High-P_T muon ID/Reco/trigger efficiencies for Period 9(updated) and Period 10

Samples

- **Data**
  - Period 9 dataset bhmumi (runs 222529 - 228596) ~ 165 pb^{-1}
  - Period 10 dataset bhmumi (runs 228664 - 233111) ~ 255 pb^{-1}
  - v16 of goodrun list (no silicon)
  - Total Lumi = 1.604 fb^{-1}

- **MC**
  - Period 9 zewkmm
  - Period 10 zemtdm

Muon ID cuts

For all events:

No cosmic tag.

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

Additionally for:

CMUP muons

$\|\Delta x_{CMU}\|$	<	7 cm
$\|\Delta x_{CMP}\|$	<	5 cm

CMX muons

$\|\Delta x_{CMX}\|$	<	6 cm
run	>	150144

Fiducial cuts

Fiducial distance from CMU:

x-fid < 0 cm

z-fid < 0cm

Fiducial distance from CMP:

x-fid < 0 cm

z-fid < -3 cm

ρCOT > 140 cm

Fiducial distance from CMX:

x-fid < 0 cm

z-fid < -3 cm

No muons from keystone for run < 190697

No muons from miniskirt for run < 190697

Arches:

$0^o \leq \phi < 75^o$ or $105^o < \phi < 225^o$

or $315^o < \phi < 360^o$

Keystone:

$(75^o \leq \phi \leq 105^o)$ and $\eta < 0$

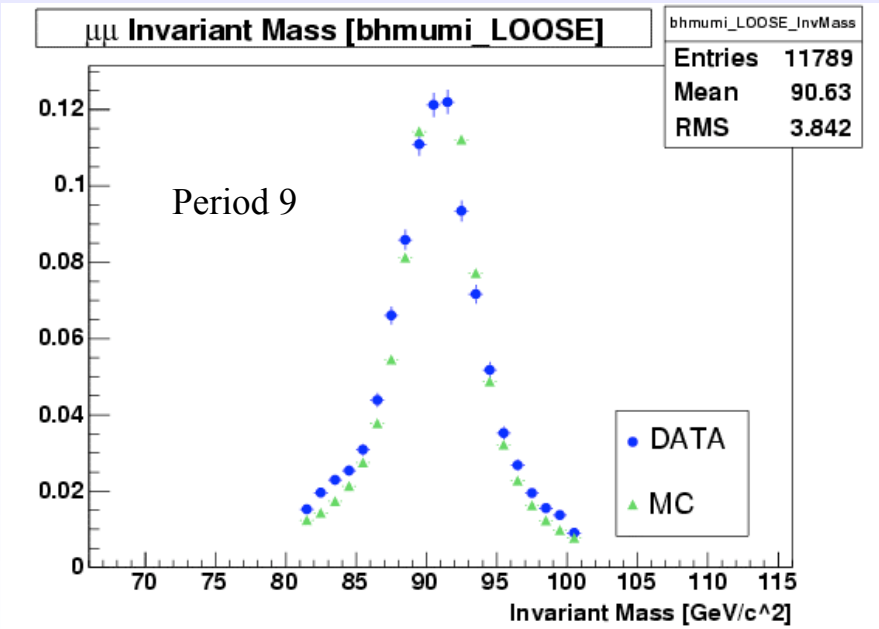
Miniskirt:

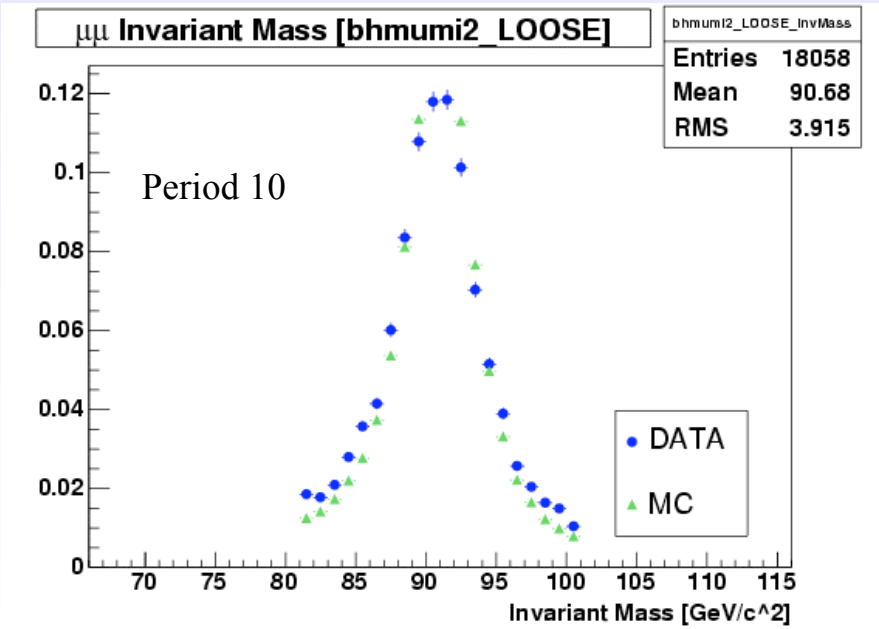
$225 \leq \phi \leq 315^o$

$Z \rightarrow \mu\mu$

Cuts to select $Z \rightarrow \mu\mu$ events:

- the event must not have cosmic tag
- the Z_0 of the two legs must pass: $|z_0^{(1)}-z_0^{(2)}| < 4$cm
- the inv mass of the two tracks must pass: 81 GeV/c^2 < m($\mu\mu$) < 101 GeV/c^2





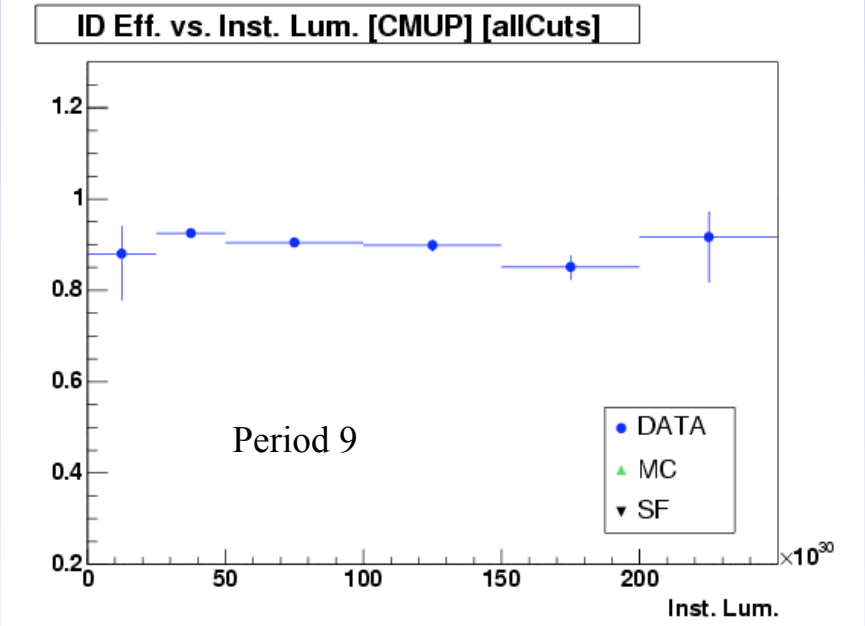
Muon ID Efficiencies (CMUP)

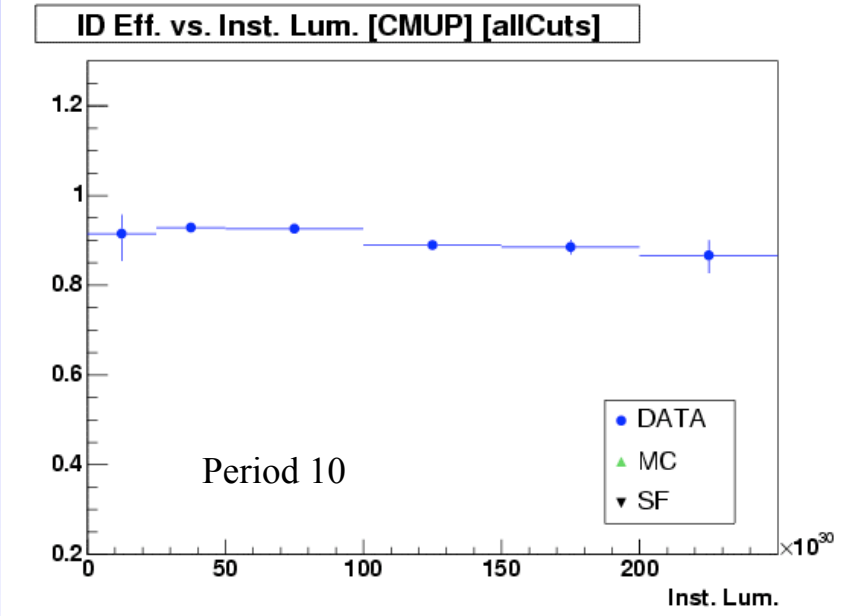
We are using $Z \rightarrow \mu^+\mu^-$ events with one identified leg (CMUP or CMX).
This first leg must pass all the ID cuts and must match to level 1 trigger information.
We are then looking if the second leg pas ID cuts in question.

