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Efficiencies of the CMX Single Muon Triggers in Run IA

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1 Introduction

The CMX Level 1 inclusive muon trigger requires at least one high p_T muon stub. A trigger stub consists of hits on radially-aligned wires which pass the Δt (p_T) cut imposed by the MX1T cards and which match a coincidence of inner and outer CSX scintillator hits. The Δt cut was 42 (125) ns for the high (low) p_T thresholds of 10 (3) GeV/c^2. In the last part of Run IA, a matching hit from the hadron calorimeter TDC FASTOUTs was also required to form a stub. The FASTOUTs are ANDed with the MX1T outputs in a separate card (MX1H/MH1T [1]) before input to the MATCHBOX (MU2X) cards.

There were two CMX Level 2 high p_T muon triggers in Run IA–CMX_CFT_9_2 and CMX_CFT_13–with nominal CFT thresholds of 9.2 (bin 4) and 13 GeV/c^2 (bin 5). Both triggers required a GOLD muon. A GOLD muon consists of a match between a CMX Level 1 stub and a CFT track. The match is made by the MU2X card. If a GOLD muon is found, a Level 2 muon cluster is made. During most of Run IA, non-zero energy in the calorimeter trigger towers matching the CMX stub was required for a cluster to be made. This reduced the number of accidental coincidences between a CFT track (which has only phi information) and a CMX stub coming from the beam pipe or forward calorimeter. It imposed the same requirement later added at Level 1 by the hadron TDC cards–namely, that a track traverse the calorimeter towers matching the stub. The 9 and 13 GeV triggers used the same Level 2 clusters. For the 13 GeV trigger, the Track List Board (TLB) was used to do a more stringent stub-CFT match than that of the MU2X. The TLB match was a

[1] The characters are different but the issues at least as important as in the case of the J/ψ.

nominal 5° match of a high p_T MX1T stub (no CSX or hadron TDC required) as opposed to the MU2X nominal 15° match to a low p_T MX1T*CSX*hadron TDC stub.

The trigger efficiency was not the same for all of Run IA. A series of changes to the CSX detector and trigger hardware were begun at run 45245 and finished before run 45837. [2] Another change occurred at run 46146 when the hadron TDC requirement was added to the trigger. Data taken with trigger table 114_1 and its successors have this requirement. We divide Run IA into 4 periods of time, the second of which we exclude from our analysis because the detector and trigger hardware were changing (see Table 1).

Period	Run Range	
1	< 45245	original hardware configuration
2	$45245 \leq$Run< 45837	changes to the CSX took place
3	$45837 \leq$Run$< 46146, 46148$	no hadron TDC requirement
4	$46146, 46147; 46149 \leq$Run	final configuration

Table 1: Run ranges for different CMX trigger hardware configurations in Run IA.

In the following analysis, we have measured a separate trigger efficiency for each piece of trigger information. We then assume they are independent (except where we say otherwise) and combine the measurements to get Level 1 and Level 2 trigger efficiencies. This reduces the statistical uncertainty on our measurements and allows us to evaluate the efficiency of the different pieces of hardware.

2 Selection of Unbiased Data Samples

An unbiased sample of high p_T CMX muons was selected from Mark Krasberg's inclusive WZ sample (see Tables 2 and 3). [3]

An unbiased sample of CMX Zs was assembled from Mark's sample by selecting those events which had

[2] This story is available from Jon Lewis or one of the authors.

[3] There is a popular misconception that one can enhance the number of muons for a measurement such as this by relaxing the energy cuts. Don't try it. It won't work.

good run
non-beam-constrained $p_T > 18\text{GeV/c}$
beam-constrained $p_T > 20\text{GeV/c}$
$E_{CHA} < 6\text{GeV}$
$E_{CEM} < 2\text{GeV}$
Impact parameter $< 0.2\text{cm}$
CTC exit radius $>$ super-layer 6
$E^{coneR=0.4} - E^{\mu} < 16\text{GeV}$
cosmic flag $= 1$ (if CMUO)
$\lvert\Delta x\rvert$ CMU $< 2\text{cm}$
$\lvert\Delta x\rvert$ CMP $< 5\text{cm}$
$\lvert\Delta x\rvert$ CMX $< 6\text{cm}$

