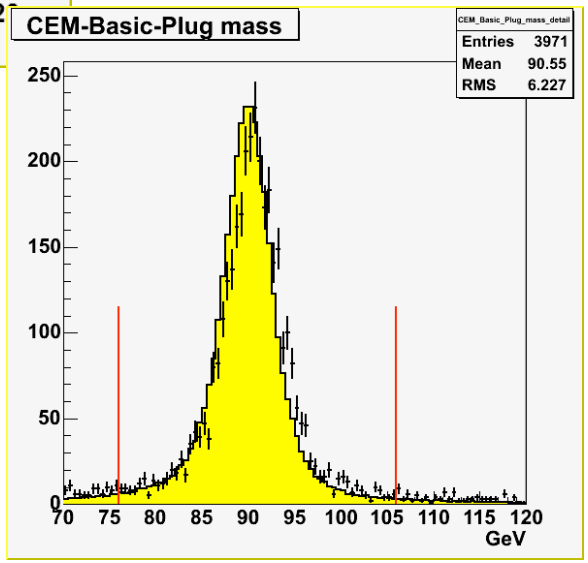




Electron ID Z candidates







Electron Trigger

PerflDia

http://ncdf70.fnal.gov:8001/PerflDia/PerflDia.html

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- Documentation:
  - Web Page (under construction)
  - CDF Note 7939
- Code:
  - Instructions on how to run the code
- Results:
  - Post ShutDown data (June 2006 to September 2006): Runs 217990 to 222426 (MC s zewkcd):
    - Number of events for NoSi GRL
    - Number of events for Si GRL
  - bhel0i Pre SD
  - bhel0h
  - bhel0f

How to run the electron trigger efficiency code on TopNtuple
Preliminary
There are two steps in producing trigger efficiencies (tracking only for the moment):

- First step: a standalone (release dependent code runs on TopNt). Here are the instructions:
  newrel -t 6.1.4 testrel;
  cd testrel;
  addpkg TopMods; setenv USESHLIBS yes ; gmake TopMods.nobin
  addpkg JetUser jetCorr06b
  gmake JetUser.lib LINK_SHARED_ROOT=yes
  cvsroot zoom
  addpkg ZMutility
  addpkg Exceptions
  gmake ZMutility.all USESHLIBS=1
  gmake Exceptions.all USESHLIBS=1
  in the test release add the following files (tar file with them here :
  ana.cc
  ana.hh

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.

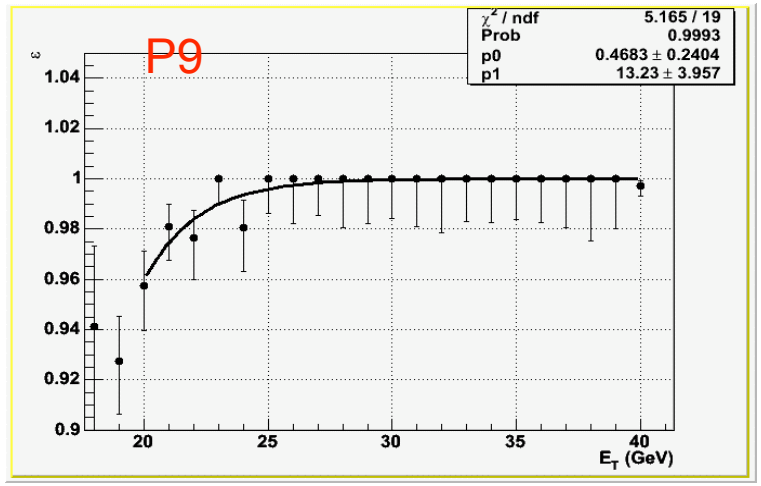
$$\epsilon(\text{L3_CEM18}) = \frac{\text{numEl \& passed EL_CENT_8_NO_L2 \& L2_CEM16 \& L3_CEM18}}{\text{numEl \& passed EL_CENT_8_NO_L2 \& L2_CEM16}}$$

Electron Trigger: Results

Trigger	Period 9	Period 10
L1_XFT_PT8	0.9651(6)	0.9677(5)
L2_XFT_PT8	0.9992(1)	0.9993(1)
L3 tracking	0.9954(2)	0.9924(2)
Total Tracking	0.9598(7)	0.9596(6)

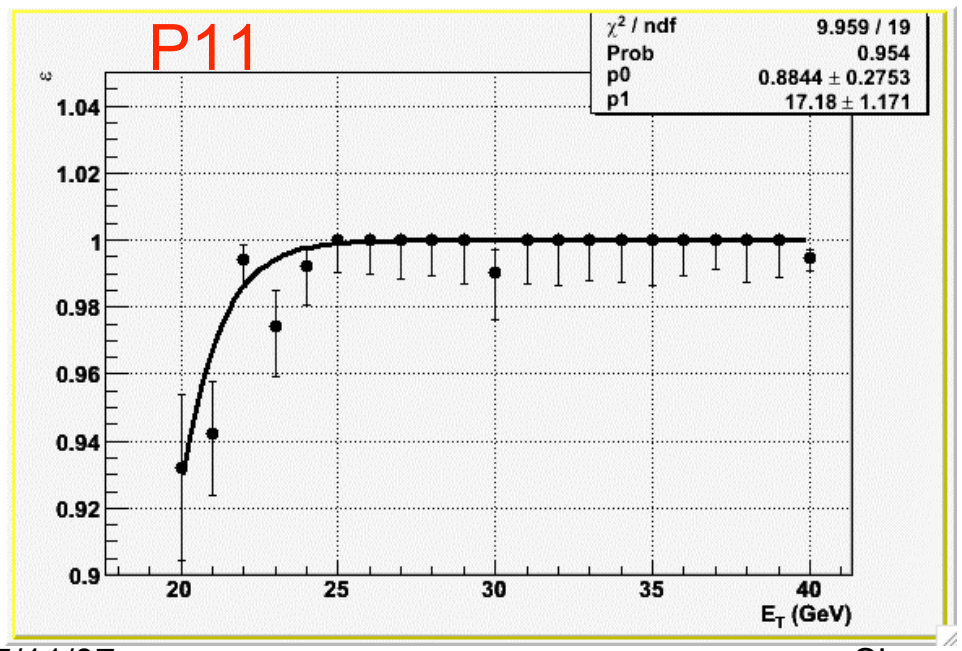
Trigger	Period 9	Period 10A	Period 10B	Period 11
L1_XFT_PT8	0.9651(6)	0.9673(7)	0.9650(29)	0.9687(4)
L2_XFT_PT8	0.9992(1)	0.9993(1)	0.9992(5)	0.9988(4)
L3 tracking	0.9954(2)	0.9932(3)	0.9968(9)	0.9934(4)
Total Tracking	0.9598(7)	0.9600(8)	0.9611(31)	0.9612(4)

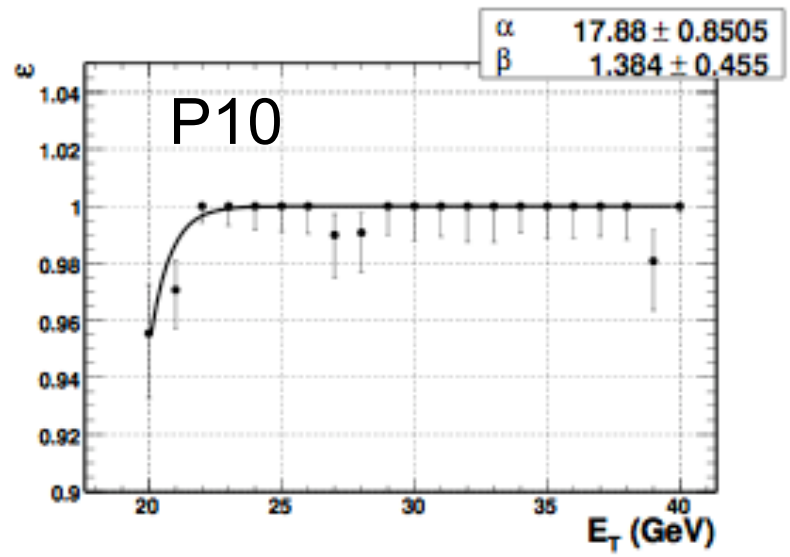
Electron Trigger : Results



L2_CEM16 calorimeter efficiency

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





Everything looks fine

Muons

Dataset bhelmj: Runs 233133 to 237795
MC sample : zewkem
GRL : goodrun_em_mu_si_cmxignored_v17.list

Files: Skim Lepton Files
http://www-cdf.fnal.gov/internal/physics/top/RunIITopProp/gen6/filelists/gen6/bhmumj1_lepton.rootlist

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.