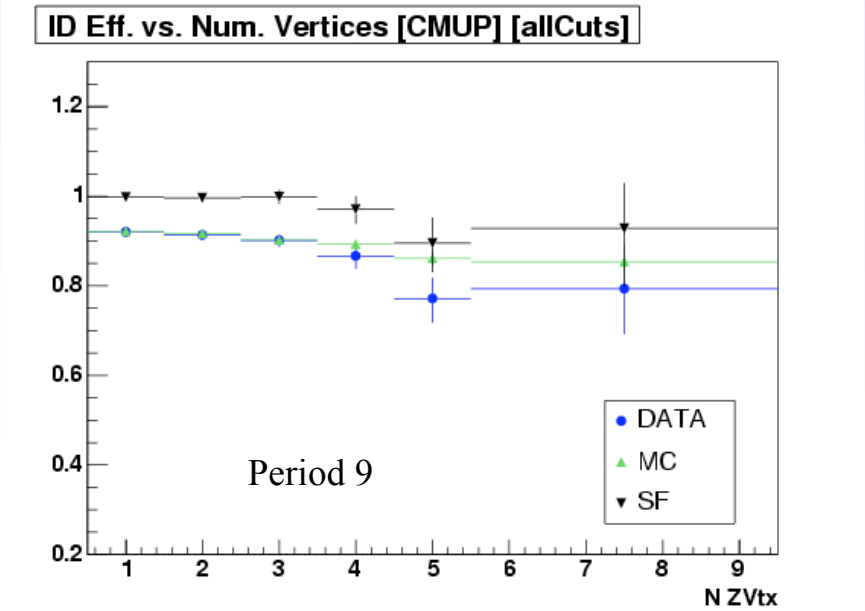
	Efficiency (%)				
	bhmu0i2 p8	**bhmumi p9**	***zewkmm***	**bhmumi p10**	***zemtdm***
E_{EM} cut	96.35 ± 0.36	$97.36^{+0.32}_{-0.36}$	$96.22^{+0.08}_{-0.08}$	$97.68^{+0.23}_{-0.26}$	$96.20^{+0.06}_{-0.06}$
E_{HAD} cut	97.91 ± 0.27	$98.32^{+0.25}_{-0.29}$	$98.31^{+0.05}_{-0.06}$	$98.45^{+0.19}_{-0.22}$	$98.30^{+0.04}_{-0.04}$
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	$91.43^{+0.53}_{-0.54}$	$91.87^{+0.12}_{-0.12}$	$91.86^{+0.45}_{-0.48}$	$91.82^{+0.08}_{-0.09}$

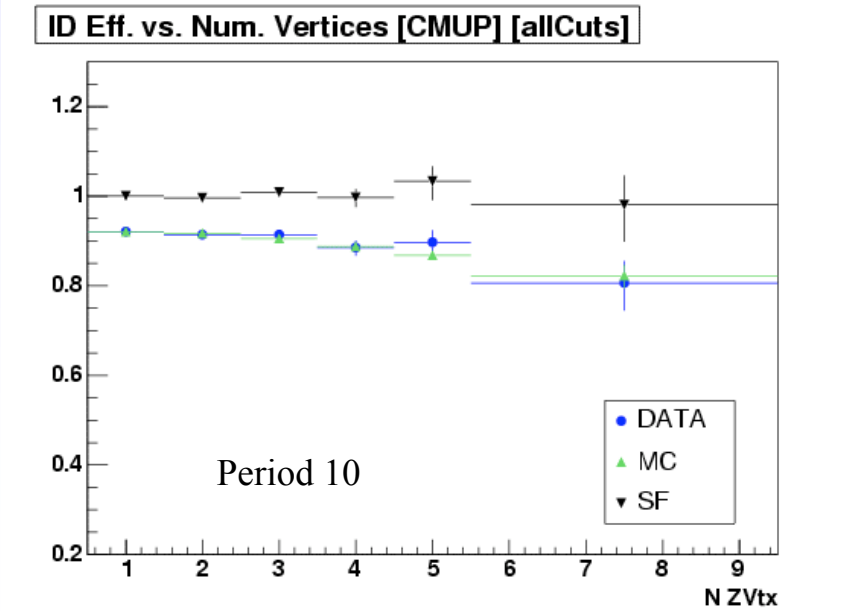
Everything looks **OK**

Muon ID Efficiencies (CMUP)