Table 2: List of cuts for selection of a Z sample. Except for the Δx cut, the cuts are applied to both legs. The Δx cuts are ORed; at least one leg must pass the Δx requirement. Implicit in the beam-constrained p_T cut is that the track was successfully beam-constrained.

good run
non-beam-constrained $p_T > 18\mathrm{GeV/c}$
beam-constrained $p_T > 20\mathrm{GeV/c}$
$E_{CHA} < 6\mathrm{GeV}$
$E_{CEM} < 2\mathrm{GeV}$
Impact parameter $< 0.2\mathrm{cm}$
CTC exit radius > super-layer 6
isolation $= \frac{E^{coneR=0.4} - E^{\mu}}{p_T} < 0.1$
cosmic flag $= 1$
$\lvert\Delta x\rvert < 6\mathrm{cm}$
Missing$-\mathrm{E_T} > 20\mathrm{GeV}$

Table 3: List of cuts for selection of a W sample. The missing energy is corrected for the muon using the beam-constrained track parameters.

a CMX muon and passed the first two levels of the trigger with one or more of the triggers in Table 4. An

Level 1
CMU_CMP_6PT0_BBC
CMU_CMP_6PT0
Level 2
CMU_CMP_CFT_9_2_V1
CMUP_CFT_9_2_5DEG_V1
CMUP_CFT_6_5DEG_V2

Table 4: List of Level 1/2 triggers for selection of an unbiased Z sample. An event in the sample passed one or more of the triggers at each level.

unbiased sample of Ws was assembled by selecting those events which which had a CMX muon and passed the first two levels of the trigger with one or more of the triggers in Table 5.

Level 1
CMU_CMP_6PT0_BBC
CMU_CMP_6PT0
L1_*
Level 2
JET*
MET*
TAU*

Table 5: List of Level 1/2 triggers for selection of an unbiased W sample.

3 Raw Numbers

Trigger information is matched to muon object (CMUO) banks using C$MUO:CMSTTL.CDF. We match the following trigger information to the CMUO.

Bank	Information	
TEXD	MX1T low p_T hit	
	MX1T high p_T hit	
SCLD	HTDC latch hit)	
TCMD	MX1T(*HTDC) low p_T hit	input to the MU2X
	MX1T(*HTDC) high p_T hit	input to the MU2X
	CSX coincidence hit	
	L1 low p_T trigger	Note that low/high refer to the p_T of the
	L1 high p_T trigger	muon stub; GOLD requires a CFT match
	Low p_T gold muon	
	High p_T gold muon	
	CTCX p_T bin of matched track	if any
TL2D	L2 cluster p_T	if a matching cluster was found; note that a
	L2 cluster total energy	cluster is made only if a GOLD muon exists; and,
		for most of Run IA, $E_{tot}^{L2} > 0$ (CMX only).

CMSTTL.CDF returns trigger information for the trigger tower pointed to by the tower word in CMUO and for the two adjacent trigger towers. We then examine the trigger information associated with each CMX muon in our unbiased sample. Tables 6 and 7 summarize this information for the various time periods. Several corrections to these raw numbers are discussed in the next section.

4 Subtle Points

There are a number of issues that need to be understood in our matching of offline muons to trigger information.

Period	TOWER	CMX CMUO	MX1T LOW	MX1T HI	CSX	L1 LOW	L1 HI	CTCX $p_T^{CFT} \geq 4$	L2 Cluster	$E_{tot}^{L2} > 0$
1	SAME	72	68	65	40	37	25	62	33	27
1	PREVIOUS		3	3	5	1	1	40		
1	NEXT		16	14	16	10	4	50		
3	SAME	4	4	4	3	3	3	3	3	2
3	PREVIOUS		0	0	1	0	0	3		
3	NEXT		1	1	2	1	1	1		
4	SAME	35	33	32	31	29	28	31	25	21
4	PREVIOUS		0	0	5	0	0	21		
4	NEXT		5	5	9	4	4	24		

Table 6: Summary of the trigger information associated with the CMX CMUO in the unbiased sample of Zs. The trigger tower is that of the tower word in CMUO. Time periods were defined previously. The columns of trigger information give the number of muons passing that particular part of the trigger. p_T^{CFT} is given in the natural unit: bin number.