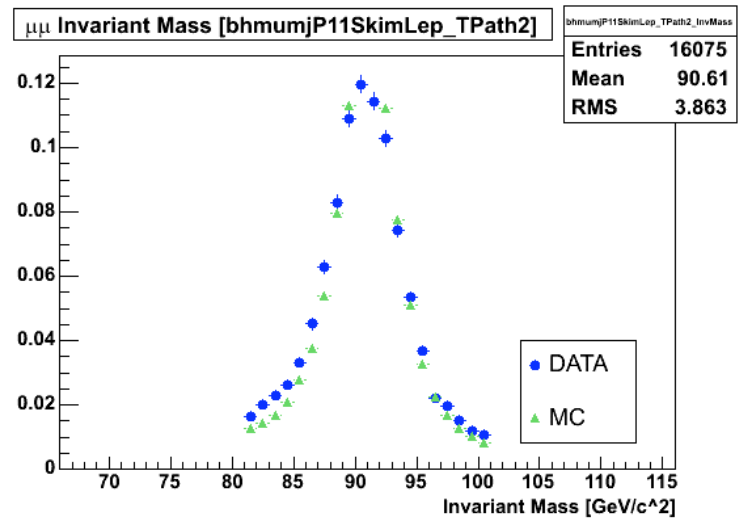
Arches:
$0^\circ \leq \phi \leq 75^\circ$ or $105^\circ \leq \phi \leq 225^\circ$ or $315^\circ \leq \phi < 360^\circ$
Additionally, for runs 190697 - 209760, remove:
$210^\circ < \phi \leq 225^\circ$ if $\eta < 0$
Keystone:
$75^\circ < \phi < 105^\circ$ and $\eta < 0$
Miniskirt:
$225^\circ < \phi <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

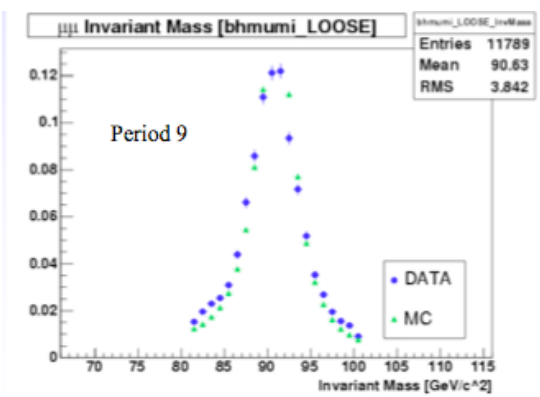
Table 3: Cuts on ϕ for distinguishing parts of the CMX detector when determining reconstruction efficiencies.

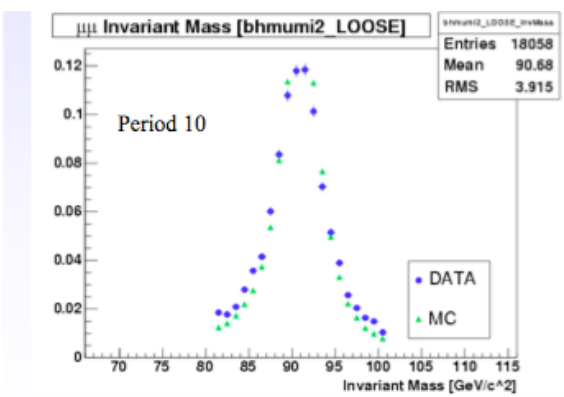
ID Efficiency Calculation

- 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

We are using $Z \rightarrow \mu^+\mu^-$ events with one identified leg (CMUP or CMX).
This first leg must pass all the ID cuts and must match to level 1 trigger information.
We are then looking if the second leg pas ID cuts in question.

	Efficiency (%)				
	bhmu0i2 p8	**bhmumi p9**	***zewkmm***	**bhmumi p10**	***zemtdm***
E_{EM} cut	96.35 ± 0.36	$97.36^{+0.32}_{-0.36}$	$96.22^{+0.08}_{-0.08}$	$97.68^{+0.23}_{-0.26}$	$96.20^{+0.06}_{-0.06}$
E_{HAD} cut	97.91 ± 0.27	$98.32^{+0.25}_{-0.29}$	$98.31^{+0.05}_{-0.06}$	$98.45^{+0.19}_{-0.22}$	$98.30^{+0.04}_{-0.04}$
COT hits cut	99.96 ± 0.04	$99.93^{+0.04}_{-0.10}$	$99.99^{+0.00}_{-0.01}$	$99.95^{+0.04}_{-0.07}$	$100.0^{+0.0}_{-0.00}$
d_0 cut	99.71 ± 0.10	$99.50^{+0.12}_{-0.17}$	$99.87^{+0.02}_{-0.02}$	$99.56^{+0.10}_{-0.13}$	$99.72^{+0.0}_{-0.02}$
Isolation cut	96.79 ± 0.34	$96.90^{+0.35}_{-0.39}$	$97.24^{+0.07}_{-0.06}$	$96.86^{+0.29}_{-0.30}$	$97.31^{+0.0}_{-0.05}$
Δx_{CMU} cut	99.60 ± 0.12	$99.75^{+0.10}_{-0.13}$	$99.99^{+0.00}_{-0.01}$	$99.51^{+0.12}_{-0.14}$	$99.99^{+0.0}_{-0.00}$
Δx_{CMP} cut	98.52 ± 0.23	$98.04^{+0.28}_{-0.31}$	$99.43^{+0.03}_{-0.03}$	$98.45^{+0.19}_{-0.22}$	$99.42^{+0.0}_{-0.03}$
All above cuts	89.53 ± 0.58	$90.44^{+0.53}_{-0.54}$	$91.49^{+0.12}_{-0.11}$	$91.08^{+0.44}_{-0.48}$	$91.41^{+0.09}_{-0.10}$
All cuts excl. isol.	92.34 ± 0.51	$93.08^{+0.50}_{-0.52}$	$93.94^{+0.10}_{-0.10}$	$93.89^{+0.37}_{-0.41}$	$93.76^{+0.08}_{-0.08}$
Sliding isol. cut	97.40 ± 0.30	$97.97^{+0.25}_{-0.29}$	$97.66^{+0.06}_{-0.06}$	$97.71^{+0.23}_{-0.26}$	$97.77^{+0.05}_{-0.05}$
All cuts (sliding isol.)	90.07 ± 0.57	$91.43^{+0.53}_{-0.54}$	$91.87^{+0.12}_{-0.12}$	$91.86^{+0.45}_{-0.48}$	$91.82^{+0.08}_{-0.09}$

bhmumj		zewkem
Count	Efficiency (%)	Efficiency (%)
3443		
3329	$96.69^{+0.31}_{-0.33}$	$96.23^{+0.06}_{-0.07}$
3371	$97.91^{+0.25}_{-0.26}$	$98.33^{+0.04}_{-0.04}$
3442	$99.97^{+0.02}_{-0.07}$	$99.99^{+0.00}_{-0.00}$
3419	$99.30^{+0.15}_{-0.17}$	$99.84^{+0.01}_{-0.01}$
3301	$95.88^{+0.34}_{-0.34}$	$96.80^{+0.06}_{-0.06}$
3428	$99.56^{+0.11}_{-0.14}$	$99.99^{+0.00}_{-0.01}$
3379	$98.14^{+0.24}_{-0.25}$	$99.44^{+0.02}_{-0.03}$
3047	$88.50^{+0.54}_{-0.58}$	$91.07^{+0.10}_{-0.10}$
3168	$92.01^{+0.44}_{-0.48}$	$93.93^{+0.08}_{-0.08}$
3336	$96.89^{+0.30}_{-0.33}$	$97.59^{+0.05}_{-0.05}$
3077	$89.37^{+0.55}_{-0.58}$	$91.79^{+0.10}_{-0.10}$

CMX ID Efficiency

	Efficiency (%)				
	bhmu0i2 p8	**bhmumi p9**	***zewkmm***	**bhmumi p10**	***zemtdm***
E_{EM} cut	96.59 ± 0.44	$97.34^{+0.39}_{-0.44}$	$96.32^{+0.10}_{-0.10}$	$97.24^{+0.34}_{-0.39}$	$96.40^{+0.07}_{-0.08}$
E_{HAD} cut	98.14 ± 0.33	$97.88^{+0.34}_{-0.40}$	$97.88^{+0.08}_{-0.08}$	$98.03^{+0.29}_{-0.30}$	$97.90^{+0.06}_{-0.06}$
COT hits cut	100.0 ± 0.00	$100.0^{+0.00}_{-0.11}$	$100.0^{+0.00}_{-0.01}$	$99.92^{+0.05}_{-0.10}$	$99.99^{+0.00}_{-0.01}$
d_0 cut	99.64 ± 0.15	$99.76^{+0.11}_{-0.19}$	$99.88^{+0.02}_{-0.02}$	$96.85^{+0.35}_{-0.39}$	$99.78^{+0.02}_{-0.02}$
Isolation cut	97.85 ± 0.36	$97.03^{+0.40}_{-0.48}$	$97.43^{+0.08}_{-0.09}$	$96.85^{+0.35}_{-0.39}$	$97.40^{+0.07}_{-0.07}$
Δx_{CMX} cut	99.64 ± 0.15	$99.39^{+0.18}_{-0.26}$	$99.83^{+0.02}_{-0.03}$	$99.88^{+0.06}_{-0.12}$	$99.86^{+0.01}_{-0.02}$
All above cuts	92.22 ± 0.66	$92.31^{+0.71}_{-0.76}$	$91.72^{+0.14}_{-0.15}$	$92.11^{+0.51}_{-0.56}$	$91.76^{+0.11}_{-0.11}$
All cuts excl. isol.	94.08 ± 0.58	$94.85^{+0.51}_{-0.57}$	$93.99^{+0.13}_{-0.13}$	$94.83^{+0.45}_{-0.47}$	$94.04^{+0.10}_{-0.10}$
Sliding isol. cut	98.38 ± 0.31	$97.40^{+0.38}_{-0.45}$	$97.81^{+0.08}_{-0.08}$	$97.83^{+0.29}_{-0.35}$	$97.91^{+0.06}_{-0.06}$
All cuts (sliding isol.)	92.70 ± 0.64	$92.62^{+0.70}_{-0.67}$	$92.06^{+0.14}_{-0.15}$	$92.98^{+0.50}_{-0.53}$	$92.21^{+0.11}_{-0.12}$