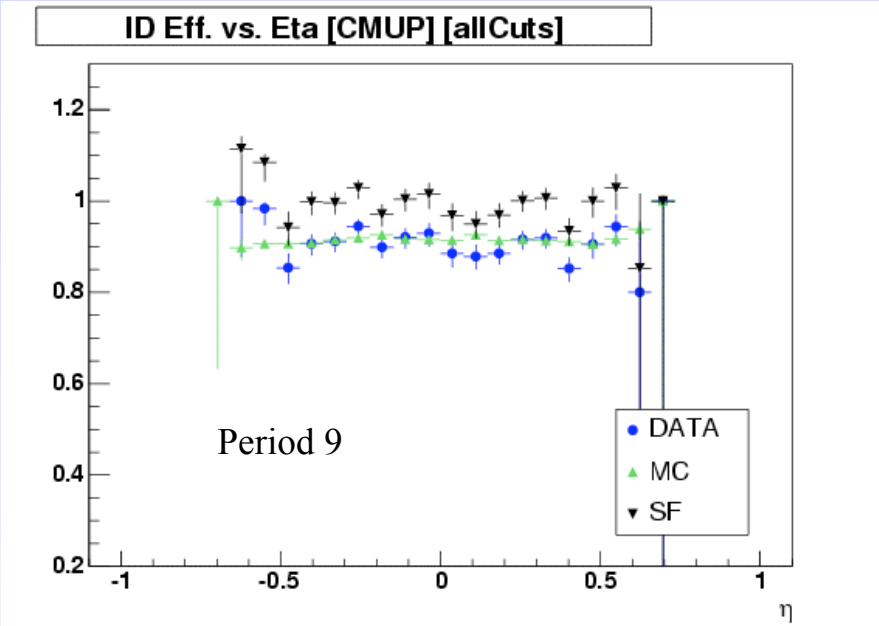


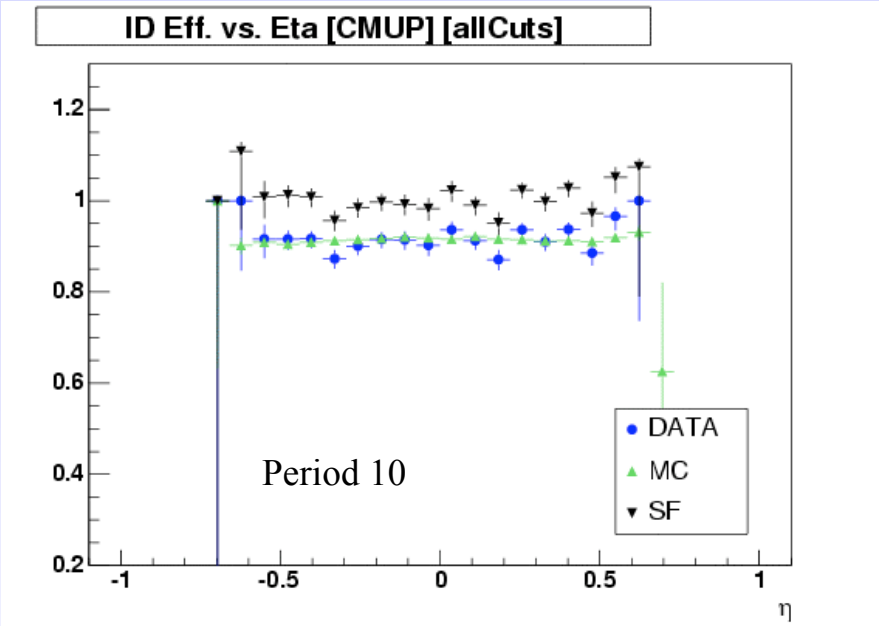


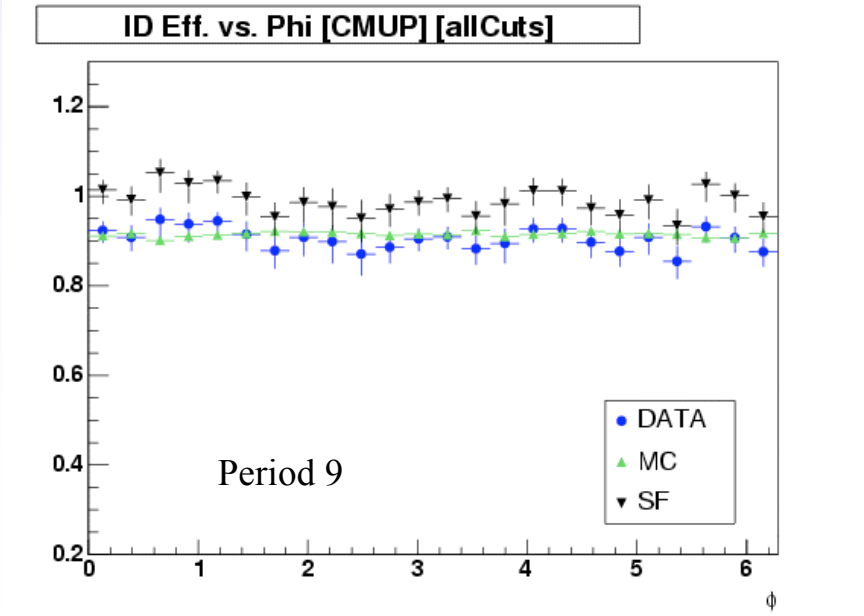


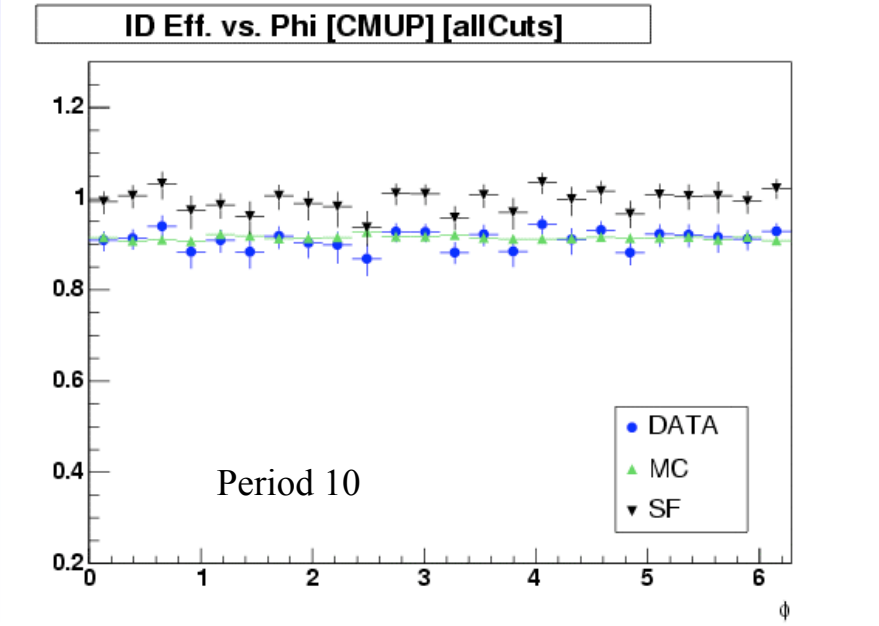


Muon ID Efficiencies (CMUP)







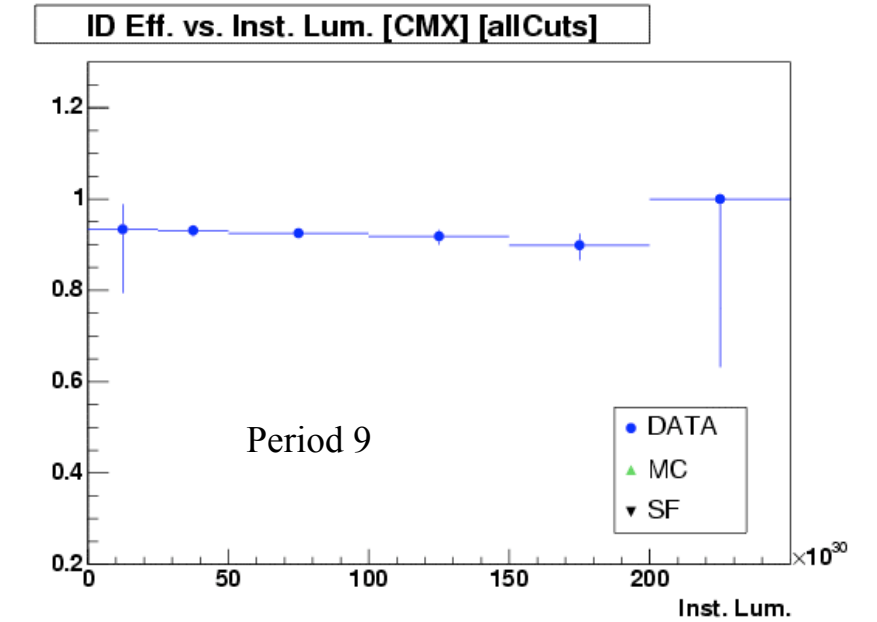


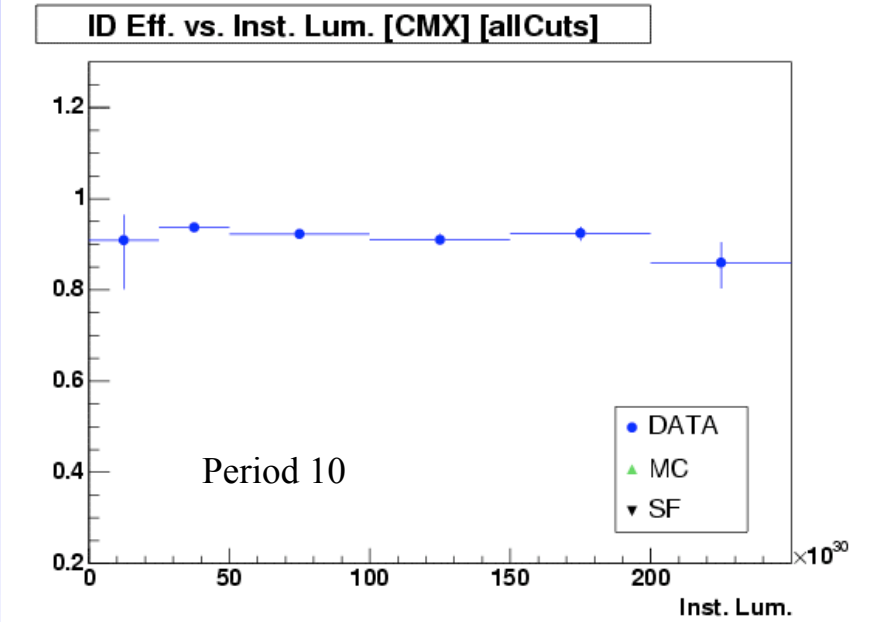
Muon ID Efficiencies (CMX)

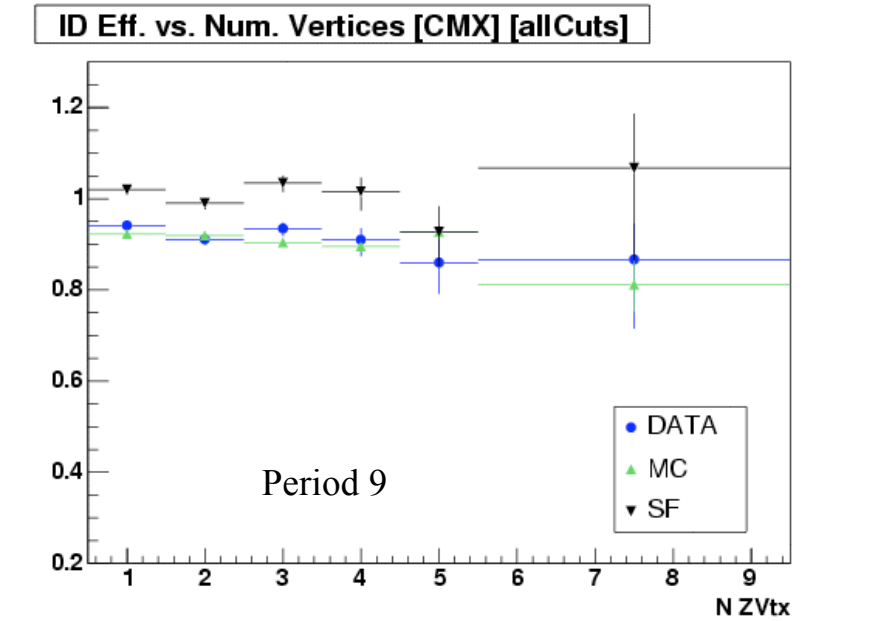
	Efficiency (%)				
	bhmu0i2 p8	**bhmumi p9**	***zewkmm***	**bhmumi p10**	***zemtdm***
E_{EM} cut	96.59 ± 0.44	$97.34^{+0.39}_{-0.44}$	$96.32^{+0.10}_{-0.10}$	$97.24^{+0.34}_{-0.39}$	$96.40^{+0.07}_{-0.08}$
E_{HAD} cut	98.14 ± 0.33	$97.88^{+0.34}_{-0.40}$	$97.88^{+0.08}_{-0.08}$	$98.03^{+0.29}_{-0.30}$	$97.90^{+0.06}_{-0.06}$
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	$92.62^{+0.70}_{-0.67}$	$92.06^{+0.14}_{-0.15}$	$92.98^{+0.50}_{-0.53}$	$92.21^{+0.11}_{-0.12}$