Period	TOWER	CMX CMUO	MX1T LOW	MX1T HI	CSX	L1 LOW	L1 HI	CTCX $p_T^{CFT} \geq 4$	L2 Cluster	$E_{tot}^{L2} > 0$
1	SAME	59	58	55	31	31	24	44	25	22
1	PREVIOUS		2	1	1	1	0	28		
1	NEXT		10	9	12	7	5	33		
3	SAME	3	3	3	2	2	1	1	1	1
3	PREVIOUS		0	0	0	0	0	1		
3	NEXT		1	1	0	0	0	1		
4	SAME	21	20	20	19	18	18	20	15	15
4	PREVIOUS		1	1	1	1	1	10		
4	NEXT		3	3	7	3	3	16		

Table 7: Summary of the trigger information associated with the CMX CMUO in the unbiased sample of Ws. The information is as described in Table 6.

The first have to do with how we match CFT tracks to the muon. The CFT information in the TCMD bank gives the wedge of the CFT track, not the tower. One could, in principle, redo the MATCHBOX matching and determine if the offline tower matched the CFT track. We used the following algorithm instead. For a muon stub in tower 0 of wedge n, we count a CFT match if there is a CFT track in wedge n or $n-1$. If the muon stub is in tower 1, the CFT track is counted if it is in wedge n. For a stub in tower 2, the CFT track is counted if in wedge n or $n+1$. Given the way the hardware works, there is also the possibility that the CFT track will appear in a wedge far from the offline muon (although it will still fire the trigger). [1] We excluded such events. (There were four; they are listed in Appendix A.)

If one looks at the CFT efficiency for all CMX muons in the W or Z samples, it is lower than that measured elsewhere. [2] This is due to muons that don't pass through CTC super-layer 8. Since the CFT reconstruction requires a hit in super-layer 8 (the outermost layer), these muons can not have CFT tracks. Since the CMX extends to $\eta = 1$, there will be such tracks. Table 8 gives the measured CFT efficiencies

Sample	Muons	$p_T^{CFT} \geq 4$	ϵ
all Z muons	111	99	$0.892^{+0.030}_{-0.038}$
Z muons SL8 required	99	96	$0.970^{+0.016}_{-0.029}$
all W muons	83	69	$0.831^{+0.042}_{-0.051}$
W muons SL8 required	72	67	$0.931^{+0.030}_{-0.044}$
all muons	194	168	$0.866^{+0.025}_{-0.029}$
muons SL8 required	171	163	$0.953^{+0.016}_{-0.022}$

Table 8: CFT efficiency for CMX muons for all Zs/Ws in the sample and after requiring that the muon track have hits in CTC super-layer 8.

for CMX muons without and with the requirement that the offline track use hits in SL8. After making the SL8 hit requirement, the CFT efficiency is consistent with other measurements. Note that requiring hits in SL8, overestimates the CFT efficiency somewhat, as we suppress events where the track passes through SL8 but there are no hits or they are not found. A less-biased way to correct for this effect would have been to require only that the track pass through SL8.

The 15° wedge boundaries and the 5° tower boundaries in CMX are completely arbitrary. There are no physical gaps. For CMX stubs with hits on both sides of a trigger tower boundary, the reconstruction code preferentially puts the low-ϕ tower in the CMUS/CMUO tower word. The actual trigger can be on either side of the boundary. One can see the effect in in Tables 6 and 7, where the number of MX1T and CSX passes are systematically higher in the "next" tower than in the "previous" tower. To avoid overestimating the trigger efficiency, we would like to look for the trigger associated with an offline muon in as small a part of the detector as possible. We don't want to get fooled by a trigger from a particle that was not the muon of interest. [4] This is how we included the information from adjacent towers. If the muon stub track used hits on both sides of a trigger tower boundary, we OR the MX1T and CSX information in the two trigger towers. Otherwise, we look only in the CMUS/CMUO tower. In practice (see appendices), we did this by dumping all events which had an MX1T or CSX failure and examining them by hand to see if they had hits in two towers and, if so, a matching trigger in either of the towers. [5] We also excluded from the sample muons which failed the trigger because the trigger tower was masked. The results are given in Tables 9 and 10. Separate summaries of the efficiency of the Δt and CSX coincidence requirements are given in Tables 11 and 12.