bhmumj		zewkem
Count	Efficiency (%)	Efficiency (%)
2226		
2150	$96.59^{+0.36}_{-0.42}$	$96.35^{+0.08}_{-0.09}$
2179	$97.89^{+0.28}_{-0.35}$	$97.83^{+0.07}_{-0.07}$
2226	$100.00^{+0.00}_{-0.08}$	$99.98^{+0.01}_{-0.01}$
2219	$99.69^{+0.11}_{-0.17}$	$99.88^{+0.01}_{-0.02}$
2147	$96.45^{+0.40}_{-0.43}$	$97.08^{+0.07}_{-0.08}$
2224	$99.91^{+0.06}_{-0.12}$	$99.85^{+0.02}_{-0.02}$
2020	$90.75^{+0.61}_{-0.66}$	$91.40^{+0.12}_{-0.12}$
2095	$94.12^{+0.49}_{-0.54}$	$94.00^{+0.11}_{-0.10}$
2171	$97.53^{+0.35}_{-0.39}$	$97.79^{+0.06}_{-0.07}$
2044	$91.82^{+0.61}_{-0.66}$	$92.04^{+0.11}_{-0.12}$

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.

	Efficiency (%)				
DATA	**bhmu0h**	**bhmu0i**	**bhmu0i2 p8**	**bhmumi p9**	**bhmumi p10**
CMUP	91.63 ± 0.34	91.78 ± 0.42	93.04 ± 0.47	$92.70^{+0.49}_{-0.53}$	$91.22^{+0.46}_{-0.47}$
CMX	97.47 ± 0.25	97.39 ± 0.31	96.67 ± 0.44	$95.09^{+0.57}_{-0.60}$	$95.99^{+0.37}_{-0.41}$
Arches	99.07 ± 0.18	98.68 ± 0.25	98.91 ± 0.29	$98.05^{+0.37}_{-0.46}$	$98.47^{+0.29}_{-0.3}$
Miniskirt	92.57 ± 0.94	92.62 ± 1.18	87.96 ± 1.81	$82.09^{+2.18}_{-2.50}$	$85.59^{+1.62}_{-1.9}$
Keystone	91.67 ± 2.13	94.50 ± 2.18	95.77 ± 2.39	$93.65^{+3.03}_{-4.78}$	$92.63^{+2.49}_{-3.6}$

bhmumj

Efficiency (%)
$90.58^{+0.51}_{-0.52}$
$95.10^{+0.43}_{-0.50}$
$98.20^{+0.31}_{-0.37}$
$81.46^{+2.03}_{-2.07}$
$96.34^{+1.90}_{-3.47}$

	Efficiency (%)			
MC	**zewk9m**	**zewkbm**	**zewkmm**	**zemtdm**
CMUP	97.57 ± 0.03	97.43 ± 0.06	$97.42^{+0.06}_{-0.06}$	$97.58^{+0.05}_{-0.05}$
CMX	99.61 ± 0.02	99.62 ± 0.03	$99.65^{+0.03}_{-0.04}$	$99.64^{+0.02}_{-0.03}$
Arches	99.79 ± 0.02	99.80 ± 0.03	$99.80^{+0.03}_{-0.03}$	$99.80^{+0.02}_{-0.02}$
Miniskirt	99.06 ± 0.06	99.07 ±0.12	$99.26^{+0.10}_{-0.12}$	$99.17^{+0.09}_{-0.09}$
Keystone	98.99 ± 0.13	98.90 ± 0.26	$98.70^{+0.30}_{-0.33}$	$98.90^{+0.21}_{-0.23}$

zewkem

Efficiency (%)
$97.60^{+0.05}_{-0.05}$
$99.61^{+0.03}_{-0.03}$
$99.79^{+0.02}_{-0.03}$
$99.05^{+0.10}_{-0.1}$
$98.96^{+0.20}_{-0.24}$

Reco and ID SF

ID Scale Factor				
Category	**bhmu0i**	**bhmu0i2 p8**	**bhmumi p9**	**bhmumi p10**
CMUP all cuts.	0.9753 ± 0.0052	0.9752 ± 0.0064	$0.9885^{+0.0059}_{-0.0061}$	$0.9964^{+0.0049}_{-0.0054}$
Excl. Isol.	0.9854 ± 0.0044	0.9821 ± 0.0055	$0.9908^{+0.0054}_{-0.0030}$	$1.0014^{+0.0040}_{-0.0049}$
Sliding Isol. cut	0.9804 ± 0.0050	0.9952 ± 0.0031	$1.0031^{+0.0027}_{-0.0030}$	$0.9993^{+0.0024}_{-0.0037}$
CMX all cuts	1.0012 ± 0.0057	1.0001 ± 0.0073	$1.0065^{+0.0078}_{-0.0085}$	$1.0038^{+0.0057}_{-0.0062}$
Excl. Isol.	1.0010 ± 0.0049	0.9989 ± 0.0063	$1.0092^{+0.0056}_{-0.0062}$	$1.0085^{+0.0049}_{-0.0051}$
Sliding Isol. cut	1.0020 ± 0.0056	1.0034 ± 0.0032	$0.9957^{+0.0040}_{-0.0047}$	$0.9992^{+0.0030}_{-0.0036}$

bhmumj P11

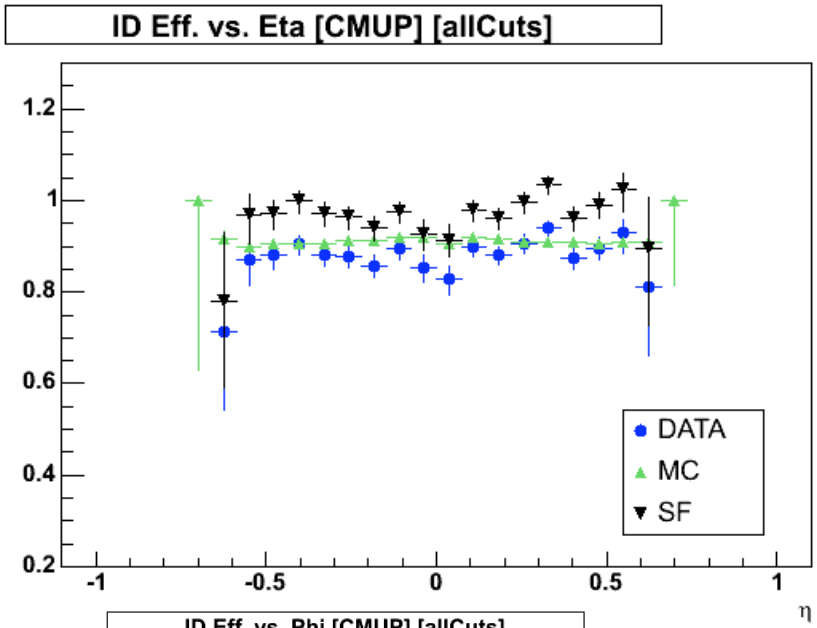
$0.9717^{+0.0060}_{-0.0065}$
$0.9796^{+0.0048}_{-0.0052}$
$0.9929^{+0.0031}_{-0.0035}$
$0.9928^{+0.0068}_{-0.0073}$
$1.0012^{+0.0053}_{-0.0058}$
$0.9973^{+0.0036}_{-0.0040}$