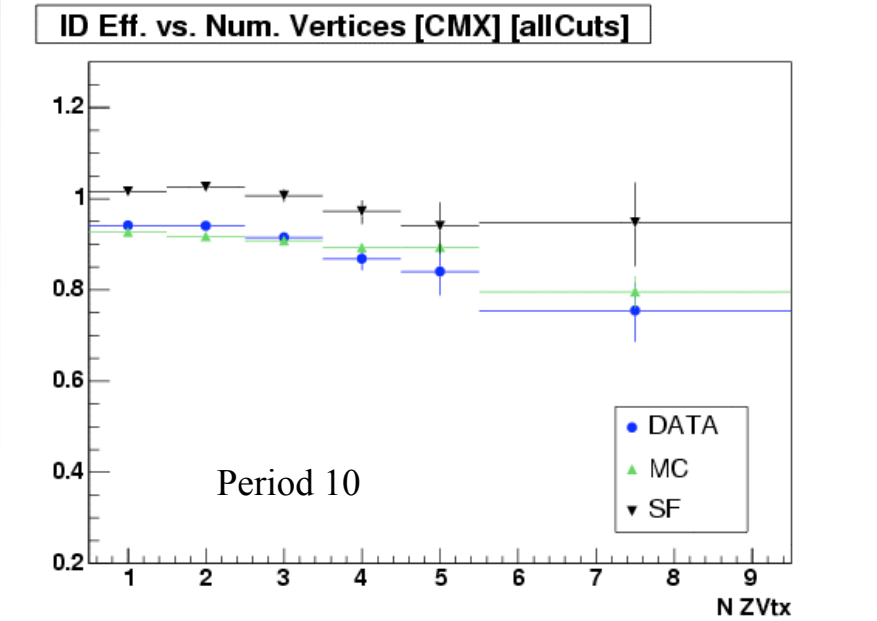
Everything looks **OK**

Muon ID Efficiencies (CMX)

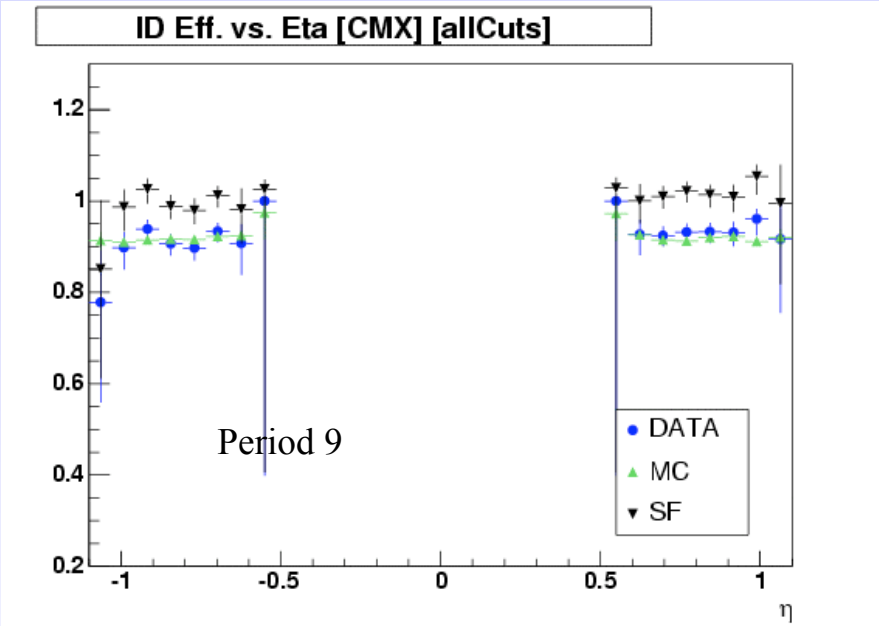


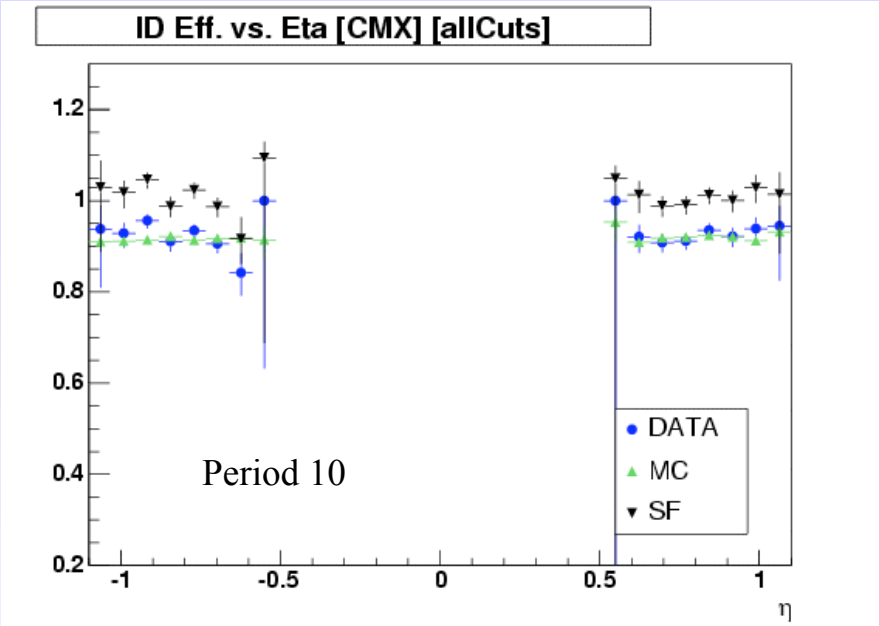


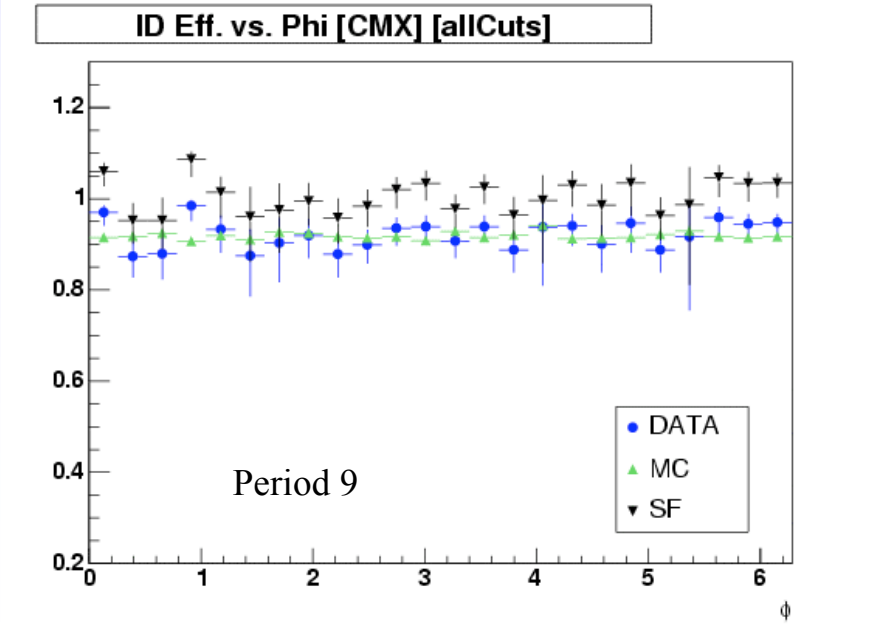


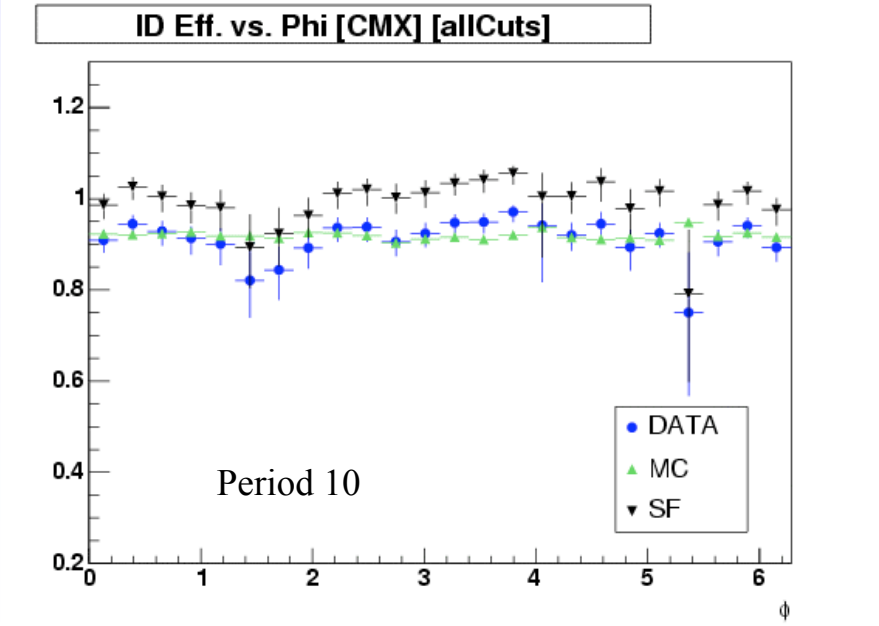


Muon ID Efficiencies (CMX)









