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

Simona Rolli

Muons

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

Files: 15 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.

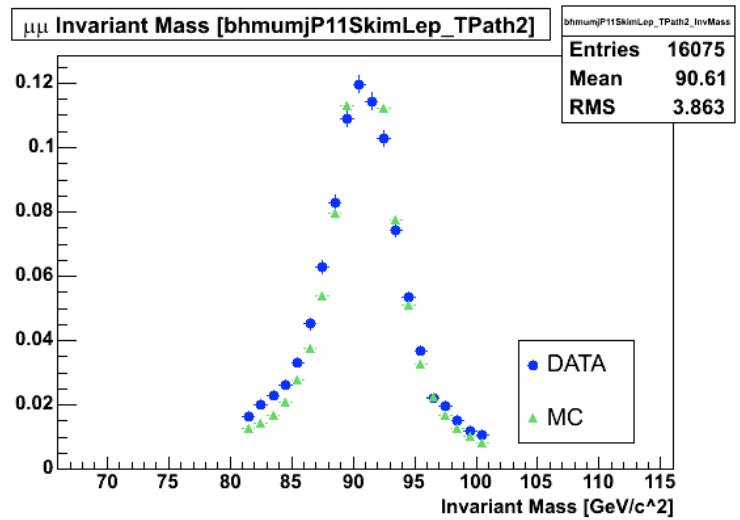
Arches:
$0^\circ \leq \phi \leq 75^\circ$ or $105^\circ \leq \phi \leq 225^\circ$ or $315^\circ \leq \phi < 360^\circ$
Additionally, for runs 190697 - 209760, remove:
$210^\circ < \phi \leq 225^\circ$ if $\eta < 0$
Keystone:
$75^\circ < \phi < 105^\circ$ and $\eta < 0$
Miniskirt:
$225^\circ < \phi <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

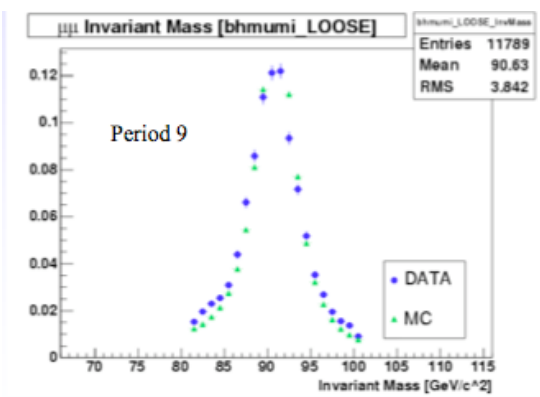
Table 3: Cuts on ϕ for distinguishing parts of the CMX detector when determining reconstruction efficiencies.

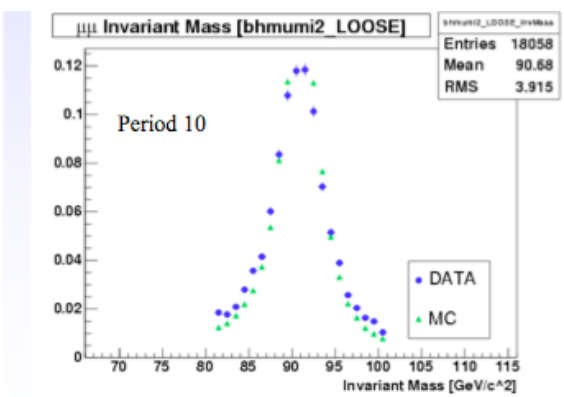
ID Efficiency Calculation

- 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	$99.93^{+0.04}_{-0.10}$	$99.99^{+0.00}_{-0.01}$	$99.95^{+0.04}_{-0.07}$	$100.0^{+0.00}_{-0.00}$
d_0 cut	99.71 ± 0.10	$99.50^{+0.12}_{-0.17}$	$99.87^{+0.02}_{-0.02}$	$99.56^{+0.10}_{-0.13}$	$99.72^{+0.02}_{-0.02}$
Isolation cut	96.79 ± 0.34	$96.90^{+0.35}_{-0.39}$	$97.24^{+0.07}_{-0.06}$	$96.86^{+0.29}_{-0.30}$	$97.31^{+0.05}_{-0.05}$
Δx_{CMU} cut	99.60 ± 0.12	$99.75^{+0.10}_{-0.13}$	$99.99^{+0.00}_{-0.01}$	$99.51^{+0.12}_{-0.14}$	$99.99^{+0.00}_{-0.00}$
Δx_{CMP} cut	98.52 ± 0.23	$98.04^{+0.28}_{-0.31}$	$99.43^{+0.03}_{-0.03}$	$98.45^{+0.19}_{-0.22}$	$99.42^{+0.03}_{-0.03}$
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	$89.37^{+0.55}_{-0.58}$	$91.79^{+0.10}_{-0.10}$

CMUP ID Efficiencies

P9

Cut	Count	Efficiency (%)
No cut	2792	
E_{EM} cut	2691	$96.38^{+0.37}_{-0.41}$
E_{HAD} cut	2734	$97.92^{+0.25}_{-0.29}$
COT hits cut	2791	$99.96^{+0.03}_{-0.08}$
d_0 cut	2778	$99.50^{+0.12}_{-0.17}$
Isolation cut	2703	$96.81^{+0.33}_{-0.35}$
Δx_{CMU} cut	2781	$99.61^{+0.12}_{-0.16}$
Δx_{CMP} cut	2750	$98.50^{+0.22}_{-0.27}$
All above cuts	2495	$89.36^{+0.63}_{-0.64}$
All cuts excl. isol.	2573	$92.16^{+0.50}_{-0.53}$
Sliding isol. cut	2720	$97.42^{+0.31}_{-0.33}$
All cuts (sliding isol.)	2510	$89.90^{+0.58}_{-0.59}$
χ^2 cut	2792	$100.00^{+0.00}_{-0.07}$
All cuts (χ^2)	2495	$89.36^{+0.63}_{-0.64}$
All track cuts	2544	$91.12^{+0.53}_{-0.57}$
All trk cuts excl. isol.	2624	$93.98^{+0.48}_{-0.50}$

P8

Cut	Count	Efficiency (%)
No cut	2777	
E_{EM} cut	2703	$97.34^{+0.30}_{-0.34}$
E_{HAD} cut	2731	$98.34^{+0.25}_{-0.28}$
COT hits cut	2775	$99.93^{+0.04}_{-0.10}$
d_0 cut	2763	$99.50^{+0.13}_{-0.17}$
Isolation cut	2690	$96.87^{+0.33}_{-0.36}$
Δx_{CMU} cut	2770	$99.75^{+0.09}_{-0.13}$
Δx_{CMP} cut	2722	$98.02^{+0.25}_{-0.29}$
All above cuts	2510	$90.39^{+0.58}_{-0.59}$
All cuts excl. isol.	2584	$93.05^{+0.48}_{-0.50}$
Sliding isol. cut	2720	$97.95^{+0.27}_{-0.32}$
All cuts (sliding isol.)	2538	$91.39^{+0.55}_{-0.55}$
χ^2 cut	2777	$100.00^{+0.00}_{-0.07}$
All cuts (χ^2)	2510	$90.39^{+0.58}_{-0.59}$
All track cuts	2568	$92.47^{+0.52}_{-0.55}$
All trk cuts excl. isol.	2645	$95.25^{+0.38}_{-0.45}$