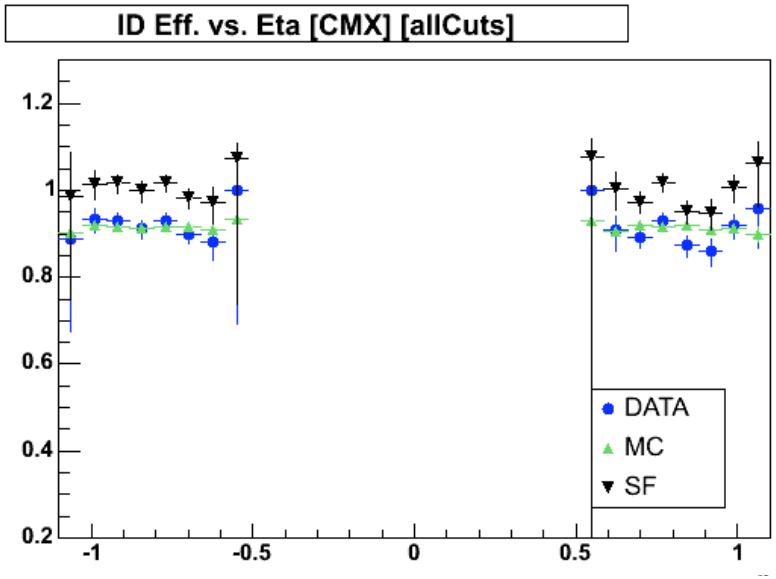
RECO Scale Factor				
	bhmu0i	**bhmu0i2 p8**	**bhmumi p9**	**bhmumi p10**
CMUP	0.9406 ± 0.0043	0.9550 ± 0.0049	$0.9515^{+0.0051}_{-0.0055}$	$0.9348^{+0.0047}_{-0.0048}$
CMX	0.9777 ± 0.0031	0.9703 ± 0.0044	$0.9542^{+0.0057}_{-0.0061}$	$0.9634^{+0.0037}_{-0.0041}$
Arches	0.9889 ± 0.0025	0.9911 ± 0.0029	$0.9824^{+0.0037}_{-0.0046}$	$0.9867^{+0.0029}_{-0.0030}$
Mini./Key.	0.9386 ± 0.0106	0.9024 ± 0.0157	$0.8484^{+0.0193}_{-0.0193}$	$0.8758^{+0.0158}_{-0.0158}$

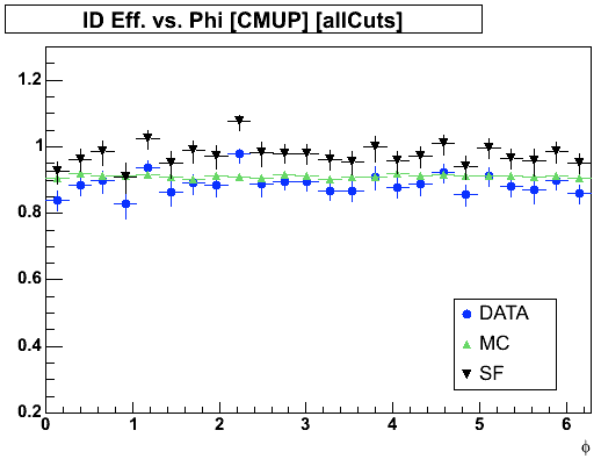
bhmumj P11

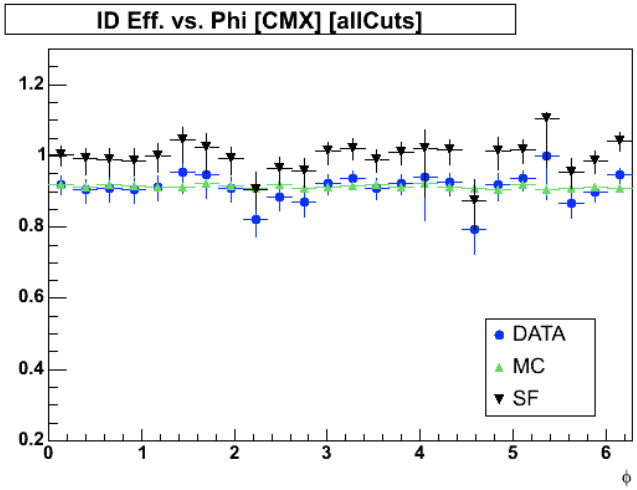
$0.9281^{+0.0052}_{-0.0053}$
$0.9547^{+0.0043}_{-0.0050}$
$0.9840^{+0.0032}_{-0.0037}$
$0.8476^{+0.0172}_{-0.0172}$