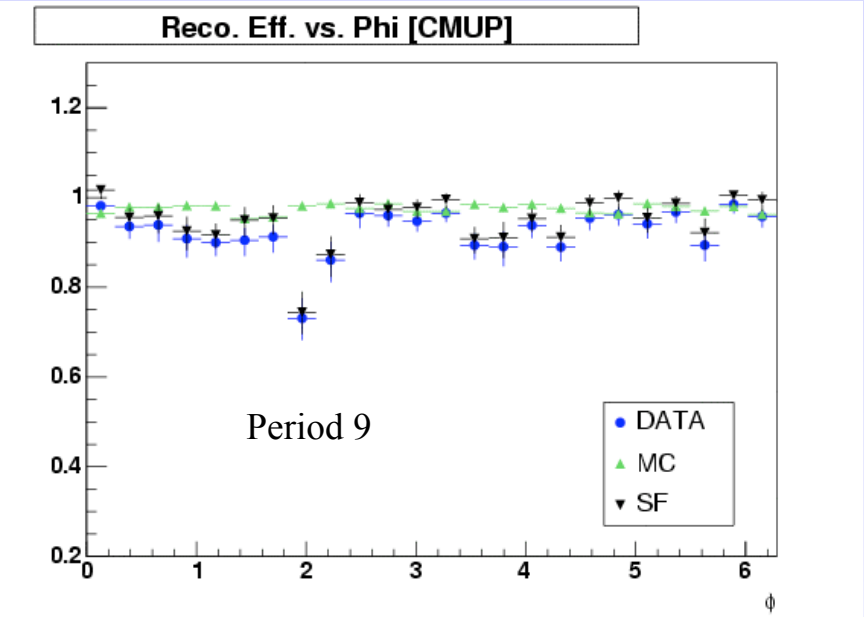
Reconstruction Efficiency

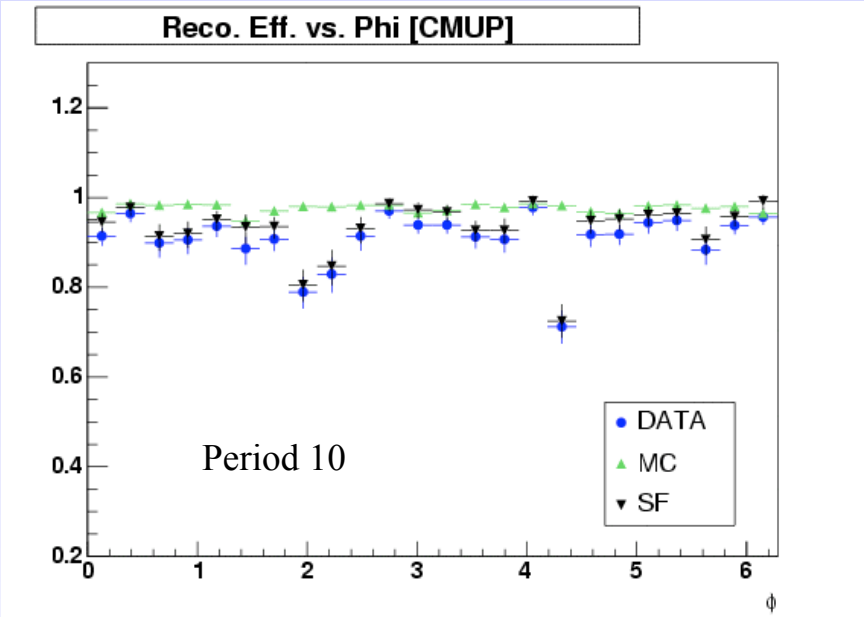
The first leg must pass all the ID and Fid. cuts and must match to the level 1 trigger information. If the second leg is Fiducial, and pass "P_T, E_{EM}, E_{HAD}" cuts, we examine this track to see if is linked to a muon stub or not.

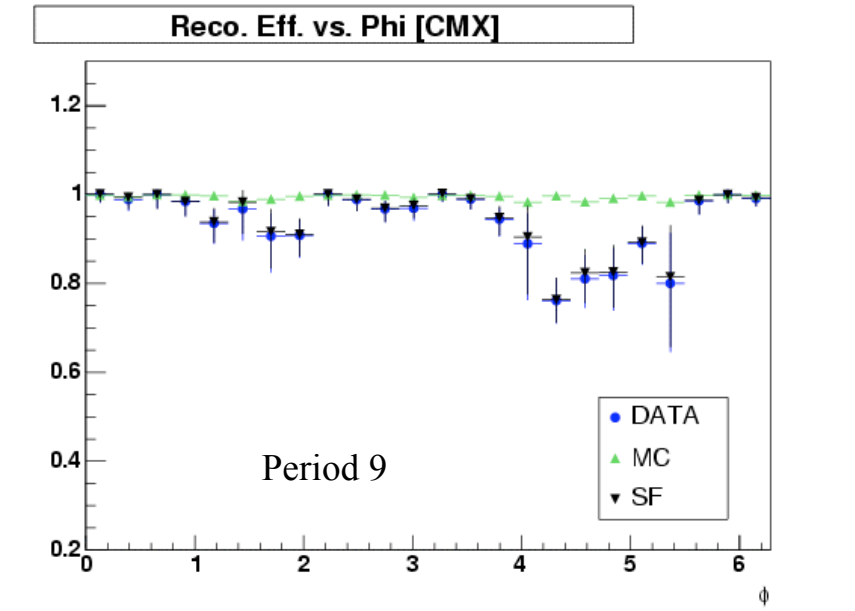
	Efficiency (%)				
DATA	**bhmu0h**	**bhmu0i**	**bhmu0i2 p8**	**bhmumi p9**	**bhmumi p10**
CMUP	91.63 ± 0.34	91.78 ± 0.42	93.04 ± 0.47	$92.70^{+0.49}_{-0.53}$	$91.22^{+0.46}_{-0.47}$
CMX	97.47 ± 0.25	97.39 ± 0.31	96.67 ± 0.44	$95.09^{+0.57}_{-0.60}$	$95.99^{+0.37}_{-0.41}$
Arches	99.07 ± 0.18	98.68 ± 0.25	98.91 ± 0.29	$98.05^{+0.37}_{-0.46}$	$98.47^{+0.29}_{-0.30}$
Miniskirt	92.57 ± 0.94	92.62 ± 1.18	87.96 ± 1.81	$82.09^{+2.18}_{-2.50}$	$85.59^{+1.62}_{-1.90}$
Keystone	91.67 ± 2.13	94.50 ± 2.18	95.77 ± 2.39	$93.65^{+3.03}_{-4.78}$	$92.63^{+2.49}_{-3.76}$

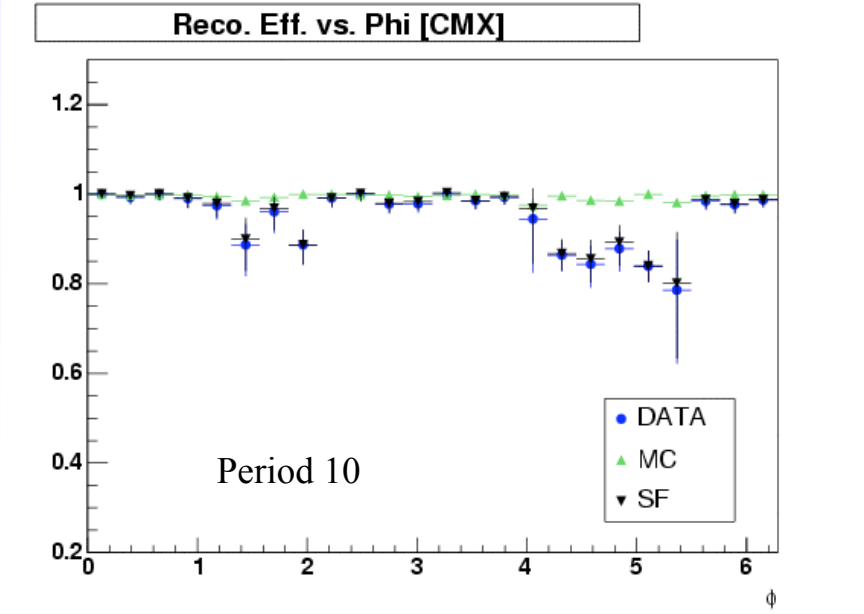
	Efficiency (%)			
MC	**zewk9m**	**zewkbm**	**zewkmm**	**zemtdm**
CMUP	97.57 ± 0.03	97.43 ± 0.06	$97.42^{+0.06}_{-0.06}$	$97.58^{+0.05}_{-0.05}$
CMX	99.61 ± 0.02	99.62 ± 0.03	$99.65^{+0.03}_{-0.04}$	$99.64^{+0.02}_{-0.03}$
Arches	99.79 ± 0.02	99.80 ± 0.03	$99.80^{+0.03}_{-0.03}$	$99.80^{+0.02}_{-0.02}$
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	$98.70^{+0.30}_{-0.33}$	$98.90^{+0.21}_{-0.23}$