Cut	Count	Efficiency (%)
No cut	3819	
E_{EM} cut	3731	$97.70^{+0.24}_{-0.27}$
E_{HAD} cut	3760	$98.46^{+0.19}_{-0.23}$
COT hits cut	3817	$99.95^{+0.03}_{-0.07}$
d_0 cut	3802	$99.55^{+0.11}_{-0.13}$
Isolation cut	3697	$96.81^{+0.29}_{-0.30}$
Δx_{CMU} cut	3800	$99.50^{+0.11}_{-0.14}$
Δx_{CMP} cut	3760	$98.46^{+0.19}_{-0.23}$
All above cuts	3477	$91.04^{+0.48}_{-0.49}$
All cuts excl. isol.	3586	$93.90^{+0.41}_{-0.42}$
Sliding isol. cut	3730	$97.67^{+0.24}_{-0.27}$
All cuts (sliding isol.)	3507	$91.83^{+0.43}_{-0.45}$
χ^2 cut	3819	$100.00^{+0.00}_{-0.05}$
All cuts (χ^2)	3477	$91.04^{+0.48}_{-0.49}$
All track cuts	3546	$92.85^{+0.43}_{-0.44}$
All trk cuts excl. isol.	3658	$95.78^{+0.33}_{-0.35}$

P10

Cut	Count	Efficiency (%)
No cut	3530	
E_{EM} cut	3414	$96.71^{+0.28}_{-0.35}$
E_{HAD} cut	3454	$97.85^{+0.24}_{-0.28}$
COT hits cut	3529	$99.97^{+0.02}_{-0.06}$
d_0 cut	3507	$99.35^{+0.13}_{-0.17}$
Isolation cut	3378	$95.69^{+0.33}_{-0.36}$
Δx_{CMU} cut	3514	$99.55^{+0.12}_{-0.14}$
Δx_{CMP} cut	3463	$98.10^{+0.23}_{-0.26}$
All above cuts	3117	$88.30^{+0.54}_{-0.58}$
All cuts excl. isol.	3246	$91.95^{+0.45}_{-0.48}$
Sliding isol. cut	3417	$96.80^{+0.30}_{-0.34}$
All cuts (sliding isol.)	3151	$89.26^{+0.51}_{-0.57}$
χ^2 cut	3530	$100.00^{+0.00}_{-0.05}$
All cuts (χ^2)	3117	$88.30^{+0.54}_{-0.58}$
All track cuts	3188	$90.31^{+0.48}_{-0.54}$
All trk cuts excl. isol.	3320	$94.05^{+0.41}_{-0.42}$

P11

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	$91.82^{+0.61}_{-0.66}$	$92.04^{+0.11}_{-0.12}$

CMX ID Efficiencies

P9

Cut	Count	Efficiency (%)
No cut	1682	
E_{EM} cut	1625	$96.61^{+0.43}_{-0.49}$
E_{HAD} cut	1650	$98.10^{+0.32}_{-0.42}$
COT hits cut	1682	$100.00^{+0.00}_{-0.11}$
d_0 cut	1671	$99.35^{+0.20}_{-0.26}$
Isolation cut	1646	$97.86^{+0.36}_{-0.42}$
Δx_{CMX} cut	1676	$99.64^{+0.15}_{-0.22}$
All above cuts	1547	$91.97^{+0.65}_{-0.71}$
All cuts excl. isol.	1578	$93.82^{+0.57}_{-0.60}$
Sliding isol. cut	1655	$98.39^{+0.31}_{-0.37}$
All cuts (sliding isol.)	1555	$92.45^{+0.67}_{-0.70}$
χ^2 cut	1682	$100.00^{+0.00}_{-0.11}$
All cuts (χ^2)	1547	$91.97^{+0.65}_{-0.71}$
All track cuts	1552	$92.27^{+0.65}_{-0.72}$
All trk cuts excl. isol.	1583	$94.11^{+0.56}_{-0.61}$

P8

Cut	Count	Efficiency (%)
No cut	1642	
E_{EM} cut	1599	$97.38^{+0.40}_{-0.43}$
E_{HAD} cut	1607	$97.87^{+0.35}_{-0.43}$
COT hits cut	1642	$100.00^{+0.00}_{-0.11}$
d_0 cut	1638	$99.76^{+0.12}_{-0.19}$
Isolation cut	1593	$97.02^{+0.42}_{-0.46}$
Δx_{CMX} cut	1632	$99.39^{+0.18}_{-0.26}$
All above cuts	1516	$92.33^{+0.69}_{-0.68}$
All cuts excl. isol.	1558	$94.88^{+0.57}_{-0.60}$
Sliding isol. cut	1599	$97.38^{+0.40}_{-0.43}$
All cuts (sliding isol.)	1521	$92.63^{+0.68}_{-0.69}$
χ^2 cut	1642	$100.00^{+0.00}_{-0.11}$
All cuts (χ^2)	1516	$92.33^{+0.69}_{-0.68}$
All track cuts	1523	$92.75^{+0.66}_{-0.71}$
All trk cuts excl. isol.	1565	$95.31^{+0.54}_{-0.54}$

Cut	Count	Efficiency (%)
No cut	2501	
E_{EM} cut	2431	$97.20^{+0.33}_{-0.35}$
E_{HAD} cut	2453	$98.08^{+0.28}_{-0.30}$
COT hits cut	2499	$99.92^{+0.05}_{-0.11}$
d_0 cut	2492	$99.64^{+0.12}_{-0.16}$
Isolation cut	2424	$96.92^{+0.37}_{-0.36}$
Δx_{CMX} cut	2498	$99.88^{+0.07}_{-0.12}$
All above cuts	2306	$92.20^{+0.52}_{-0.55}$
All cuts excl. isol.	2372	$94.84^{+0.45}_{-0.48}$
Sliding isol. cut	2449	$97.92^{+0.30}_{-0.34}$
All cuts (sliding isol.)	2328	$93.08^{+0.50}_{-0.53}$
χ^2 cut	2501	$100.00^{+0.00}_{-0.07}$
All cuts (χ^2)	2306	$92.20^{+0.52}_{-0.55}$
All track cuts	2308	$92.28^{+0.54}_{-0.54}$
All trk cuts excl. isol.	2374	$94.92^{+0.46}_{-0.46}$

P10

Cut	Count	Efficiency (%)
No cut	2296	
E_{EM} cut	2219	$96.65^{+0.40}_{-0.43}$
E_{HAD} cut	2245	$97.78^{+0.29}_{-0.34}$
COT hits cut	2296	$100.00^{+0.00}_{-0.08}$
d_0 cut	2288	$99.65^{+0.12}_{-0.18}$
Isolation cut	2215	$96.47^{+0.38}_{-0.45}$
Δx_{CMX} cut	2294	$99.91^{+0.06}_{-0.11}$
All above cuts	2082	$90.68^{+0.58}_{-0.69}$
All cuts excl. isol.	2159	$94.03^{+0.47}_{-0.55}$
Sliding isol. cut	2240	$97.56^{+0.32}_{-0.37}$
All cuts (sliding isol.)	2107	$91.77^{+0.57}_{-0.61}$
χ^2 cut	2296	$100.00^{+0.00}_{-0.08}$
All cuts (χ^2)	2082	$90.68^{+0.58}_{-0.69}$
All track cuts	2084	$90.77^{+0.59}_{-0.68}$
All trk cuts excl. isol.	2161	$94.12^{+0.48}_{-0.54}$

P11

Efficiency drop?