Reco and ID plots

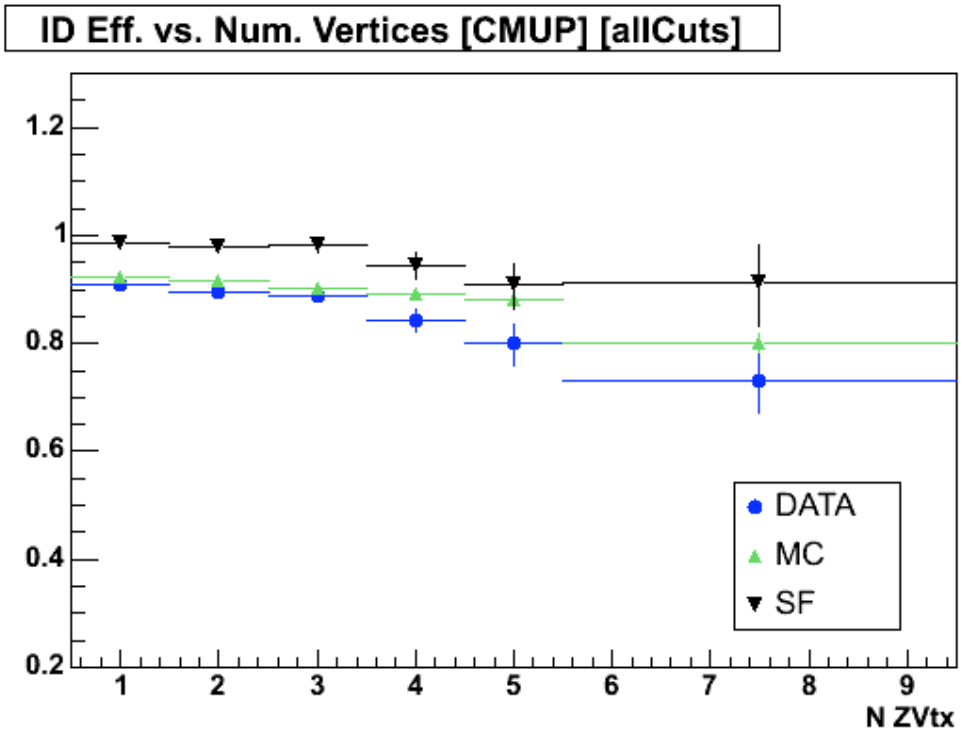


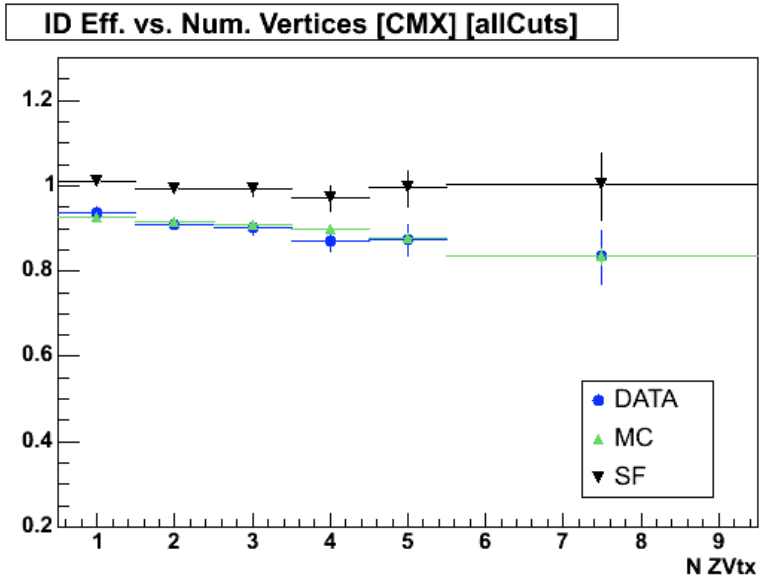




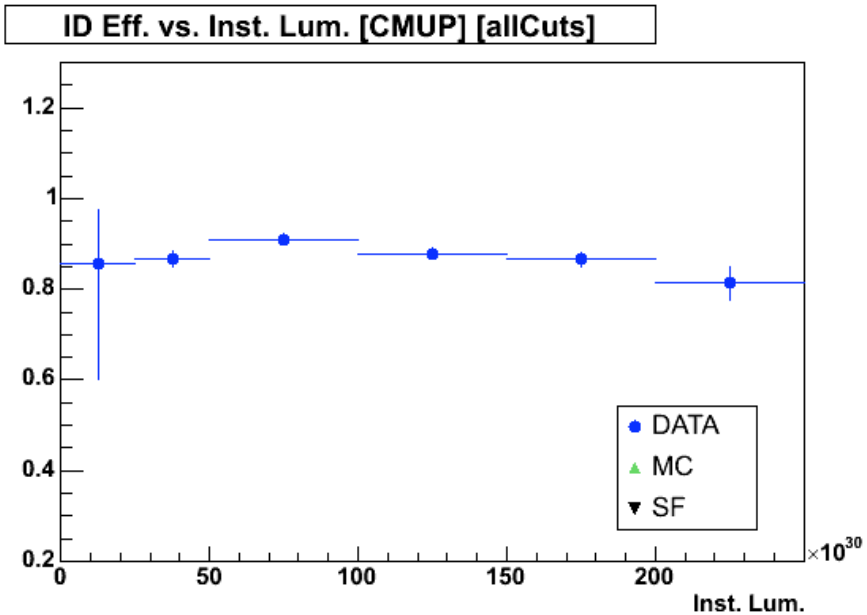


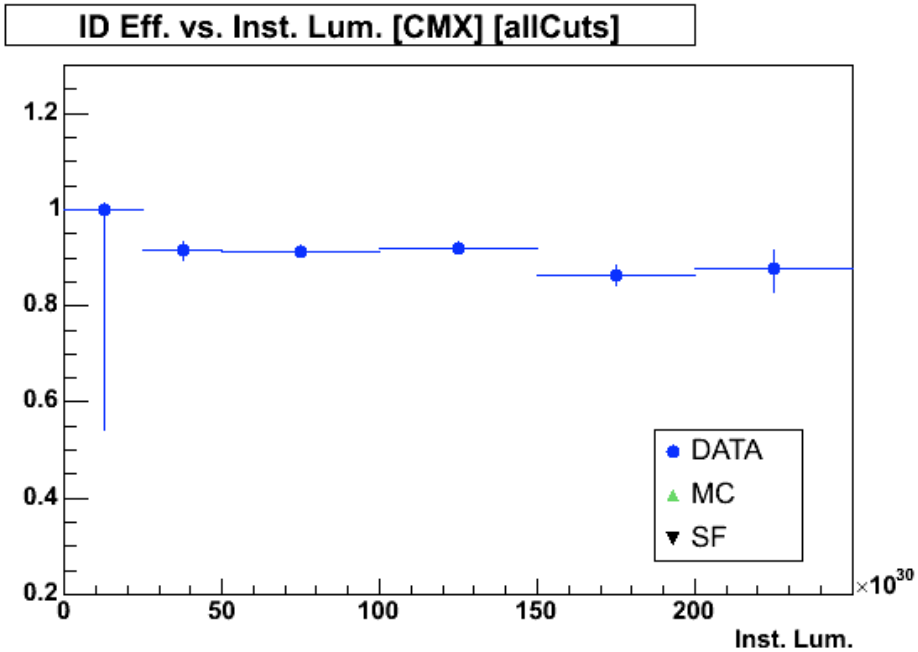
Reco and ID Plots



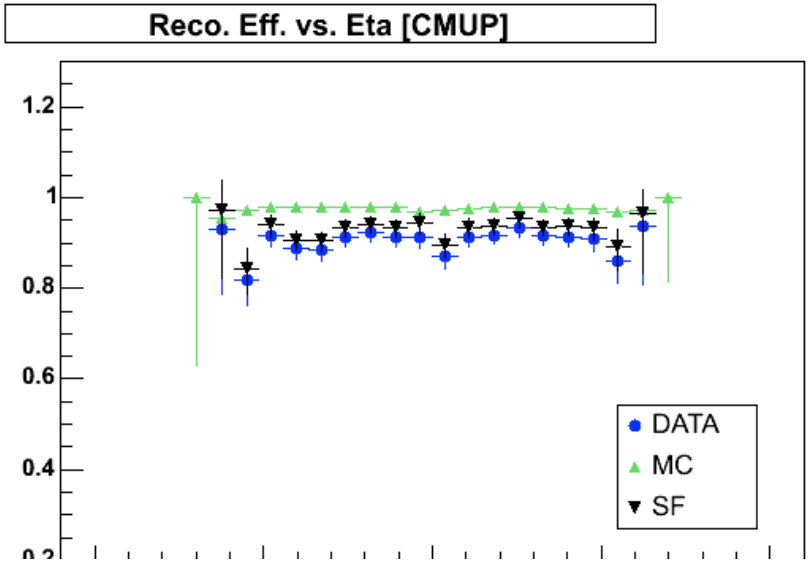


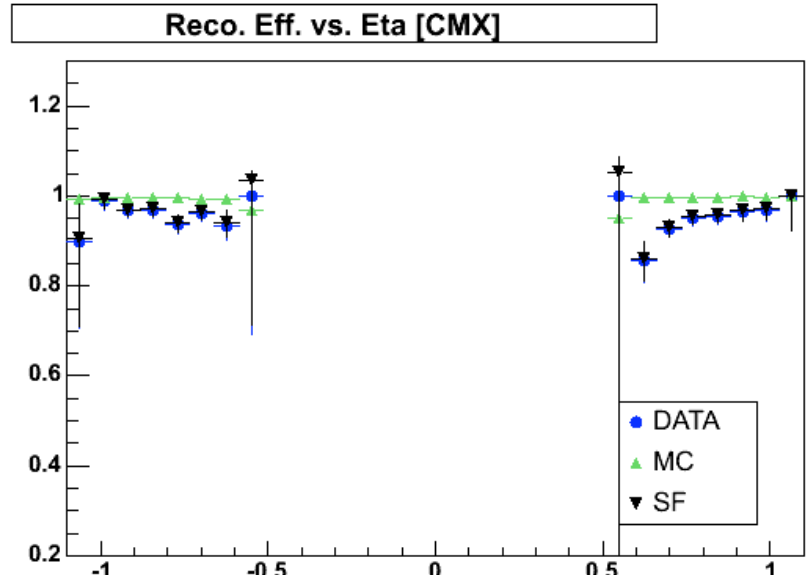
Reco and ID Plots

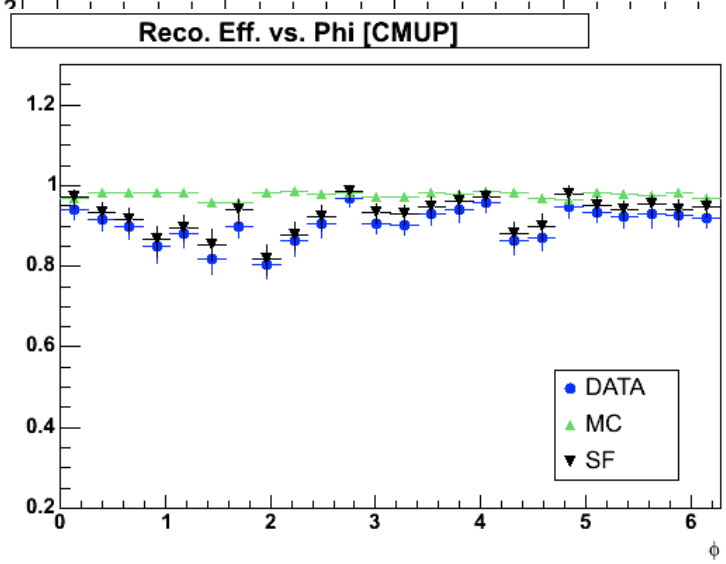


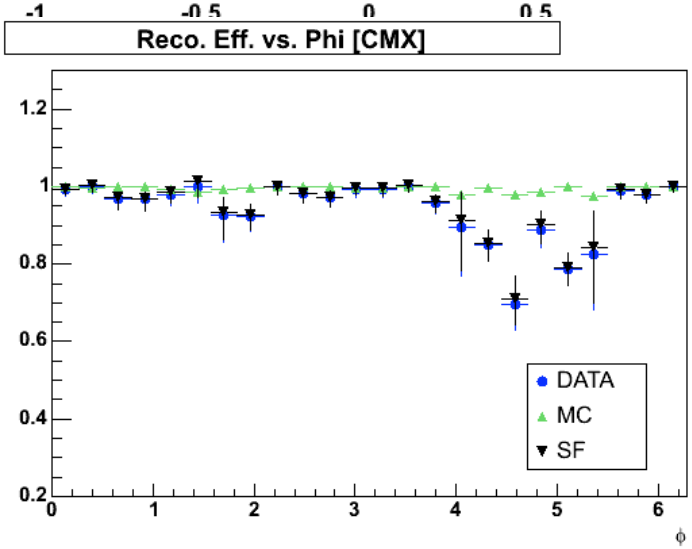


Reco and ID Plots









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:

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

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

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

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)

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

Level 3: (both leg pass L2)

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

CMX trigger efficiency is calculated in similar way.