Finally we note that a hadron TDC hit and non-zero Level 2 cluster energy are almost completely correlated pieces of information. Thus we compute a combined efficiency for the Level 2 cluster energy cut and hadron TDC requirement (see Table 13).

5 Final Numbers and Efficiencies

The efficiencies for the various pieces of hardware in the CMX trigger are given in Table 14. The efficiencies of the CMX high p_T Level 1 and Level 2 single muon triggers for each set of running conditions are given in Tables 15 and 16. The numbers in the latter are those cited in CDF Note 2169. [3] Estimates of the

[4] The problem is non-negligible given the amount of beam pipe and forward calorimeter spray hitting CMX and the limited number of events we are using to measure the efficiency.

[5] There is now code in the muon library to do this painlessly.

Period	no MX1T low	Exclude	Pass	Muons	Pass	ϵ
1,3,4	6	1	3	110	108	$0.982^{+0.012}_{-0.023}$
Period	no MX1T high	Exclude	Pass	Muons	Pass	ϵ
1,3,4	10	1	6	110	107	$0.973^{+0.015}_{-0.026}$
Period	no CSX	Exclude	Pass	Muons	Pass	ϵ
1	35		3	72	40	$0.556^{+0.064}_{-0.066}$
3,4	7		3	39	35	$0.897^{+0.048}_{-0.074}$
Period	no L1 low	Exclude	Pass	Muons	Pass	ϵ
1	35	1	1	71	38	$0.535^{+0.065}_{-0.066}$
3	1	0	0	4	3	$0.75^{+0.21}_{-0.37}$
4	6	0	2	35	31	$0.886^{+0.054}_{-0.081}$
3,4	7	0	2	39	34	$0.872^{+0.054}_{-0.077}$
Period	no L1 high	Exclude	Pass	Muons	Pass	ϵ
1	47	1	12	71	37	$0.521^{+0.066}_{-0.066}$
3	1	0	0	4	3	$0.75^{+0.21}_{-0.37}$
4	7	0	3	35	31	$0.886^{+0.054}_{-0.081}$
3,4	8	0	3	39	34	$0.872^{+0.054}_{-0.077}$

Table 9: Results of examining muons which failed to trigger in the Z sample. The number of CSX failures is really the number of L1 low failures as CSX failures were counted by dumping all L1 low failures and counting those with a CSX hit.

Period	no MX1T low	Exclude	Pass	Muons	Pass	ϵ
1,3,4	2	0	1	83	82	$0.988^{+0.010}_{-0.027}$
Period	no MX1T high	Exclude	Pass	Muons	Pass	ϵ
1,3,4	5	0	1	83	79	$0.952^{+0.023}_{-0.036}$
Period	no CSX	Exclude	Pass	Muons	Pass	ϵ
1	28	0	0	59	31	$0.525^{+0.072}_{-0.073}$
3,4	4	0	1	24	21	$0.875^{+0.067}_{-0.107}$
Period	no L1 low	Exclude	Pass	Muons	Pass	ϵ
1	28	0	0	59	31	$0.525^{+0.072}_{-0.073}$
3	1	0	0	3	2	$0.67^{+0.28}_{-0.41}$
4	3	0	0	21	18	$0.857^{+0.077}_{-0.120}$
3,4	4	0	0	24	20	$0.833^{+0.078}_{-0.112}$
Period	no L1 high	Exclude	Pass	Muons	Pass	ϵ
1	35	0	4	59	28	$0.475^{+0.073}_{-0.072}$
3	2	0	1	3	2	$0.67^{+0.28}_{-0.41}$
4	3	0	0	21	18	$0.857^{+0.077}_{-0.120}$
3,4	5	0	1	24	20	$0.833^{+0.078}_{-0.112}$

Table 10: Results of examining muons which failed to trigger in the W sample. The information is as described in Table 9.

Sample	p_T threshold	Muons	MX1T hit	ϵ
Z	low	110	108	$0.982^{+0.012}_{-0.023}$
	high	110	107	$0.973^{+0.015}_{-0.026}$
W	low	83	82	$0.988^{+0.010}_{-0.027}$
	high	83	79	$0.952^{+0.023}_{-0.036}$
all	low	193	190	$0.984^{+0.008}_{-0.015}$
	high	193	186	$0.963^{+0.013}_{-0.019}$

Table 11: Efficiency for CMX muons to pass the *Deltat* cuts.