Reconstruction Efficiency









Muon ID/RECO Scale Factors

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	$0.9908^{+0.0054}_{-0.0030}$	$1.0014^{+0.0040}_{-0.0045}$
Sliding Isol. cut	0.9804 ± 0.0050	0.9952 ± 0.0031	$1.0031^{+0.0027}_{-0.0030}$	$0.9993^{+0.0024}_{-0.0027}$
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	$0.9957^{+0.0040}_{-0.0047}$	$0.9992^{+0.0030}_{-0.0036}$

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	$0.8484^{+0.0193}_{-0.0193}$	$0.8758^{+0.0158}_{-0.0158}$

ID/RECO conclusion

- **ID and RECO efficiencies agree well with previous DATA and MC.**

Trigger Efficiency

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)

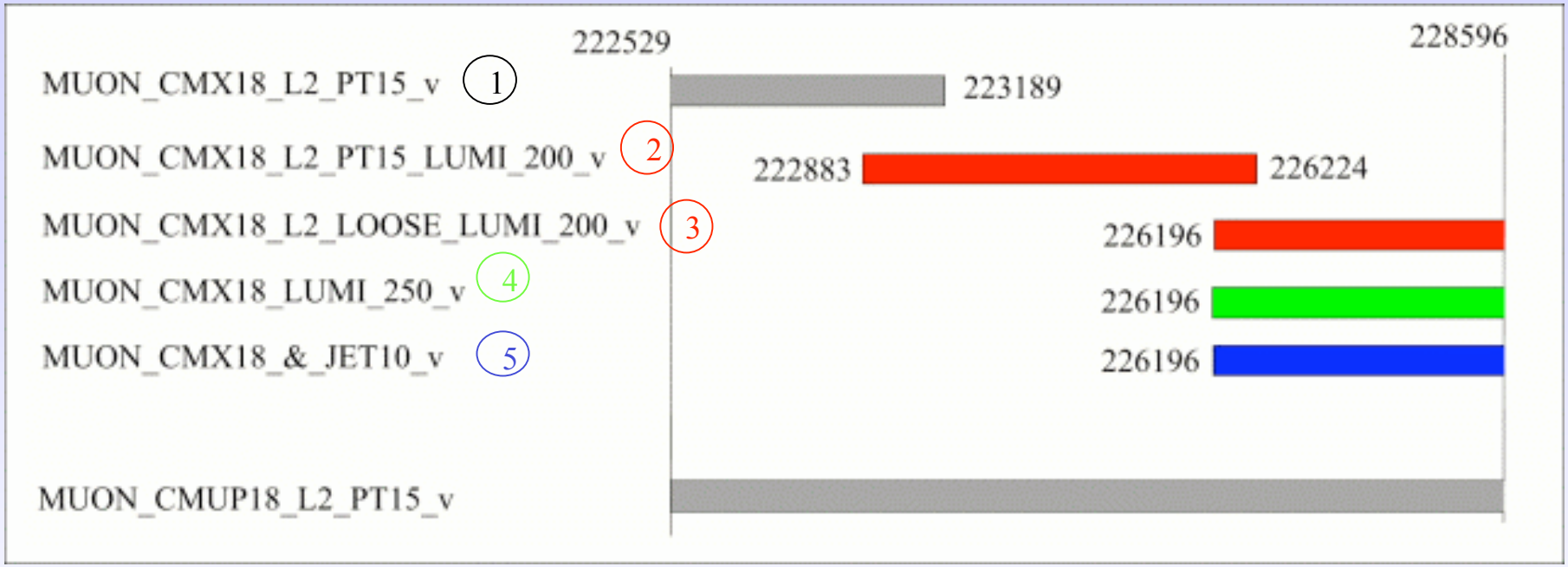
$$\mathring{a}^{L2}_{CMUP} = \frac{\#\text{ of events pass both L2 triggers}}{\#\text{ of events pass L2 CMX trigger}}$$

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.

CMX/CMUP trigger in period **9**



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

Et cut

	bhmumi <223189	LUMI 200	LOOSE	SLAM	JET10 20
CMX eff. naming	**1**	**2**	**3**	**4**	**5**

Efficiency for “MUON_CMX18_LUMI_250” trigger is labeled: “SLAM”

Trigger Efficiency in Period 9

Level 1 trigger efficiency (%)

	bhmu0i2 p8	bhmumi p9
CMUP	92.57 ± 0.51	$94.18^{+0.50}_{-0.45}$
CMX	88.90 ± 0.77	$88.63^{+0.84}_{-0.83}$

Level 2 trigger efficiency (%)

	bhmu0i2 p8	bhmumi <223189	LUMI 200	LOOSE	SLAM	JET10 20
CMUP	≡ 100.0 ± 0.0	≡ $100.0^{+0.0}_{-0.0}$	$98.35^{+0.53}_{-0.74}$		-	
CMX	≡ 100.0 ± 0.0	≡ $100.0^{+0.0}_{-0.0}$	$91.98^{+1.48}_{-1.84}$	$96.13^{+1.04}_{-1.50}$	$96.20^{+1.17}_{-1.57}$	$100.0^{+0.0}_{-4.73}$

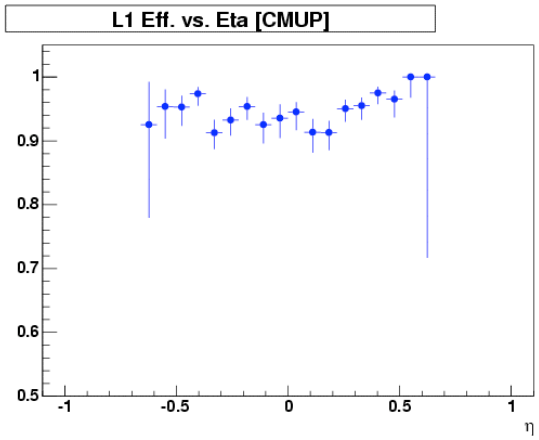
Level 3 trigger efficiency (%)

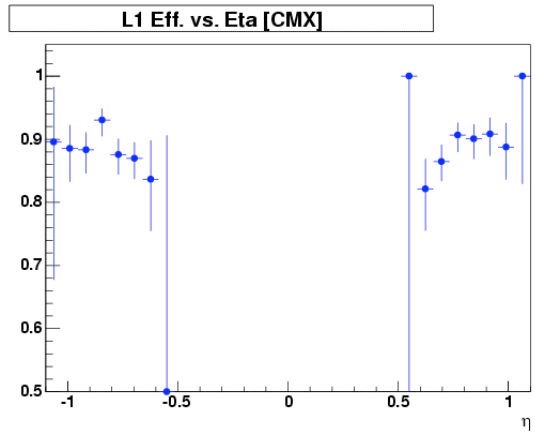
	bhmu0i2 p8	bhmumi <223189	LUMI 200	LOOSE	SLAM	JET10 20
CMUP	98.63 ± 0.38	$98.70+^{0.66}_{-1.29}$	$99.83^{+0.13}_{-0.38}$		-	
CMX	99.47 ± 0.24	$99.13^{+0.53}_{-1.13}$	$99.33^{+0.45}_{-0.89}$	$100.0^{+0.0}_{-0.62}$	$100.0^{+0.0}_{-0.73}$	$100.0^{+0.0}_{-4.73}$

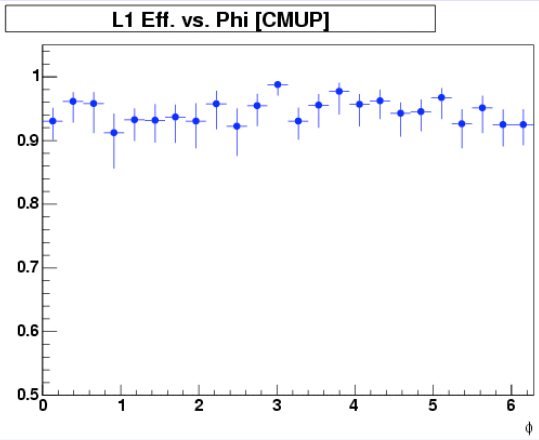
Combined trigger efficiency (%)