Could it depends indeed on the cmx18 bool selection?
Indeed to calculate the ID/REco the code selects legs satisfying the bool cmx18 = true.
This is a variable that indicates whether there is a stub.
Since, now we have events triggered by the CMX + JET mixed in (probably in larger number than before) this means that some of these events will have a jet.
However we do not require a jet offline when calculating the Reco/ID efficiency, as there is no way to check if individual events passed the CMX18 + JET trigger.
It's true that we would have had events with jets even before P11 but maybe this time we are getting more or of "better quality" (ie making the lepton less isolated...)

One way to verify the hypothesis is to calculate the efficiency in the case of 0 jets in the event.
The efficiency indeed increases of about 1%.
Still lower than P10 and P9, but in agreement with P8.

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	$93.65^{+3.03}_{-4.78}$	$92.63^{+2.49}_{-3.6}$

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	$98.70^{+0.30}_{-0.33}$	$98.90^{+0.21}_{-0.23}$

bhmumj

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

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	$0.9908^{+0.0054}_{-0.0030}$	$1.0014^{+0.0040}_{-0.0044}$
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

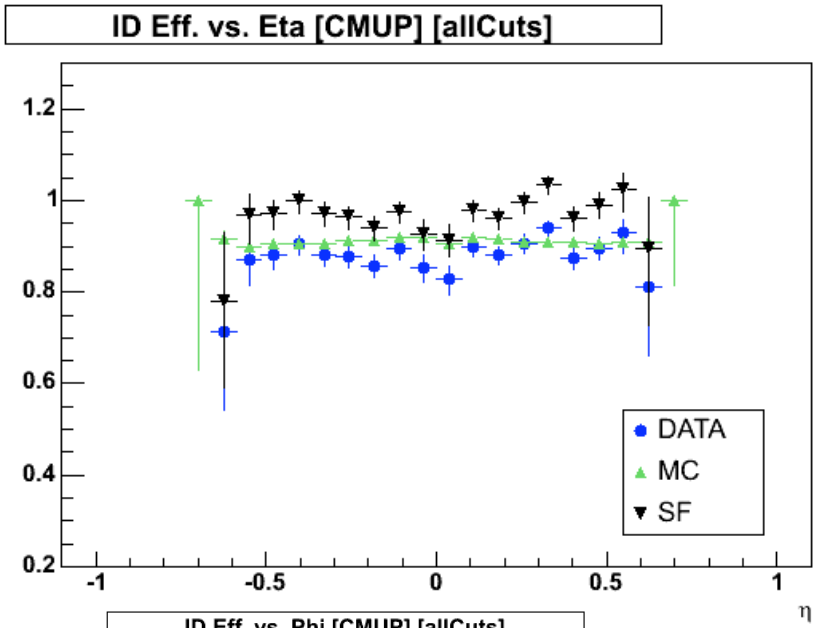
$0.9717^{+0.0060}_{-0.0065}$
$0.9796^{+0.0048}_{-0.0052}$
$0.9929^{+0.0031}_{-0.0035}$
$0.9928^{+0.0068}_{-0.0073}$
$1.0012^{+0.0053}_{-0.0058}$
$0.9973^{+0.0036}_{-0.0040}$

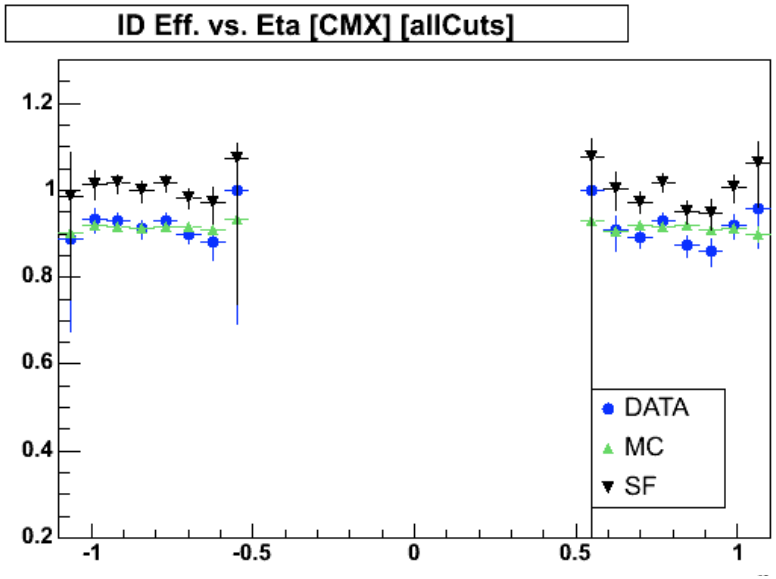
RECO Scale Factor				
	bhmu0i	**bhmu0i2 p8**	**bhmumi p9**	**bhmumi p10**
CMUP	0.9406 ± 0.0043	0.9550 ± 0.0049	$0.9515^{+0.0051}_{-0.0055}$	$0.9348^{+0.0047}_{-0.0048}$
CMX	0.9777 ± 0.0031	0.9703 ± 0.0044	$0.9542^{+0.0057}_{-0.0061}$	$0.9634^{+0.0037}_{-0.0041}$
Arches	0.9889 ± 0.0025	0.9911 ± 0.0029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

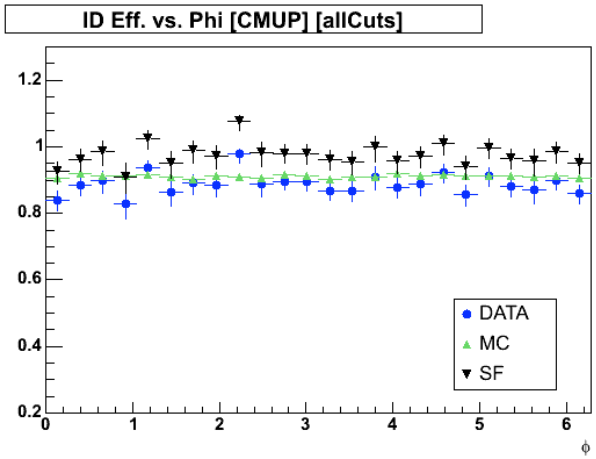
bhmumj P11

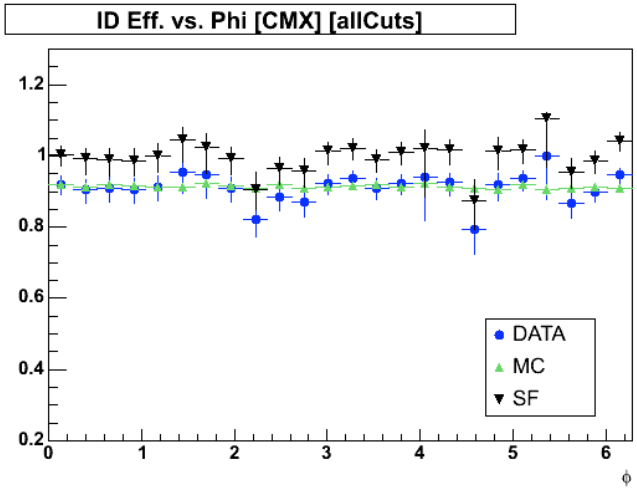
$0.9281^{+0.0052}_{-0.0053}$
$0.9547^{+0.0043}_{-0.0050}$
$0.9840^{+0.0032}_{-0.0037}$
$0.8476^{+0.0172}_{-0.0172}$