Sample	Period	Muons	CSX coincidences	ϵ
Z	1	72	40	$0.556^{+0.064}_{-0.066}$
	3,4	39	35	$0.897^{+0.048}_{-0.074}$
W	1	59	31	$0.525^{+0.072}_{-0.073}$
	3,4	24	21	$0.875^{+0.067}_{-0.107}$
all	1	131	71	$0.542^{+0.047}_{-0.048}$
	3,4	63	56	$0.889^{+0.040}_{-0.055}$

Table 12: CSX efficiency for CMX muons before and after fixes to detector and trigger hardware.

Sample	Period	Muon Clusters	Cluster $E_{tot}^{L2} > 0$	ϵ
Z	1,3	36	29	$0.806^{+0.069}_{-0.089}$
W	1,3	26	23	$0.885^{+0.062}_{-0.100}$
all	1,3	62	52	$0.839^{+0.048}_{-0.061}$
Sample	**Period**	**Muons**	**Hadron TDC fired**	ϵ
Z	4	35	34	$0.971^{+0.024}_{-0.063}$
W	4	21	20	$0.952^{+0.039}_{-0.101}$
all	4	56	54	$0.964^{+0.023}_{-0.045}$
Sample	**Period**	**Muons**	$E_{tot}^{L2} * TDC$	ϵ
Z	4	26	21	$0.808^{+0.080}_{-0.109}$
W	4	16	15	$0.938^{+0.052}_{-0.129}$
all	4	42	36	$0.857^{+0.055}_{-0.076}$

Table 13: Summary of the efficiency of the cluster energy and hadron TDC requirements for good muons.

	Period	Zs	Ws	Combined
MX1T - Low p_T		$0.982^{+0.012}_{-0.023}$	$0.988^{+0.010}_{-0.027}$	$0.984^{+0.008}_{-0.015}$
MX1T - High p_T		$0.973^{+0.015}_{-0.026}$	$0.952^{+0.023}_{-0.036}$	$0.963^{+0.013}_{-0.019}$
Had. TDC	4	$0.971^{+0.024}_{-0.063}$	$0.952^{+0.039}_{-0.101}$	$0.964^{+0.023}_{-0.045}$
CSX	1	$0.556^{+0.064}_{-0.066}$	$0.525^{+0.072}_{-0.073}$	$0.542^{+0.047}_{-0.048}$
CSX	3,4	$0.897^{+0.048}_{-0.074}$	$0.875^{+0.067}_{-0.107}$	$0.889^{+0.040}_{-0.055}$
CFT		$0.892^{+0.030}_{-0.038}$	$0.831^{+0.042}_{-0.051}$	$0.866^{+0.025}_{-0.029}$
CFT*		$0.970^{+0.016}_{-0.029}$	$0.931^{+0.030}_{-0.044}$	$0.953^{+0.016}_{-0.022}$
E_{tot}	1,3	$0.806^{+0.069}_{-0.089}$	$0.885^{+0.062}_{-0.100}$	$0.839^{+0.048}_{-0.061}$
$E_{tot} * TDC$	4	$0.808^{+0.080}_{-0.109}$	$0.938^{+0.052}_{-0.129}$	$0.857^{+0.055}_{-0.076}$

Table 14: Summary of the trigger efficiency for each of the pieces of hardware for each of the different sets of running conditions. "CFT*" is the efficiency if the muon track is required to have hits in SL8.

Sample	Period	Muons	Pass L1 high p_T	ϵ
Z	1	71	37	$0.521^{+0.066}_{-0.066}$
W		59	28	$0.475^{+0.073}_{-0.072}$
all		130	65	$0.500^{+0.048}_{-0.048}$
Z	3	4	3	$0.75^{+0.21}_{-0.37}$
W		3	2	$0.67^{+0.28}_{-0.41}$
all		7	5	$0.71^{+0.18}_{-0.26}$
Z	4	35	31	$0.886^{+0.054}_{-0.081}$
W		21	18	$0.857^{+0.077}_{-0.120}$
all		56	49	$0.875^{+0.045}_{-0.061}$

Table 15: Level 1 CMX high p_T inclusive muon trigger efficiency for each set of running conditions.