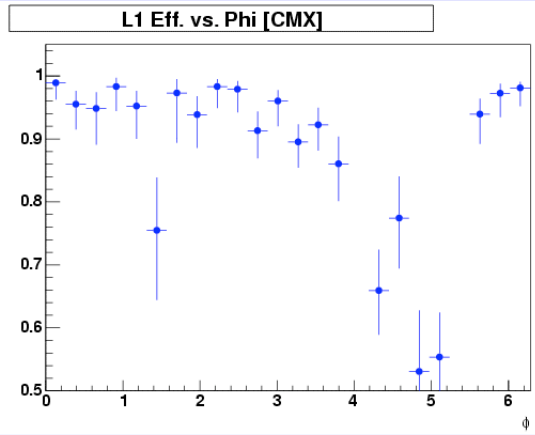
	bhmu0i2 p8	bhmumi <223189	LUMI 200	LOOSE	SLAM	JET10 20
CMUP	91.30 ± 0.61	$92.95^{+0.80}_{-1.48}$	$92.47^{+0.71}_{-0.90}$		-	
CMX	88.43 ± 0.79	$87.86^{+0.95}_{-1.47}$	$80.97^{+1.56}_{-1.92}$	$85.20^{+1.22}_{-1.63}$	$85.26^{+1.31}_{-1.72}$	$88.63^{+0.84}_{-5.99}$

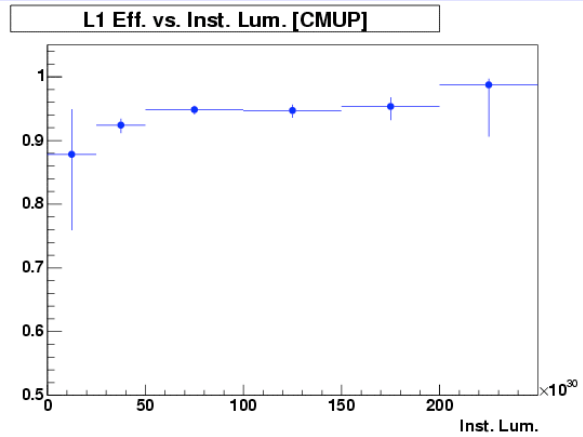
L1 Trigger Efficiency Period 9

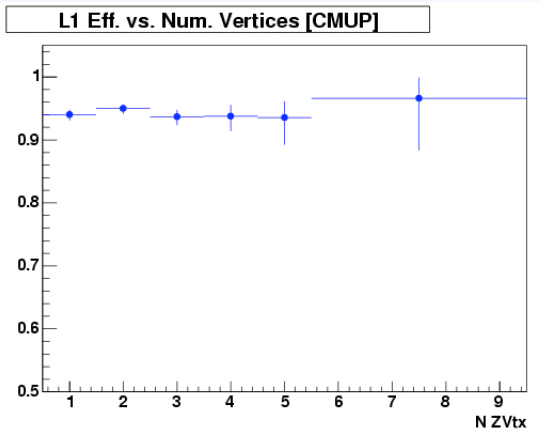


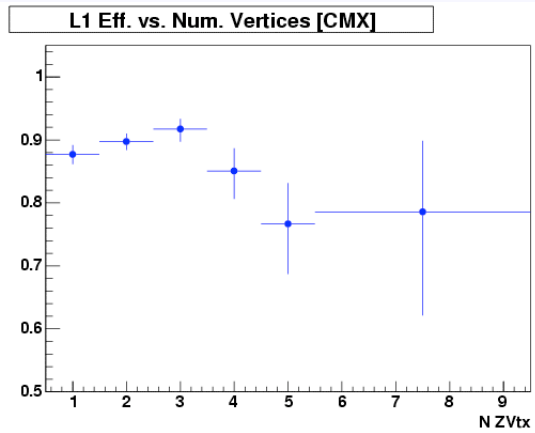


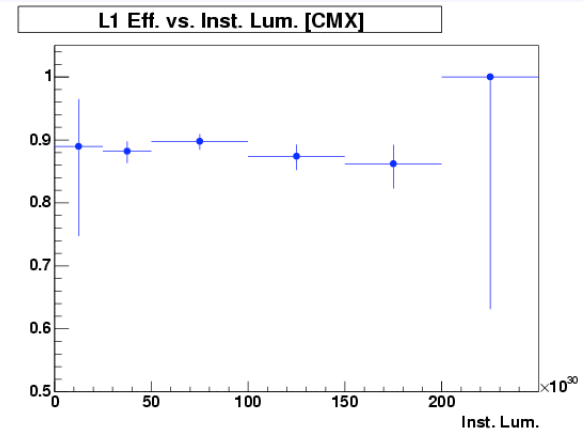




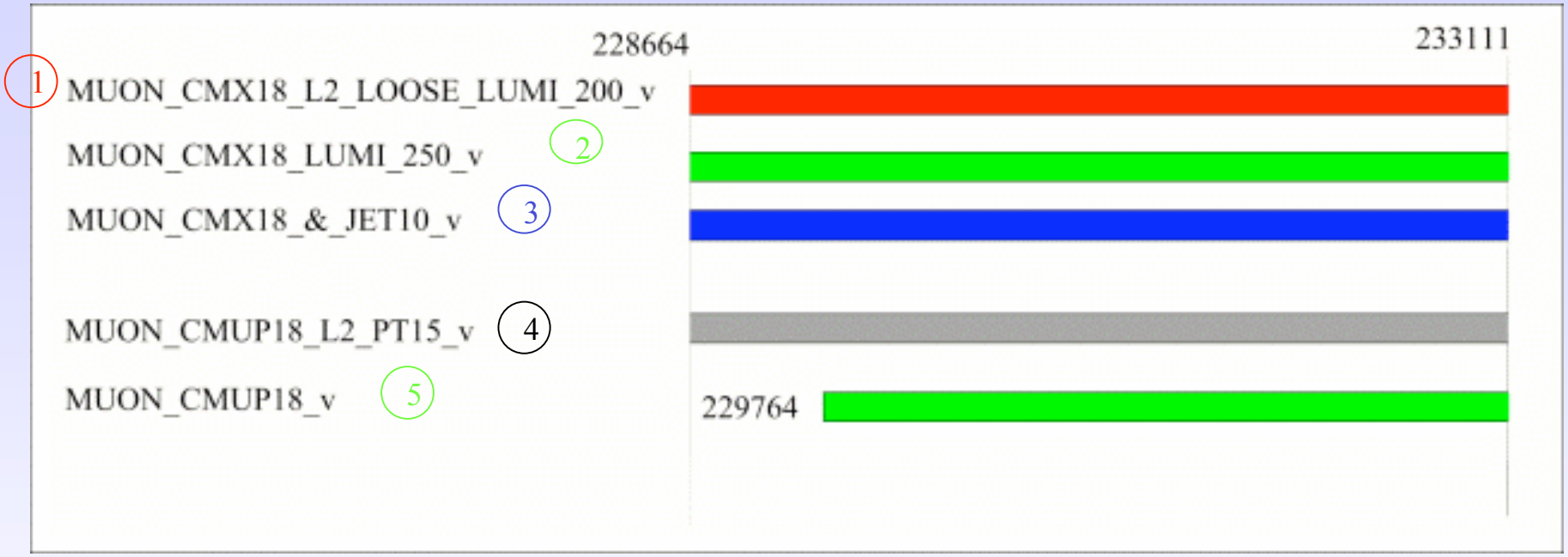








CMX/CMUP trigger in period **10**



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

	LOOSE	SLAM1	SLAM2	JET10
CMUP	4		5	
CMX	1	2	2 run>229764	3

Trigger Efficiency in Period 10

Level 1 trigger efficiency (%)

	bhmu0i2 p8	bhmumi p10
CMUP	92.57 ± 0.51	$93.71^{+0.43}_{-0.40}$
CMX	88.90 ± 0.77	$91.23^{+0.61}_{-0.56}$

Level 2 trigger efficiency (%)

	bhmu0i2 p8	SLAM1	SLAM2
CMUP	100.0 ± 0.00	-	$98.56^{+0.39}_{-0.49}$
CMX	100.0 ± 0.00	$98.42^{+0.33}_{-0.45}$	$98.28^{+0.38}_{-0.50}$

Level 3 trigger efficiency (%)

	bhmu0i2 p8	SLAM1	SLAM2
CMUP	98.63 ± 0.38	-	$99.71^{+0.16}_{-0.28}$
CMX	99.47 ± 0.24	$99.44^{+0.21}_{-0.30}$	$99.32^{+0.27}_{-0.37}$

Combined trigger efficiency (%)