Reco and ID plots

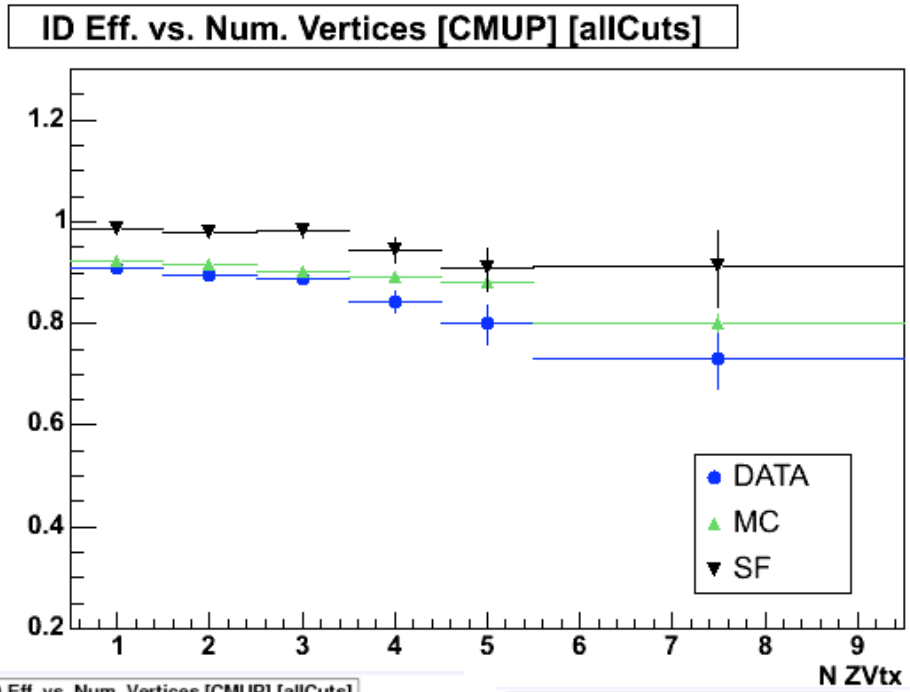


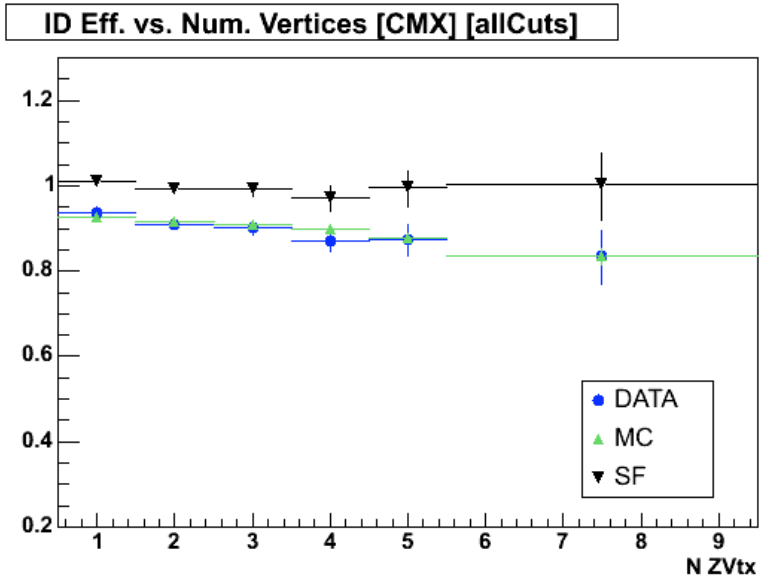


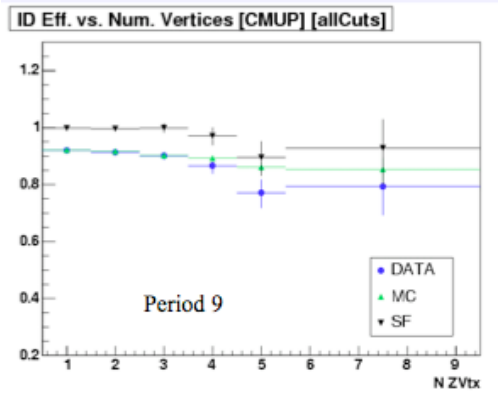


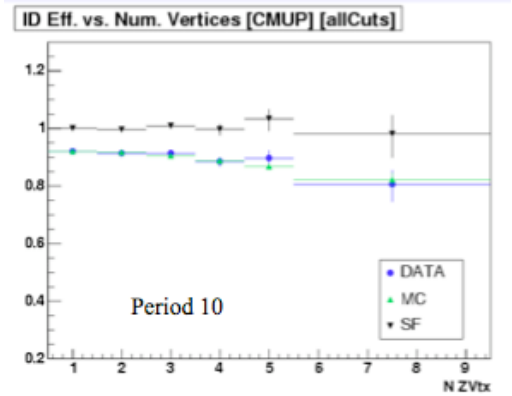


Reco and ID Plots

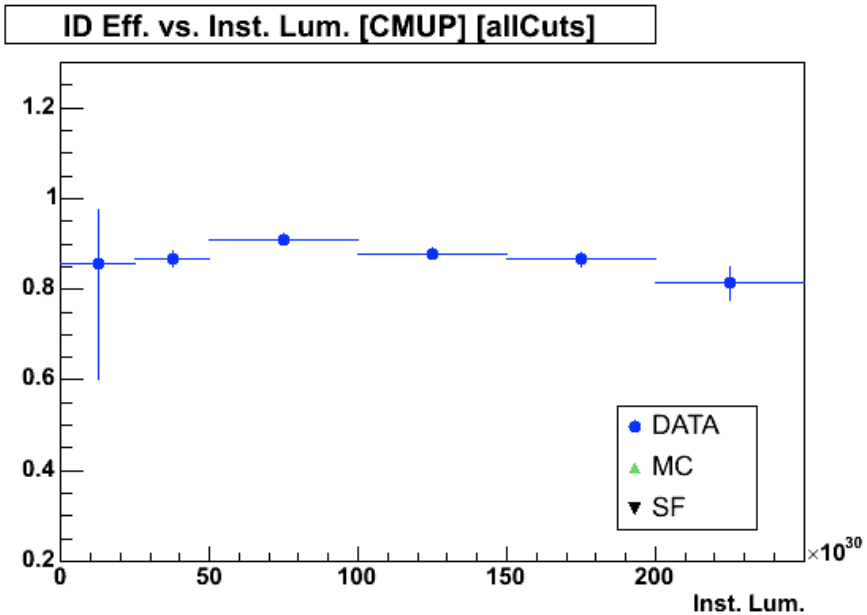


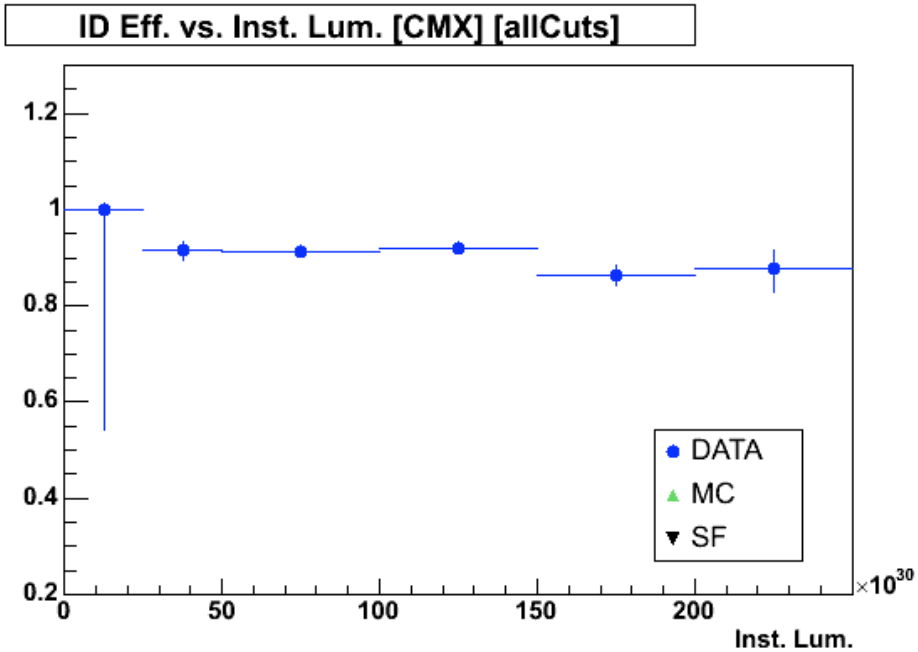




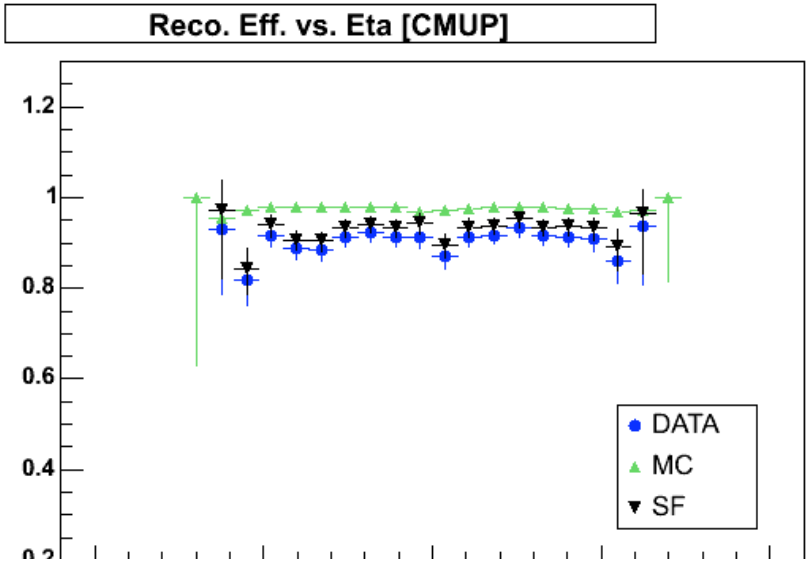


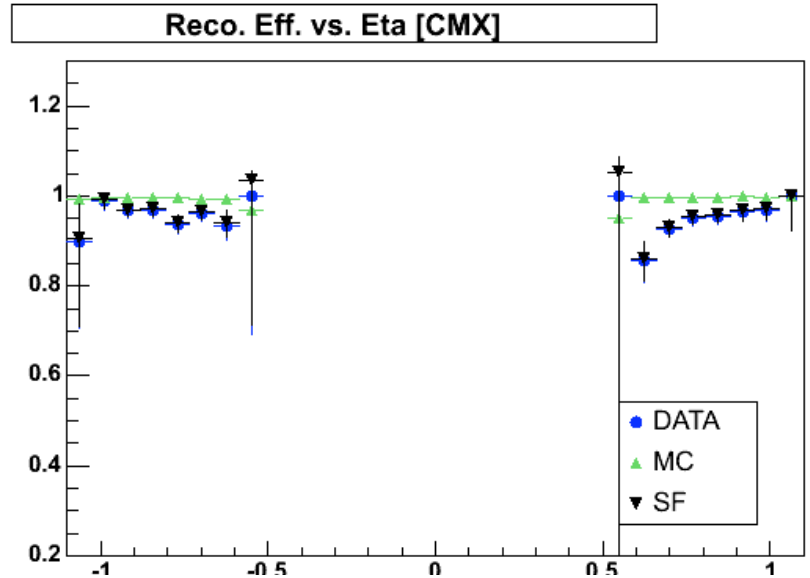
Reco and ID Plots