	Period	Zs	Ws	Combined
all tracks	1	$0.393^{+0.058}_{-0.066}$	$0.381^{+0.062}_{-0.073}$	$0.388^{+0.042}_{-0.047}$
all tracks	3	$0.633^{+0.068}_{-0.093}$	$0.636^{+0.074}_{-0.114}$	$0.636^{+0.050}_{-0.065}$
all tracks	4	$0.635^{+0.075}_{-0.105}$	$0.674^{+0.073}_{-0.132}$	$0.649^{+0.054}_{-0.074}$
# hits SL8 $\neq 0$	1	$0.427^{+0.062}_{-0.071}$	$0.427^{+0.067}_{-0.080}$	$0.426^{+0.045}_{-0.050}$
# hits SL8 $\neq 0$	3	$0.689^{+0.071}_{-0.098}$	$0.712^{+0.078}_{-0.125}$	$0.699^{+0.053}_{-0.070}$
# hits SL8 $\neq 0$	4	$0.690^{+0.079}_{-0.112}$	$0.755^{+0.076}_{-0.145}$	$0.714^{+0.058}_{-0.080}$

Table 16: Level 2 CMX high p_T inclusive muon trigger efficiency for each set of running conditions. This is the Level 2 efficiency only. It is not independent of the Level 1 efficiency in Table 15. (The Level 1/2 trigger efficiency is NOT the product of the efficiencies cited in the two tables.) It is the efficiency appropriate for a muon in an event that passed Level 1 on a non-CMX trigger.

combined Level 1 and 2 trigger efficiency for the inclusive CMX triggers are given in Table 17. We should make a number of cautionary remarks about the numbers in Table 17. First, we ignore both the rate-limited Level 1 input and the CDT cluster requirement in Level 1 stub definition, both of which were present during most of periods 1, 2 and 3. Second, in the calculation of the efficiency of the 13 GeV trigger, we ignore the complications of the Track List Board (TLB) and assumed the efficiency to be 100%. We found no evidence that the latter was untrue. When someone figures out how to treat the TLB efficiency correctly, we will be happy to do the same.

	Period	Zs	Ws	Combined
all tracks	1	$0.389^{+0.058}_{-0.066}$	$0.368^{+0.060}_{-0.071}$	$0.379^{+0.041}_{-0.046}$
all tracks	3	$0.627^{+0.067}_{-0.092}$	$0.613^{+0.072}_{-0.111}$	$0.622^{+0.049}_{-0.064}$
all tracks	4	$0.629^{+0.075}_{-0.104}$	$0.649^{+0.071}_{-0.128}$	$0.635^{+0.054}_{-0.073}$
# hits SL8 $\neq$ 0	1	$0.423^{+0.061}_{-0.071}$	$0.412^{+0.066}_{-0.078}$	$0.417^{+0.044}_{-0.049}$
# hits SL8 $\neq$ 0	3	$0.682^{+0.071}_{-0.098}$	$0.686^{+0.076}_{-0.122}$	$0.685^{+0.052}_{-0.069}$
# hits SL8 $\neq$ 0	4	$0.684^{+0.079}_{-0.112}$	$0.727^{+0.075}_{-0.141}$	$0.699^{+0.057}_{-0.079}$

Table 17: CMX high p_T inclusive muon trigger efficiency for each set of running conditions. This is our estimate of the combined Level 1 and 2 efficiency. Level 2 is assumed to have Level 1 as a prerequisite.

References

[1] Thanks to Bill Badgett for patiently explaining this to me.

[2] Tom LeCompte *et al. High P_t CMU/CMP Muon Trigger Efficiencies for Run IA.* CDF Note 2367.

[3] Phil Schlabach and Jorge Troconiz. *Searching for Top Decay to Muon + Jets in CMX.* CDF Note 2169. The efficiencies in CDF Note 2186 are slightly different. A few typographical errors were corrected and a mistake was corrected.(We excluded the masked events from the number of total events but not the number of failures.).

A List of Events Excluded from the Analysis

These events were excluded from the analysis because of inadequacies in our FORTRAN ("gold mu error") or our understanding ("cluster error"). The former passed the trigger and should have. We were and remain somewhat confused by the latter.