Triggers for Period 11

L3 PATH	L2 PATH	Run Range
MUON_CMUP18_L2_LOOSE_DPS	L2_CMUP6_PT15_DPS	Run > 236132
MUON_CMUP18_L2_PT15	L2_CMUP6_PT15	?
MUON_CMUP18_L2_LOOSE_LUMI_240	L2_CMUP6_PT15_LUMI_240	Run > 234462
MUON_CMUP18_L2_LOOSE_LUMI_260	L2_CMUP6_PT15_LUMI_260	Run > 233108
MUON_CMUP18	L2_CMUP6_PT15_3D	Run > 229764
MUON_CMX18_L2_LOOSE_DPS	L2_CMX6_PT15_DPS	Run >236132 (?)
MUON_CMX18_L2_LOOSE_LUMI_200	L2_CMX6_PT15_LUMI_200	Run < 236132
MUON_CMX18_DPS	L2_CMX6_PT15_3D_DPS	Run >236132 (?)
MUON_CMX18_LUMI_250	L2_CMX6_PT15_3D_LUMI_250	Run < 236132

Muon Triggers

- 10 Combinations in fetching the triggers:

MUON_CMX18_L2_LOOSE_DPS (L2_CMX6_PT15_DPS)
MUON_CMX18_L2_LOOSE_LUMI_200 (L2_CMX6_PT15_LUMI_200)
&&

1) MUON_CMUP18_L2_PT15	(L2_CMUP6_PT15)	?
2) MUON_CMUP18_L2_LOOSE_LUMI_240	(L2_CMUP6_PT15_LUMI_240)	&& run >234462
3) MUON_CMUP18_L2_LOOSE_LUMI_260	(L2_CMUP6_PT15_LUMI_260)	&& run > 233108
4) MUON_CMUP18_L2_LOOSE_DPS	(L2_CMUP6_PT15_DPS)	&& run >236132
5) MUON_CMUP18	(L2_CMUP6_PT15_3D)	&& run > 233133

MUON_CMX18_DPS (L2_CMX6_PT15_3D_DPS)
MUON_CMX18_LUMI_250 (L2_CMX6_PT15_3D_LUMI_250)
&&

6) MUON_CMUP18	(L2_CMUP6_PT15_3D)	&& run > 233133
7) MUON_CMUP18_L2_LOOSE_DPS	(L2_CMUP6_PT15_DPS)	&& run >236132
8) MUON_CMUP18_L2_PT15	(L2_CMUP6_PT15)	?
9) MUON_CMUP18_L2_LOOSE_LUMI_240	(L2_CMUP6_PT15_LUMI_240)	&& run > 234462
10) MUON_CMUP18_L2_LOOSE_LUMI_260	(L2_CMUP6_PT15_LUMI_260)	&& run > 233108

Trigger PATHS for Period11

Case 1 (1430 runs):

L3	L2	
MUON_CMX18_L2_LOOSE_DPS	L2_CMX6_PT15_DPS	216
MUON_CMX18_L2_LOOSE_LUMI_200	L2_CMX6_PT15_LUMI_200	1214
MUON_CMUP18_L2_PT15	L2_CMUP6_PT15	332

Case 2 (1430 runs):

L3	L2	
MUON_CMX18_L2_LOOSE_DPS	L2_CMX6_PT15_DPS	216
MUON_CMX18_L2_LOOSE_LUMI_200	L2_CMX6_PT15_LUMI_200	1214
MUON_CMUP18_L2_LOOSE_LUMI_240	L2_CMUP6_PT15_LUMI_240	857 (run > 234462)

Case 3 (1430 runs):

L3	L2	
MUON_CMX18_L2_LOOSE_DPS	L2_CMX6_PT15_DPS	216
MUON_CMX18_L2_LOOSE_LUMI_200	L2_CMX6_PT15_LUMI_200	1214
MUON_CMUP18_L2_LOOSE_LUMI_260	L2_CMUP6_PT15_LUMI_260	25 (run > 233108)

Trigger PATHS for Period11

Case 4 (1430 runs):

CMX no SLAM
CMUP no SLAM

L3	L2	
MUON_CMX18_L2_LOOSE_DPS	L2_CMX6_PT15_DPS	216
MUON_CMX18_L2_LOOSE_LUMI_200	L2_CMX6_PT15_LUMI_200	1214
MUON_CMUP18_L2_LOOSE_DPS	L2_CMUP6_PT15_DPS	216 (run > 236132)

Case 5 (1430 runs):

L3	L2	
MUON_CMX18_L2_LOOSE_DPS	L2_CMX6_PT15_DPS	216
MUON_CMX18_L2_LOOSE_LUMI_200	L2_CMX6_PT15_LUMI_200	1214
MUON_CMUP18	L2_CMUP6_PT15_3D_v	1430 (all runs)

CMX no SLAM
CMUP SLAM

Trigger PATHS for Period11

CMX SLAM
CMUP SLAM

Case 6 (1430 runs):

L3	L2	
MUON_CMX18_DPS	L2_CMX6_PT15_3D_DPS	216
MUON_CMX18_LUMI_250	L2_CMX6_PT15_3D_LUMI_250)	1214
MUON_CMUP18	L2_CMUP6_PT15_3D_v	1430 (all runs)

Case 7 (1430 runs):

L3	L2	
MUON_CMX18_DPS	L2_CMX6_PT15_3D_DPS	216
MUON_CMX18_LUMI_250	L2_CMX6_PT15_3D_LUMI_250)	1214
MUON_CMUP18_L2_LOOSE_DPS	L2_CMUP6_PT15_DPS	216 (run > 236132)

Case 8 (1430 runs):

L3	L2	
MUON_CMX18_DPS	L2_CMX6_PT15_3D_DPS	216
MUON_CMX18_LUMI_250	L2_CMX6_PT15_3D_LUMI_250)	1214
MUON_CMUP18_L2_PT15	L2_CMUP6_PT15	332

Trigger PATHS for Period11

Case 9 (1430 runs):

L3	L2	
MUON_CMX18_DPS	L2_CMX6_PT15_3D_DPS	216
MUON_CMX18_LUMI_250	L2_CMX6_PT15_3D_LUMI_250)	1214
MUON_CMUP18_L2_LOOSE_LUMI_240	L2_CMUP6_PT15_LUMI_240	857 (run > 234462)

Case 10 (1430 runs):

L3	L2	
MUON_CMX18_DPS	L2_CMX6_PT15_3D_DPS	216
MUON_CMX18_LUMI_250	L2_CMX6_PT15_3D_LUMI_250)	1214
MUON_CMUP18_L2_LOOSE_LUMI_260	L2_CMUP6_PT15_LUMI_260	25 (run >233108)

Results

L1 Trigger Efficiencies

1st leg	2nd leg	1st passes	both pass	Efficiency (%)
CMUP	CMUP	1140	1009	-
CMX	CMUP	1426	1341	$93.96^{+0.46}_{-0.42}$
CMUP	CMX	1466	1341	-
CMX	CMX	485	394	$90.94^{+0.67}_{-0.63}$
CMUP	ARCH	1172	1140	-
CMUP	MK	294	201	-
ARCH	ARCH	345	312	-
ARCH	MK	105	65	-
MK	ARCH	66	65	$96.83^{+0.47}_{-0.40}$
MK	MK	34	17	$76.02^{+2.29}_{-2.06}$

The same for all cases

Results

CMX SLAM
CMUP SLAM

Case 6 (1430 runs, run > 233133, all runs in P11):

L3	L2	
MUON_CMX18_DPS	L2_CMX6_PT15_3D_DPS	216
MUON_CMX18_LUMI_250	L2_CMX6_PT15_3D_LUMI_250)	1214
MUON_CMUP18	L2_CMUP6_PT15_3D_v	1430

L3 Trigger Efficiencies

Category	Events Passing	Efficiency (%)
Pass L2	1160	-
CMUP	1157	$99.74^{+0.15}_{-0.24}$
CMX	1154	$99.48^{+0.21}_{-0.30}$
CMUP-CMX	1151	-
CMUPA	979	-
CMUPMK	178	-
CMUPARCH	974	$99.49^{+0.23}_{-0.36}$
CMUP-MK	177	$99.44^{+0.51}_{-1.24}$

Category	Events Passing	Efficiency (%)
Pass L1	1341	-
CMUP	1196	$98.72^{+0.32}_{-0.41}$
CMX	1175	$96.99^{+0.50}_{-0.58}$
CMUP-CMX	1160	-
CMUPA	1011	-
CMUPMK	185	-
CMUPARCH	981	$97.03^{+0.57}_{-0.60}$
CMUP-MK	179	$96.76^{+1.19}_{-1.93}$

L2 Trigger Efficiencies

Category	Efficiency (%)
CMUP	$92.52^{+0.56}_{-0.61}$
CMX	$87.74^{+0.81}_{-0.85}$
ARCH	$93.48^{+0.75}_{-0.77}$
MK	$73.14^{+2.41}_{-2.63}$

Muon combined trigger efficiencies

Results

CMX no SLAM
CMUP SLAM

Case 5 (1430 runs, run > 233133, all runs):

L3
MUON_CMX18_L2_LOOSE_DPS
MUON_CMX18_L2_LOOSE_LUMI_200
MUON_CMUP18

L2
L2_CMX6_PT15_DPS 216
L2_CMX6_PT15_LUMI_200 1214
L2_CMUP6_PT15_3D_v 1430

Category	Events Passing	Efficiency (%)
Pass L1	1341	-
CMUP	1196	$98.93^{+0.32}_{-0.42}$
CMX	1118	$92.47^{+0.74}_{-0.82}$
CMUP-CMX	1106	-
CMUPA	1011	-
CMUPMK	185	-
CMUPARCH	936	$92.58^{+0.83}_{-0.93}$
CMUP-MK	170	$91.89^{+1.96}_{-2.54}$