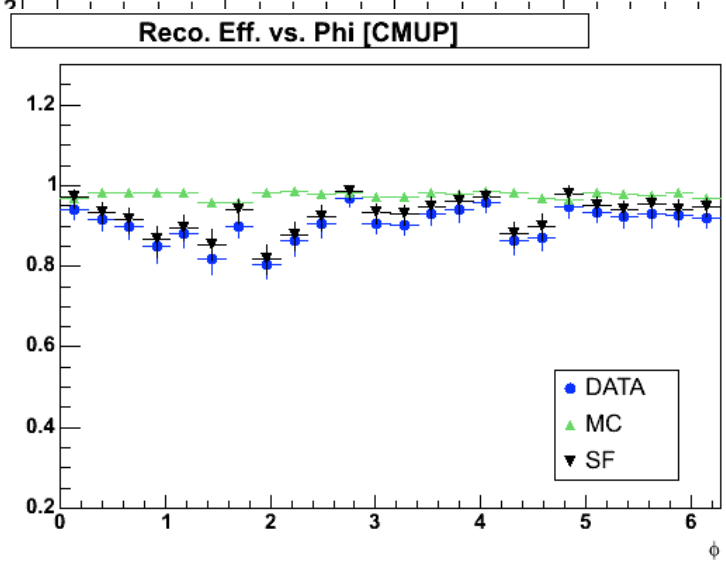


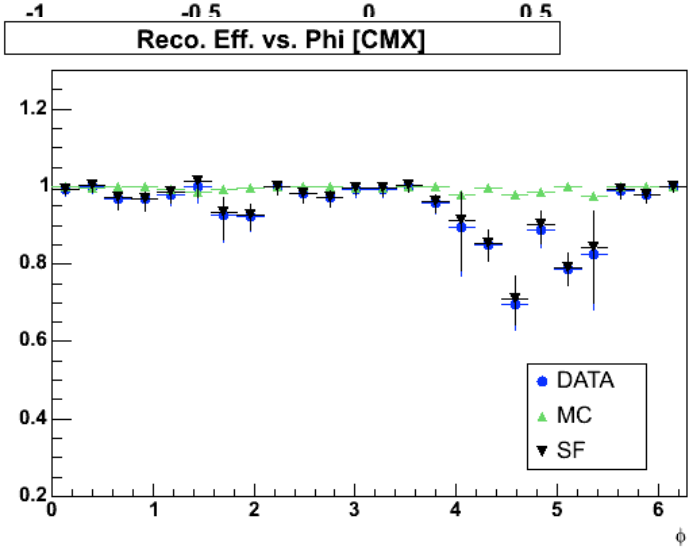


Reco and ID Plots









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:

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

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

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

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.