Run	Event	
46697	118124	gold mu error (Z)
47125	152617	cluster error (Z)
46655	340871	gold mu error (W)
46935	412737	gold mu error (W)

B Muons with No MX1T Low Trigger

These events contain good CMX muons that did no fire the MX1T low p_T trigger. In (x,y) are given the Δt for hits in the (same, next) tower if appropriate.

Run	Event		
Zs			
42145	65572	3 hit stub, no 2 same wire pair	FAIL
42353	176322	3 hit stub, no 2 same wire pair	FAIL
43045	38227	masked; next tower hit and fired (4,8)	PASS
43351	209	masked	EXCLUDE
46595	52448	no HAD TDC; MX1T fired	PASS
46795	144995	next tower hit, fired (176,20)	PASS
Ws			
41481	3023	large Δt (120)	FAIL
46818	221912	no HAD TDC (crack?); MX1T fired	PASS

C Muons with No MX1T High Trigger

These events contain good CMX muons that did no fire the MX1T high p_T trigger.

Run	Event		
Zs			
42005	18438	large Δt (44,60)	FAIL
42145	65572	3 hit stub, no 2 same wire pair	FAIL
42353	176322	3 hit stub, no 2 same wire pair	FAIL
43045	38227	masked; next tower hit and fired (4,8)	PASS
43066	198725	next tower hit and fired (72,20)	PASS
43351	209	masked	EXCLUDE
45019	10119	next tower hit and fired (56,40)	PASS
46247	78735	next tower hit and fired (84,4)	PASS
46595	52448	no HAD TDC; MX1T fired	PASS
46795	144995	next tower hit and fired (176,20)	PASS
Ws			
41481	3023	large Δt (120)	FAIL
42670	168232	large Δt; fired low, not high (468)	FAIL
42899	576879	large Δt; fired low, not high (48,60)	FAIL
45178	351142	large Δt; fired low, not high (40)	FAIL
46818	221912	no HAD TDC (crack?); MX1T fired	PASS

D Muons with No Level 1 Low Trigger

These events contain good CMX muons that did no fire the Level 1 low p_T trigger.

Run	Event	
Zs		
40190	101287	no CSX
40469	11408	no CSX
40708	73726	no CSX
41451	35090	no CSX
41512	300506	no CSX
41625	22422	no CSX
41958	92132	no CSX
42145	65572	CSX hit; no MX1T; 3 hit stub, no 2 same wire pair
42204	102045	no CSX
42328	63333	no CSX
42328	65840	no CSX
42353	176322	no CSX; no MX1T; 3 hit stub, no 2 same wire pair
42446	38366	no CSX
42640	13119	no CSX
42670	145761	no CSX
42727	27048	no CSX
42838	163477	no CSX
42838	191653	no CSX
43017	186362	no CSX
43045	38227	MX1T masked; 2 towers hit; CSX hit same, next; next fired MX1T (4,8)

Run	Event	
43066	198725	2 towers hit; no CSX; next fired MX1T (72,20)
43082	24019	no CSX
43170	304267	no CSX
43170	305847	no CSX
43289	168786	no CSX
43351	209	MX1T masked; CSX hit
43477	230767	no CSX
44444	8898	no CSX
44650	15569	no CSX
44931	40663	no CSX
45018	47423	no CSX
45089	79565	no CSX
45124	566061	no CSX
45199	659305	no CSX
45219	252611	no CSX
45991	47368	no CSX
46271	11179	2 towers hit; same, MX1T, no CSX; next, CSX, no MX1T; large Δt
46595	52448	CSX hit; MX1T fired; no HAD TDC
46795	144995	2 towers hit; CSX hit both; MX1T fires next
46935	342991	2 towers hit; CSX hit both; MX1T fires next
47243	48004	no CSX
47552	210533	no CSX

Run	Event	
Ws		
40382	134634	no CSX
40759	31893	no CSX
40991	7014	no CSX
41269	25080	no CSX
41319	173868	no CSX
41481	3023	no CSX; large Δt; no low, no high (120)
41784	100949	no CSX
41958	73762	no CSX
41958	140061	no CSX
42212	152311	no CSX
42446	38366	no CSX
42539	209734	no CSX
42593	55722	no CSX
42656	44979	no CSX
42686	52711	no CSX
42686	269833	no CSX
42804	62088	no CSX
42821	253569	no CSX
42984	9627	no CSX
43082	179294	no CSX