L2

Category	Events Passing	Efficiency (%)
Pass L2	1106	-
CMUP	1104	$99.82^{+0.12}_{-0.25}$
CMX	1100	$99.46^{+0.21}_{-0.32}$
CMUP-CMX	1098	-
CMUPA	935	-
CMUPMK	169	-
CMUPARCH	930	$99.47^{+0.23}_{-0.36}$
CMUP-MK	168	$99.41^{+0.45}_{-1.31}$

L3

Category	Efficiency (%)
CMUP	$92.78^{+0.55}_{-0.61}$
CMX	$83.64^{+0.93}_{-0.98}$
ARCH	$89.17^{+0.93}_{-1.02}$
MK	$69.44^{+2.58}_{-2.84}$

Muon combined trigger efficiencies

CMX SLAM

Category	Efficiency (%)
CMUP	$92.52^{+0.56}_{-0.61}$
CMX	$87.74^{+0.81}_{-0.85}$
ARCH	$93.48^{+0.75}_{-0.77}$
MK	$73.14^{+2.41}_{-2.63}$

Muon combined trigger efficiencies

Results

CMX no SLAM
CMUP no SLAM

DPS

Case 4 (1430 runs): only considers runs > 236132 (_DPS vs LumiEnable)

L3	L2	
MUON_CMX18_L2_LOOSE_DPS	L2_CMX6_PT15_DPS	216
MUON_CMX18_L2_LOOSE_LUMI_200	L2_CMX6_PT15_LUMI_200	1214
MUON_CMUP18_L2_LOOSE_DPS	L2_CMUP6_PT15_DPS	216

Category	Events Passing	Efficiency (%)
Pass L1	1341	-
CMUP	207	$98.98^{+0.67}_{-1.28}$
CMX	197	$94.20^{+1.60}_{-2.11}$
CMUP-CMX	195	-
CMUPA	175	-
CMUPMK	32	-
CMUPARCH	165	$94.29^{+1.71}_{-2.39}$
CMUP-MK	30	$93.75^{+4.30}_{-7.62}$

L2 Trigger Eff

Category	Events Passing	Efficiency (%)
Pass L2	195	-
CMUP	185	$100.00^{+0.00}_{-1.00}$
CMX	183	$98.92^{+0.74}_{-1.41}$
CMUP-CMX	183	-
CMUPA	156	-
CMUPMK	29	-
CMUPARCH	154	$98.72^{+0.84}_{-1.70}$
CMUP-MK	29	$100.00^{+0.00}_{-6.15}$

L3 Trigger Eff

Category	Efficiency (%)
CMUP	$93.00^{+0.78}_{-1.58}$
CMX	$84.74^{+1.69}_{-2.33}$
ARCH	$90.13^{+1.86}_{-2.79}$
MK	$71.27^{+3.91}_{-7.52}$

Muon combined trigger efficiencies

Results

CMX no SLAM
CMUP no SLAM

LUMI240

Case 2 (1430 runs, run > 234462 - CMUP_LUMI240 enabled):

L3	L2	
MUON_CMX18_L2_LOOSE_DPS	L2_CMX6_PT15_DPS	216
MUON_CMX18_L2_LOOSE_LUMI_200	L2_CMX6_PT15_LUMI_200	1214
MUON_CMUP18_L2_LOOSE_LUMI_240	L2_CMUP6_PT15_LUMI_240	857

Category	Events Passing	Efficiency (%)
Pass L1	1341	-
CMUP	315	$98.36^{+0.72}_{-1.14}$
CMX	304	$94.92^{+1.27}_{-1.46}$
CMUP-CMX	299	-
CMUPA	259	-
CMUPMK	56	-
CMUPARCH	244	$94.21^{+1.40}_{-1.92}$
CMUP-MK	55	$98.21^{+1.49}_{-3.98}$

L2

Category	Events Passing	Efficiency (%)
Pass L2	299	-
CMUP	299	$100.00^{+0.00}_{-0.61}$
CMX	299	$100.00^{+0.00}_{-0.61}$
CMUP-CMX	299	-
CMUPA	244	-
CMUPMK	55	-
CMUPARCH	244	$100.00^{+0.00}_{-0.75}$
CMUP-MK	55	$100.00^{+0.00}_{-3.29}$

L3

Category	Efficiency (%)
CMUP	$92.41^{+0.81}_{-1.28}$
CMX	$86.32^{+1.32}_{-1.55}$
ARCH	$91.23^{+1.42}_{-2.02}$
MK	$74.66^{+2.52}_{-4.39}$

Muon combined trigger efficiencies

CMX SLAM

Category	Efficiency (%)
CMUP	$92.02^{+0.91}_{-1.35}$
CMX	$90.94^{+0.67}_{-1.04}$
ARCH	$96.83^{+0.47}_{-1.16}$
MK	$76.02^{+2.29}_{-4.15}$

Results

CMX no SLAM
CMUP no SLAM

LUMI260

Case 3 (1430 runs, run > 233108 - CMUP_LUMI260 enabled):

L3

MUON_CMX18_L2_LOOSE_DPS
MUON_CMX18_L2_LOOSE_LUMI_200
MUON_CMUP18_L2_LOOSE_LUMI_260

L2

L2_CMX6_PT15_DPS	216
L2_CMX6_PT15_LUMI_200	1214
L2_CMUP6_PT15_LUMI_260	25

Category	Events Passing	Efficiency (%)
Pass L1	1341	-
CMUP	19	$3.41^{+0.99}_{-0.79}$
CMX	528	$94.74^{+1.09}_{-10.75}$
CMUP-CMX	18	-
CMUPA	18	-
CMUPMK	1	-
CMUPARCH	17	$94.44^{+4.38}_{-12.02}$
CMUP-MK	1	$100.00^{+0.00}_{-84.15}$

L2

Category	Events Passing	Efficiency (%)
Pass L2	18	-
CMUP	13	$70.59^{+11.44}_{-14.73}$
CMX	17	$92.31^{+6.52}_{-15.35}$
CMUP-CMX	12	-
CMUPA	13	-
CMUPMK	0	-
CMUPARCH	12	$92.31^{+6.52}_{-15.35}$
CMUP-MK	0	$0.00^{+0.00}_{-0.00}$

L3

Category	Efficiency (%)
CMUP	$2.26^{+0.75}_{-0.70}$
CMX	$79.52^{+6.61}_{-16.02}$
ARCH	$84.42^{+7.15}_{-17.69}$
MK	$0.00^{+0.00}_{-0.00}$

Muon combined trigger efficiencies

???

Questions

- Why all the runs passing the following two CMX trigger paths (supposedly not SLAM confirmed):

MUON_CMX18_L2_LOOSE_DPS	L2_CMX6_PT15_DPS	216
MUON_CMX18_L2_LOOSE_LUMI_200	L2_CMX6_PT15_LUMI_200	1214

Are also passing the following two (SLAM confirmed) ???

MUON_CMX18_DPS	L2_CMX6_PT15_3D_DPS	216
MUON_CMX18_LUMI_250	L2_CMX6_PT15_3D_LUMI_250)	1214

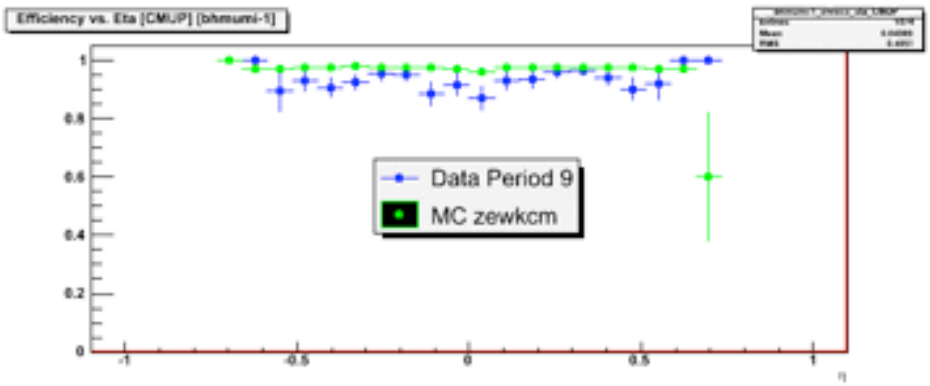
- Is run > 236132 the cut-off run for which _DPS becomes the default path?
- As for CMUP:
  - CMUP18 , SLAM confirmed, seemed to have been fired all the 1430 runs (confirmed CMUP enabled since run > 229764?)
  - All the other CMUP trigger paths have very cut-off runs where they started being implemented and/or name changed…LUMI260 ?
  - Hopefully this is the LAST period we see all these changes.
  - Calculating the efficiencies is very painful and requires a continuous change of code….
  - Waiting for Lubo to sign off on this……