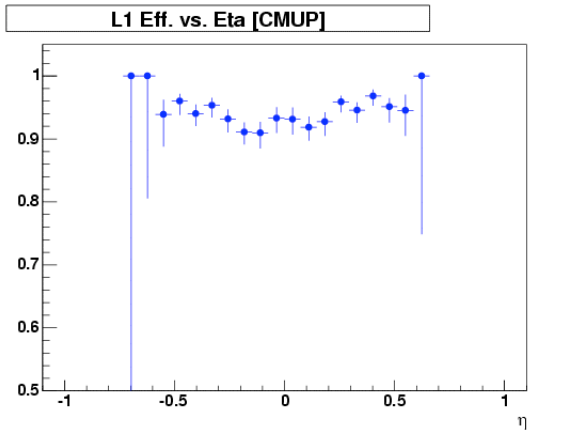
	bhmu0i2 p8	SLAM1	SLAM2
CMUP	91.30 ± 0.61	-	$92.09^{+0.58}_{-0.66}$
CMX	88.43 ± 0.79	$89.28^{+0.70}_{-0.73}$	$89.04^{+0.73}_{-0.78}$

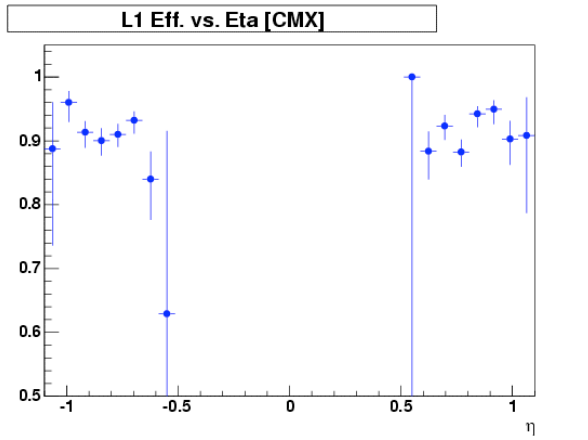
Lumi. cut	L2 LOOSE	L3 LOOSE	
$170*10^{30}$	$99.22^{+0.25}_{-0.34}$	$99.53^{+0.19}_{-0.27}$	CMX
$180*10^{30}$	$99.25^{+0.22}_{-0.32}$	$99.47^{+0.20}_{-0.29}$	CMX
$190*10^{30}$	$98.98^{+0.26}_{-0.37}$	$99.48^{+0.19}_{-0.28}$	CMX
$200*10^{30}$	$98.48^{+0.32}_{-0.41}$	$99.49^{+0.19}_{-0.28}$	CMX
NO cut	$96.06^{+0.48}_{-0.60}$	$99.49^{+0.19}_{-0.28}$	CMX
CMUP	$97.99^{+0.38}_{-0.45}$	$99.71^{+0.14}_{-0.23}$	

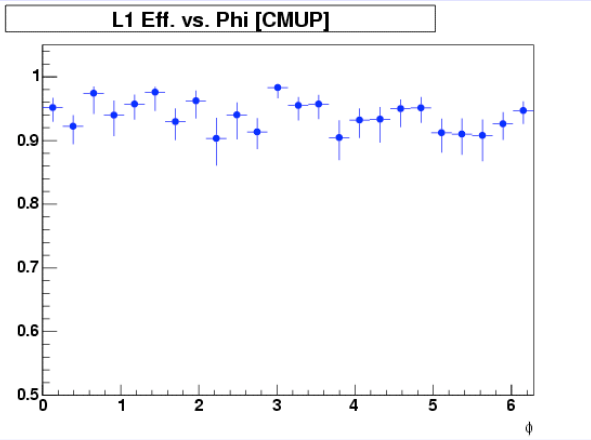
Jet Et cut (L5 corr.)	L2 CMX JET10	L3 CMX JET10
15 GeV	$82.71^{+2.35}_{-2.54}$	$97.94^{+0.93}_{-1.41}$
16 GeV	$86.59^{+2.18}_{-2.32}$	$97.90^{+0.88}_{-1.37}$
18 GeV	$94.59^{+1.60}_{-1.92}$	$97.61^{+1.12}_{-1.61}$
20 GeV	$96.91^{+1.24}_{-1.89}$	$97.86^{+1.06}_{-1.67}$
22 GeV	$98.77^{+0.79}_{-1.56}$	$97.50^{+1.23}_{-1.89}$
24 GeV	$98.58^{+0.93}_{-1.85}$	$97.10^{+1.43}_{-2.28}$
26 GeV	$99.21^{+0.65}_{-1.79}$	$96.80^{+1.54}_{-2.37}$

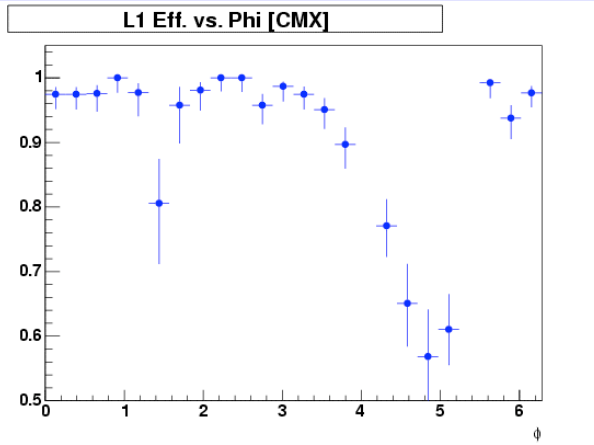
All in stat. errors., should not depend on L2 Et cut

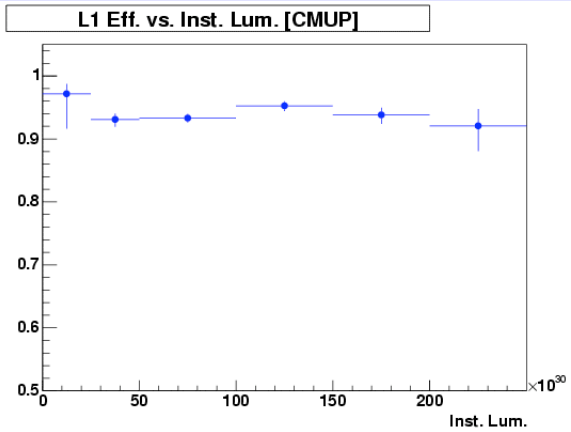
L1 Trigger Efficiency Period 10

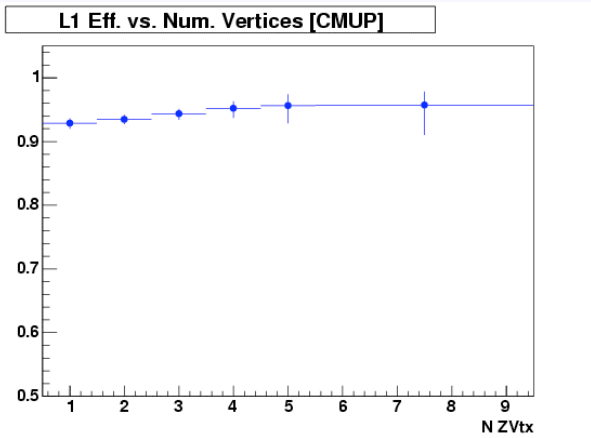


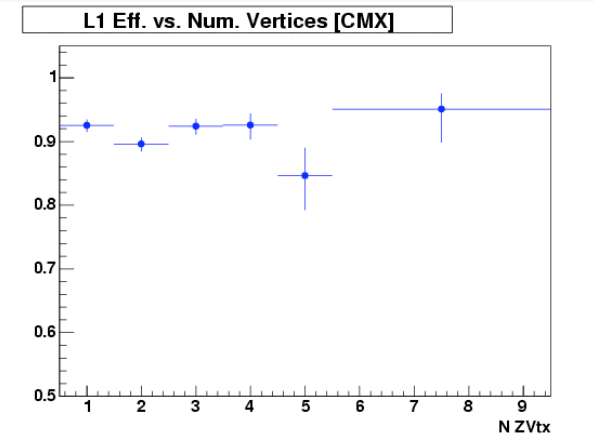


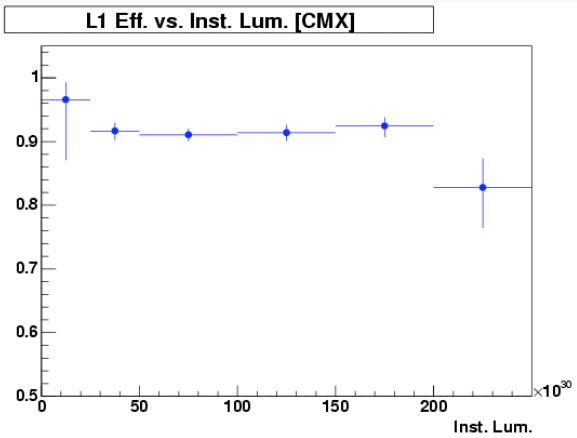












Trigger Efficiency conclusion

Period 9 trigger efficiencies final numbers are provided.

Period 10 trigger efficiencies look good, hope to be blessed soon.