Run	Event	
43139	284949	no CSX
43154	53025	no CSX
43276	5368	no CSX
43306	245096	no CSX
43336	148305	no CSX
45089	15170	no CSX
45144	96570	no CSX
45219	167635	no CSX
46031	51138	no CSX
46269	213971	no CSX
46697	12880	no CSX
46818	221912	CSX hit; MX1T fired; no HAD TDC

E Muons with No Level 1 High Trigger

These events contain good CMX muons that did no fire the Level 1 high p_T trigger. The events labelled "CDT" got on this list because of the lack of a CDT cluster. They passed the MX1T*CSX requirement.

Run	Event	
Zs		
40190	101287	no CSX
40469	11408	no CSX
40708	73726	no CSX
41374	46799	WRONG
41451	35090	no CSX
41477	47725	WRONG
41512	300506	no CSX
41625	22422	no CSX
41958	92132	no CSX
42005	18438	CSX hit; large Δt; fires low, not high (44,60)
42030	298983	WRONG
42145	65572	CSX hit; no MX1T; 3 hit stub, no 2 same wire pair
42204	102045	no CSX
42328	63333	no CSX
42328	65840	no CSX
42353	176322	no CSX; no MX1T; 3 hit stub, no 2 same wire pair
42426	108059	WRONG
42446	38366	no CSX
42490	230074	WRONG
42640	13119	no CSX

Run	Event	
42656	7472	WRONG
42670	145761	no CSX
42727	27048	no CSX
42838	163477	no CSX
42838	191653	no CSX
43017	186362	no CSX
43045	38227	MX1T masked; 2 towers hit; CSX hit same, next; next fired MX1T (4,8)
43066	198725	2 towers hit; no CSX; next fired MX1T (72,20)
43082	24019	no CSX
43170	304267	no CSX
43170	305847	no CSX
43289	168786	no CSX
43351	209	MX1T masked; CSX hit
43477	230767	no CSX
44444	8898	no CSX
44650	15569	no CSX
44931	40663	no CSX
45018	47423	no CSX
45019	10119	2 towers hit; CSX hit both; MX1T fires next (56,40)
45019	69054	WRONG

Run	Event	
45089	79565	no CSX
45124	54843	WRONG
45124	566061	no CSX
45144	30845	WRONG
45199	659305	no CSX
45219	227082	WRONG
45219	252611	no CSX
45991	47368	no CSX
46247	78735	2 towers hit; CSX hit both; MX1T fires next (84,4)
46271	11179	2 towers hit; same: MX1T, no CSX; next: CSX, no MX1T; large Δt
46595	52448	CSX hit; MX1T fired; no HAD TDC
46795	144995	2 towers hit; CSX hit both; MX1T fires next
46935	342991	2 towers hit; CSX hit both; MX1T fires next
47243	48004	no CSX
47552	210533	no CSX

Run	Event	
Ws		
40382	134634	no CSX
40759	31893	no CSX
40991	7014	no CSX
41269	25080	no CSX
41319	173868	no CSX
41417	51979	WRONG
41481	3023	no CSX; large Δt; no low, no high (120)
41771	49031	WRONG
41784	100949	no CSX
41958	73762	no CSX
41958	140061	no CSX
42030	204103	WRONG
42212	152311	no CSX
42446	38366	no CSX
42539	209734	no CSX
42593	55722	no CSX
42656	44979	no CSX
42670	168232	CSX hit; large Δt; fired low, not high (468)
42686	52711	no CSX
42686	269833	no CSX
42804	62088	no CSX

Run	Event	
42821	253569	no CSX
42899	576879	CSX hit; large Δt; fired low, not high (48,60)
42984	9627	no CSX
43082	179294	no CSX
43139	284949	no CSX
43154	53025	no CSX
43276	5368	no CSX
43306	245096	no CSX
43336	148305	no CSX
44826	17789	WRONG
45089	15170	no CSX
45144	96570	no CSX
45178	351142	CSX hit; large Δt; fired low, not high (40)
45219	167635	no CSX
46031	51138	no CSX
46031	74856	WRONG
46269	213971	no CSX
46697	12880	no CSX
46818	221912	CSX hit; MX1T fired; no HAD TDC