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

Actually all the trigger paths were more or less used during Period11 ==> Strategy to calculate the efficiencies

Efficiencies

- What do we want to quote?
  - Trigger Eff for CMX SLAM
    - MUON_CMX18_DPS
    - MUON_CMX18_LUMI_250
  - Trigger Eff for CMUP SLAM
    - MUON_CMUP18
  - Trigger Eff for CMX non SLAM
    - MUON_CMX18_L2_LOOSE_DPS
    - MUON_CMX18_L2_LOOSE_LUMI_200
  - Trigger Eff for CMUP non SLAM
    - MUON_CMUP18_L2_LOOSE_DPS
    - MUON_CMUP18_L2_PT15
    - MUON_CMUP18_L2_LOOSE_LUMI_240
    - MUON_CMUP18_L2_LOOSE_LUMI_260
  - Trigger Eff for CMX + Jet SLAM
    - MUON_CMX18_&_JET10_DPS
    - MUON_CMX18_&_JET10_LUMI_270
    - MUON_CMX18_&_JET10_v

Strategy

Based on the assumption that the trigger efficiency under investigation is uncorrelated to the trigger fired by the other Z leg:
We calculate the
1) CMX-Non SLAM and CMUP-Non SLAM efficiency using events passing:
(MUON_CMX18_LUMI_L2_LOOSE_200 ||
MUON_CMX18_L2_LOOSE_DPS) &&
(MUON_CMUP18_L2_LOOSE_DPS || MUON_CMUP18_L2_PT15 ||
MUON_CMUP18_L2_LOOSE_LUMI_240 ||
MUON_CMUP18_L2_LOOSE_LUMI_260)
2) CMX-SLAM and CMUP-SLAM efficiency using events passing:
(MUON_CMX18_LUMI_250 || MUON_CMX18_DPS) &&
MUON_CMUP18_v
3) CMX+JET (SLAM) efficiency using:
(MUON_CMX18_&_JET10_DPS || MUON_CMX18_&_JET10_LUMI_270 ||
MUON_CMX18_&_JET10_v)
&&
MUON_CMUP18_v

Results P11

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 Details P11

Case 1: CMX and CMUP non SLAM

(MUON_CMX18_LUMI_L2_LOOSE_200 || MUON_CMX18_L2_LOOSE_DPS) &&
(MUON_CMUP18_L2_LOOSE_DPS || MUON_CMUP18_L2_PT15 ||
MUON_CMUP18_L2_LOOSE_LUMI_240 || MUON_CMUP18_L2_LOOSE_LUMI_260)

Category	Events Passing	Efficiency (%)
Pass L1	1341	-
CMUP	1273	$98.14^{+0.37}_{-0.46}$
CMX	1238	$95.44^{+0.60}_{-0.67}$
CMUP-CMX	1215	-
CMUPA	1084	-
CMUPMK	189	-
CMUPARCH	1033	$95.30^{+0.65}_{-0.72}$
CMUP-MK	182	$96.30^{+1.26}_{-1.86}$

Level 2

Category	Events Passing	Efficiency (%)
Pass L2	1215	-
CMUP	1212	$99.75^{+0.14}_{-0.25}$
CMX	1208	$99.42^{+0.22}_{-0.31}$
CMUP-CMX	1205	-
CMUPA	1031	-
CMUPMK	181	-
CMUPARCH	1025	$99.42^{+0.23}_{-0.36}$
CMUP-MK	180	$99.45^{+0.50}_{-1.25}$

Level 3

Category	Efficiency (%)
CMUP	$91.98^{+0.58}_{-0.64}$
CMX	$86.29^{+0.86}_{-0.90}$
ARCH	$91.74^{+0.80}_{-0.85}$
MK	$72.80^{+2.42}_{-2.59}$

L1 x L2 x L3

Results Details P11

Case 2: CMX SLAM and CMUP SLAM

(MUON_CMX18_LUMI_250 || MUON_CMX18_DPS) && MUON_CMUP18_v

Category	Events Passing	Efficiency (%)
Pass L1	1341	-
CMUP	1196	$100.00^{+0.00}_{-0.16}$
CMX	1160	$96.99^{+0.50}_{-0.58}$
CMUP-CMX	1160	-
CMUPA	1011	-
CMUPMK	185	-
CMUPARCH	981	$97.03^{+0.57}_{-0.60}$
CMUP-MK	179	$96.76^{+1.19}_{-1.93}$

Level 2

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	$99.44^{+0.51}_{-1.24}$

Level 3

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

L1 x L2 x L3

Results Details P11

Case 3: CMX+JET (SLAM) :
(MUON_CMX18_&_JET10_DPS || MUON_CMX18_&_JET10_LUMI_270 || MUON_CMX18_&_JET10_v)
&&
MUON_CMUP18_v

Category	Events Passing	Efficiency (%)
Pass L1	1341	-
CMUP	1239	$92.65^{+0.76}_{-0.80}$
CMX	1238	$92.57^{+0.74}_{-0.83}$
CMUP-CMX	1147	-
CMUPA	1049	-
CMUPMK	190	-
CMUPARCH	972	$92.66^{+0.85}_{-0.91}$
CMUP-MK	175	$92.11^{+1.94}_{-2.55}$

Level 2

Category	Events Passing	Efficiency (%)
Pass L2	1147	-
CMUP	1144	$99.74^{+0.15}_{-0.26}$
CMX	1141	$99.48^{+0.22}_{-0.32}$
CMUP-CMX	1138	-
CMUPA	970	-
CMUPMK	174	-
CMUPARCH	965	$99.48^{+0.23}_{-0.35}$
CMUP-MK	173	$99.43^{+0.43}_{-1.33}$

Level 3

Category	Efficiency (%)
CMUP	$86.82^{+0.84}_{-0.88}$
CMX	$83.74^{+0.93}_{-0.99}$
ARCH	$89.26^{+0.95}_{-1.00}$
MK	$69.61^{+2.58}_{-2.85}$

L1 x L2 x L3

Results P11: Summary

Category	L1	L2	L3	Total
CMUP SLAM	$93.96^{+0.46}_{-0.42}$	$100.00^{+0.0}_{-0.16}$	$99.74^{+0.15}_{-0.24}$	$93.71^{+0.48}_{-0.50}$
CMX SLAM	$90.94^{+0.67}_{-0.63}$	$96.99^{+0.50}_{-0.58}$	$99.48^{+0.21}_{-0.30}$	$87.74^{+0.81}_{-0.85}$
CMUP non SLAM	$93.96^{+0.46}_{-0.42}$	$98.14^{+0.37}_{-0.46}$	$99.75^{+0.14}_{-0.25}$	$91.98^{+0.58}_{-0.64}$
CMX non SLAM	$90.94^{+0.67}_{-0.63}$	$95.44^{+0.60}_{-0.67}$	$99.42^{+0.22}_{-0.31}$	$86.29^{+0.86}_{-0.90}$
CMX + JET	$90.94^{+0.67}_{-0.63}$	$100^{+0.00}_{-1.16}$	$100.00^{+0.0}_{-1.17}$	$90.94^{+0.67}_{-1.62}$

Results P10 : Summary

Category	L1	L2	L3	Total
CMUP SLAM	$93.66^{+0.42}_{-0.39}$	$100^{+0.00}_{-0.18}$	$99.51^{+0.21}_{-0.33}$	$93.20^{+0.43}_{-0.20}$
CMX SLAM	$91.22^{+0.60}_{-0.57}$	$98.37^{+0.38}_{-0.49}$	$99.22^{+0.27}_{-0.36}$	$89.03^{+0.72}_{-0.79}$
CMUP non SLAM	$93.66^{+0.42}_{-0.39}$	$98.47^{+0.33}_{-0.40}$	$99.70^{+0.14}_{-0.23}$	$91.96^{+0.53}_{-0.58}$
CMX non SLAM	$91.22^{+0.60}_{-0.57}$	$96.17^{+0.56}_{-0.61}$	$99.41^{+0.21}_{-0.30}$	$87.20^{+0.79}_{-0.82}$
CMX + JET	$91.22^{+0.60}_{-0.57}$	$100^{+0.0}_{-1.2}$	$100^{+0.0}_{-1.2}$	$91.22^{+0.60}_{-1.63}$