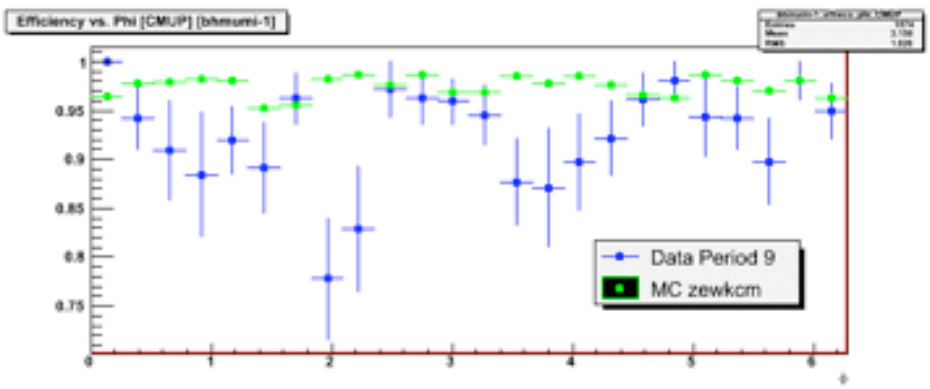
Conclusions

- High PT Lepton ID/Reco/Trigger Efficiencies and SF for Period 11 completed
  - All data processed
  - MC done
    - Electrons ok : ID and Trigger
    - Muons ok: ID and Reco
      - Waiting for the expert to sign off on trigger efficiencies

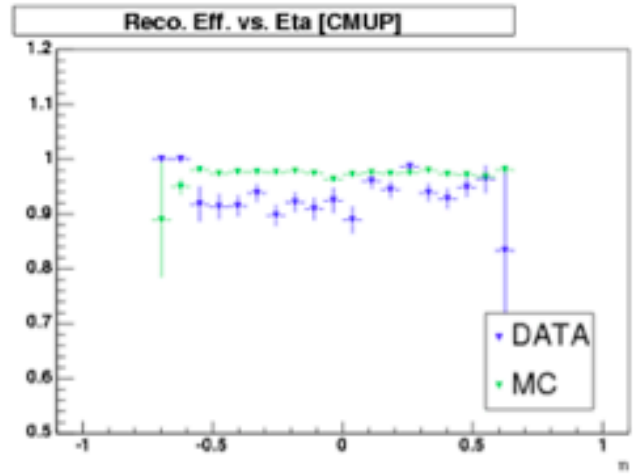
Reco Eff Previous Periods

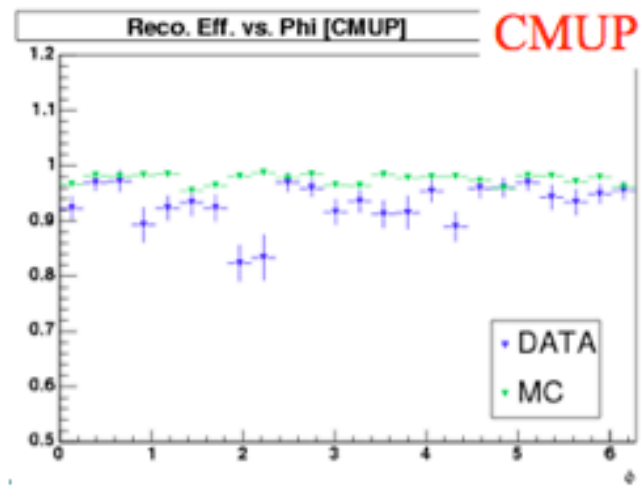
Period 9





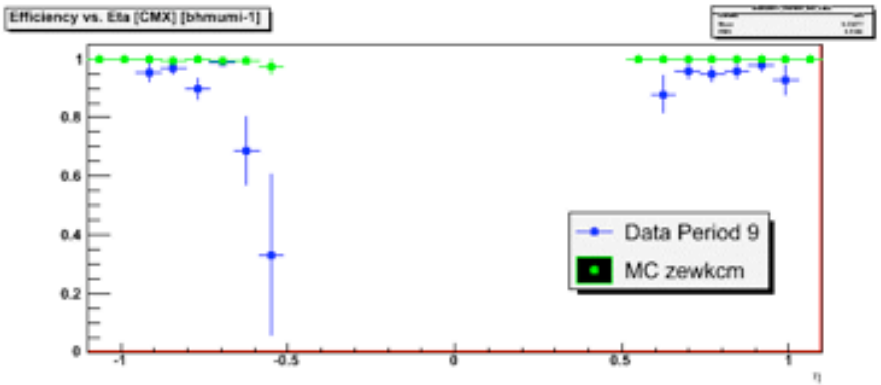
Period 8

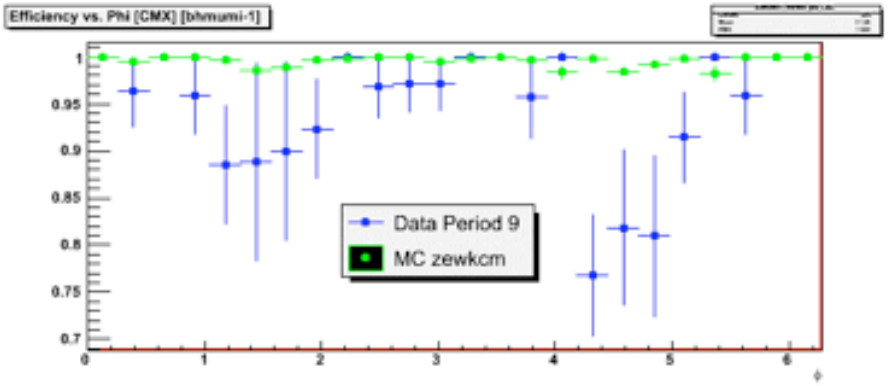




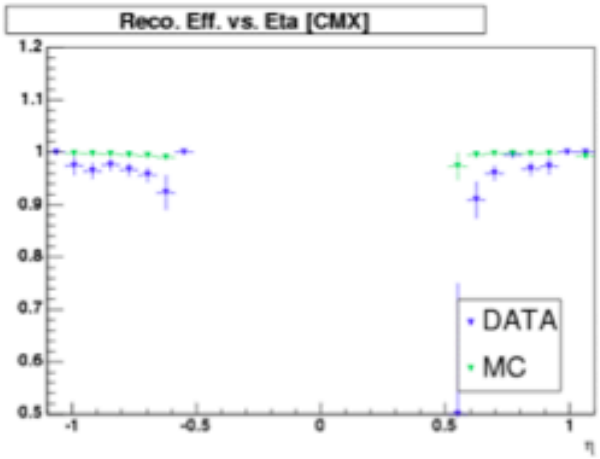
Reco Eff Previous Periods

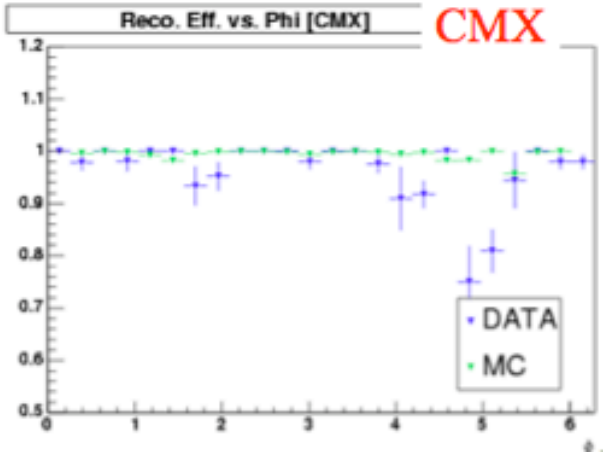
Period 9





Period 8





Results

CMX no SLAM
CMUP no SLAM

Case 4 (1430 runs, run > 233133, all runs):

L3	L2	
MUON_CMX18_L2_LOOSE_DPS	L2_CMX6_PT15_DPS	216
MUON_CMX18_L2_LOOSE_LUMI_200	L2_CMX6_PT15_LUMI_200	1214
MUON_CMUP18_L2_LOOSE_DPS	L2_CMUP6_PT15_DPS	216

Category	Events Passing	Efficiency (%)
Pass L1	1341	-
CMUP	207	$15.75^{+1.11}_{-1.04}$
CMX	1238	$94.20^{+1.60}_{-2.11}$
CMUP-CMX	195	-
CMUPA	175	-
CMUPMK	32	-
CMUPARCH	165	$94.29^{+1.71}_{-2.39}$
CMUP-MK	30	$93.75^{+4.30}_{-7.62}$

L2 Trigger Eff

Category	Events Passing	Efficiency (%)
Pass L2	195	-
CMUP	185	$95.31^{+1.46}_{-2.05}$
CMX	192	$98.92^{+0.74}_{-1.41}$
CMUP-CMX	183	-
CMUPA	156	-
CMUPMK	29	-
CMUPARCH	154	$98.72^{+0.84}_{-1.70}$
CMUP-MK	29	$100.00^{+0.00}_{-6.15}$

L3 Trigger Eff

Category	Efficiency (%)
CMUP	$14.11^{+1.02}_{-0.98}$
CMX	$84.74^{+1.69}_{-2.33}$
ARCH	$90.13^{+1.86}_{-2.79}$
MK	$71.27^{+3.91}_{-7.52}$

Muon combined trigger efficiencies