Results P9 : Summary

Category	L1	L2	L3	Total
CMUP SLAM	$94.21^{+0.51}_{-0.44}$	NA	0.00	0.00
CMX SLAM	$88.50^{+0.85}_{-0.80}$	$100.00^{+0.0}_{-0.63}$	$100.00^{+0.0}_{-0.63}$	$88.50^{+0.85}_{-1.12}$
CMUP non SLAM	$94.21^{+0.51}_{-0.44}$	$98.51^{+0.39}_{-0.53}$	$99.89^{+0.09}_{-0.26}$	$92.70^{+0.63}_{-0.70}$
CMX non SLAM	$88.50^{+0.85}_{-0.80}$	$98.93^{+0.31}_{-0.47}$	$99.42^{+0.60}_{-0.67}$	$84.42^{+1.00}_{-1.04}$
CMX + JET	$88.50^{+0.85}_{-0.80}$	$100^{+0.0}_{-0.6}$	$100^{+0.0}_{-0.6}$	$88.50^{+0.85}_{-1.40}$

Results P8 : Summary

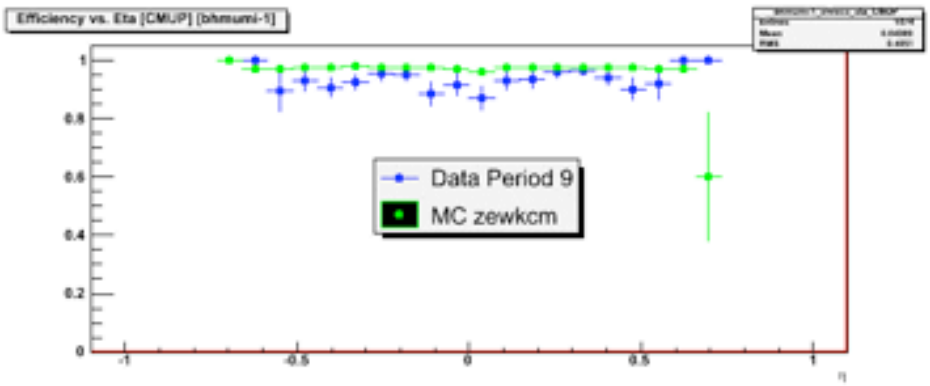
Category	L1	L2	L3	Total
CMUP SLAM	$92.56^{+0.56}_{-0.51}$	0.0	0.0	0.0
CMX SLAM	$88.85^{+0.87}_{-0.78}$	0.0	0.0	0.0
CMUP non SLAM	$92.56^{+0.56}_{-0.51}$	$99.27^{+0.27}_{-0.37}$	$99.37^{+0.27}_{-0.37}$	$91.30^{+0.65}_{-0.69}$
CMX non SLAM	$88.85^{+0.87}_{-0.78}$	$99.89^{+0.09}_{-0.24}$	$99.58^{+0.19}_{-0.37}$	$88.39^{+0.88}_{-0.86}$
CMX + JET	NA	NA	NA	NA

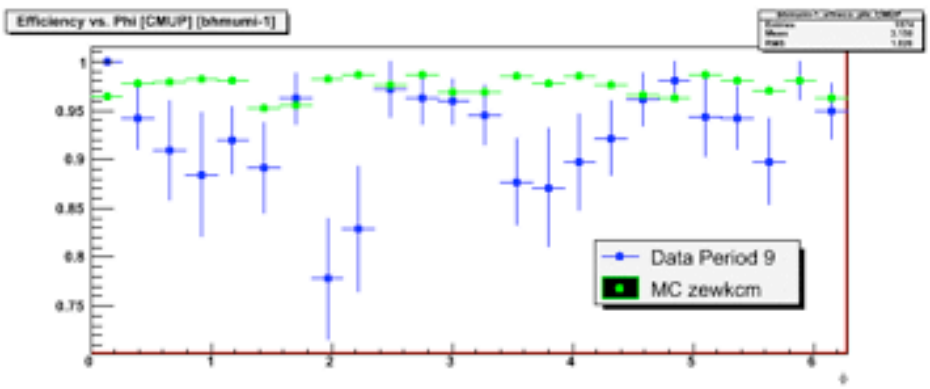
Conclusions

- 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
      - Trigger eff. need to be “weighted” by the correct DPS factor

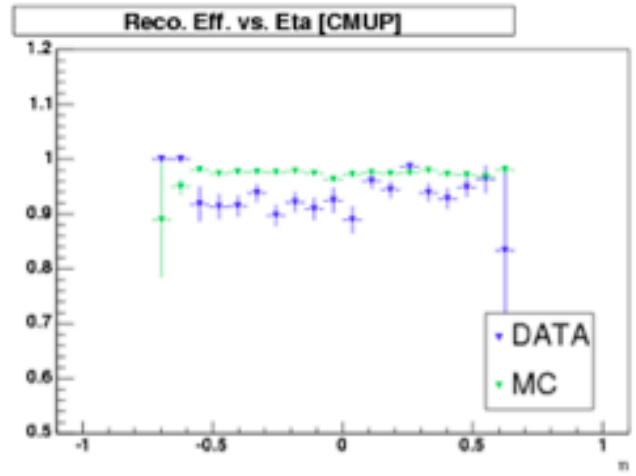
Reco Eff Previous Periods

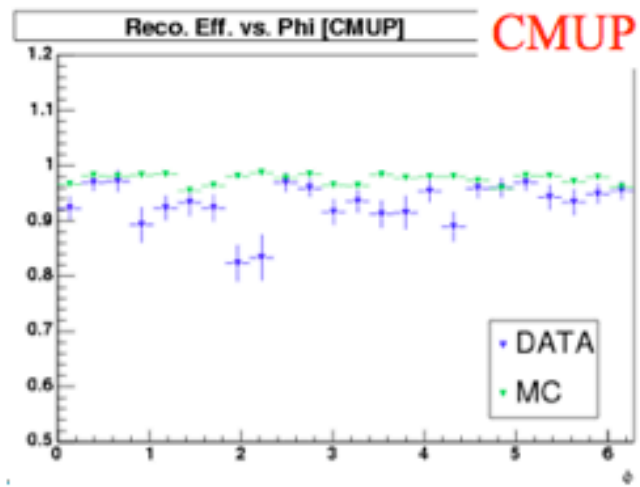
Period 9





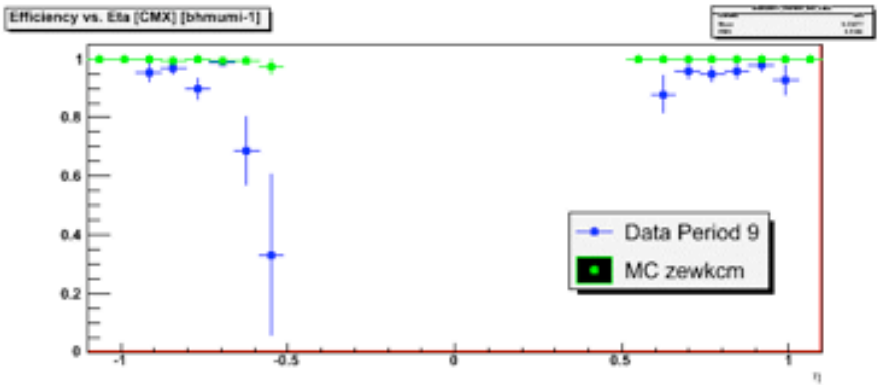
Period 8

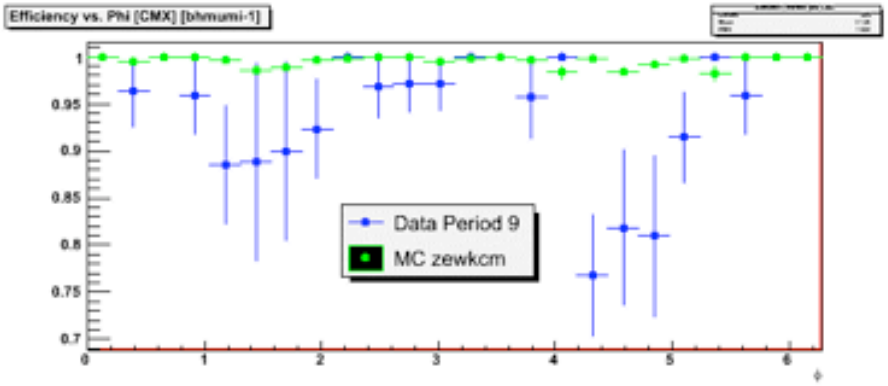




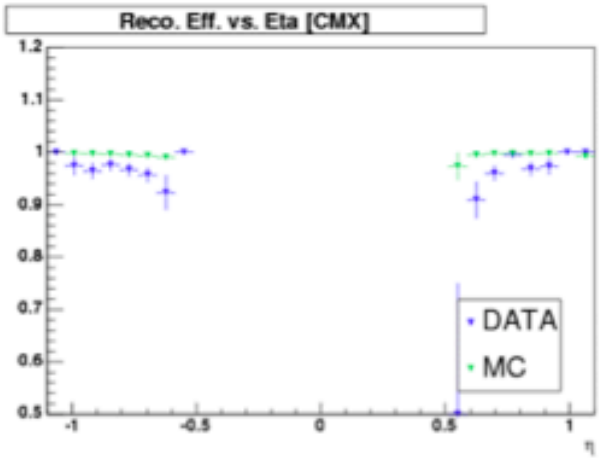
Reco Eff Previous Periods

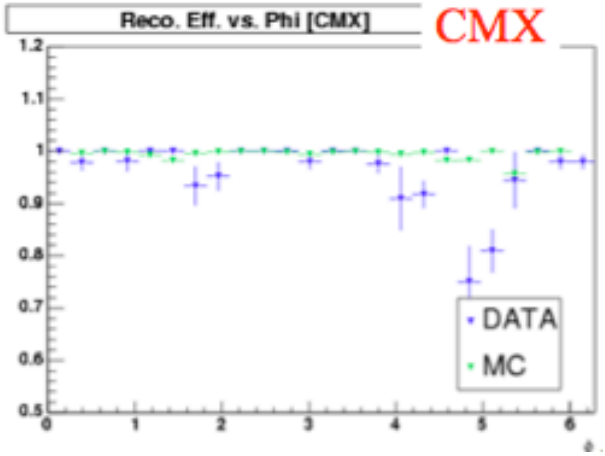
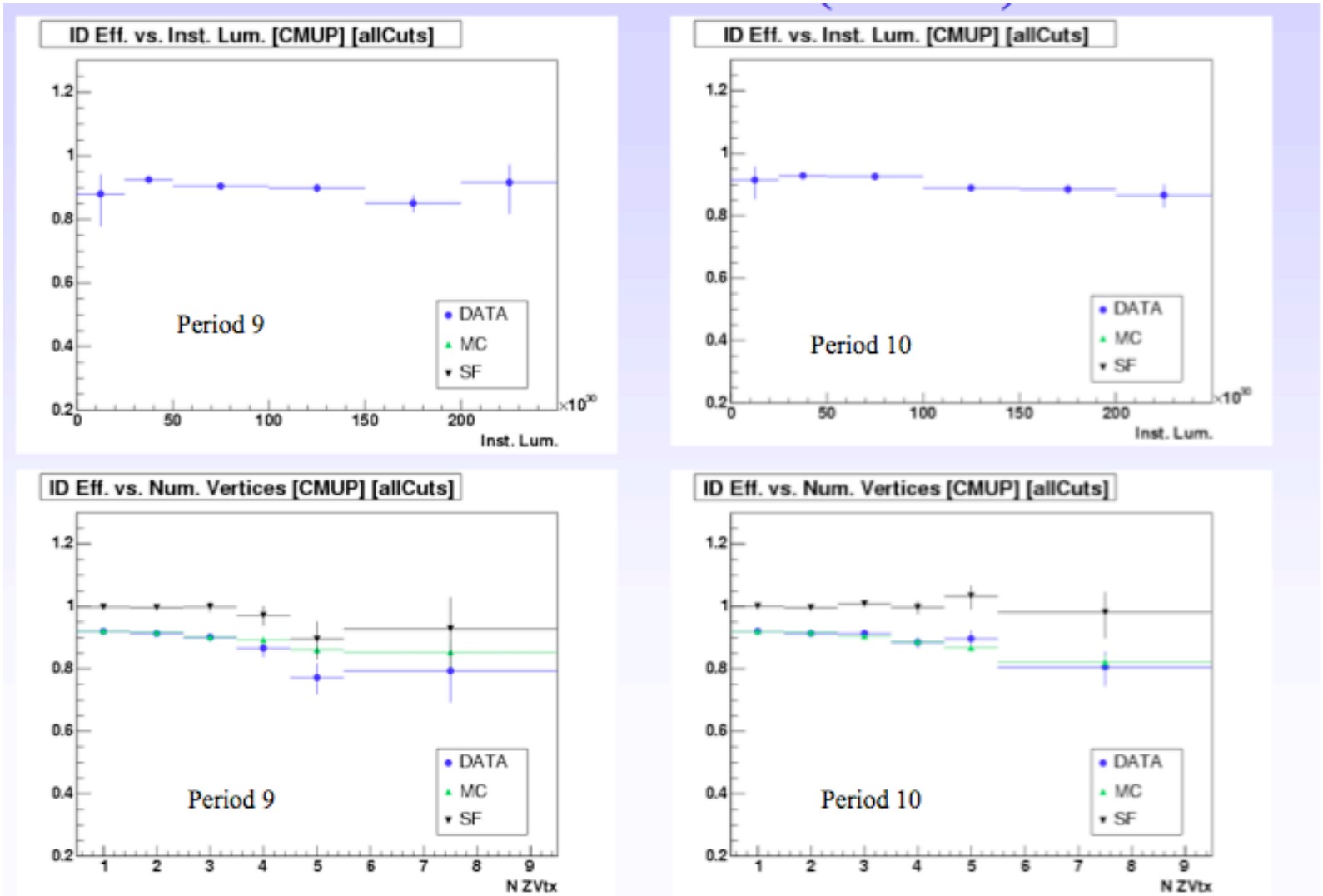
Period 9





Period 8





ID Eff Previous Periods