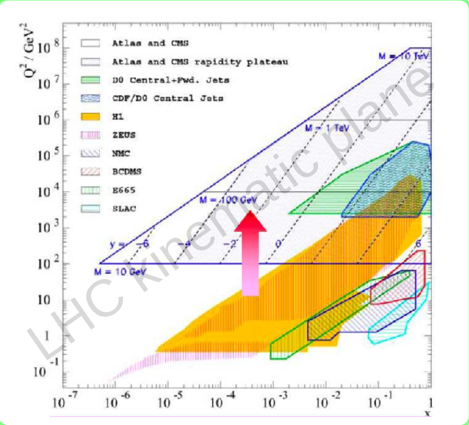
Muon charge asymmetry in inclusive $pp \to W(\mu\nu) + X$ production at $\sqrt{s}$ = 10 TeV.

PAS-EWK-09-003, CMS-AN 2009/054

October 26, LHC'09.

LHC kinematic plane

$$d\sigma_X = \sum_{ij} \int dx_1 dx_2 f_i(x_1, Q^2) f_j(x_2, Q^2) d\hat{\sigma}_{ij \to X}$$

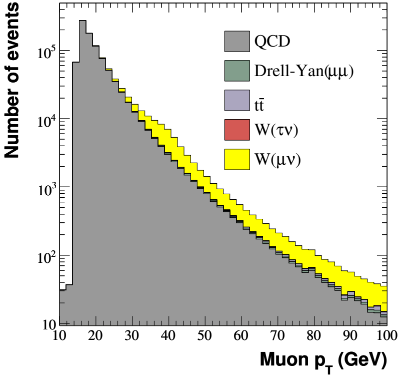


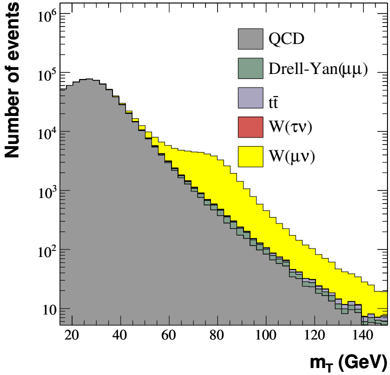
- For measurable rapidity range $|y| < 2.5$, x values remain in the range, $5 \times 10^{-4} < x < 5 \times 10^{-2}$.
- W and Z production : Leading order process is $q\bar{q} \to W/Z$, the cross-section is ~ 10 nb.

Kinematic variables and event selection

Trigger and event selection

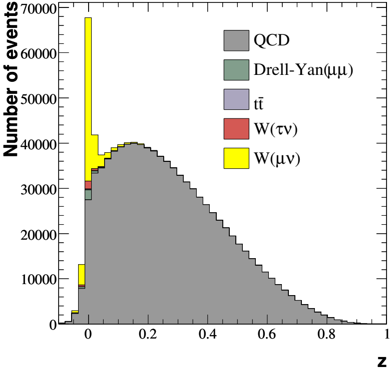
- A Global Muon per event matched with HLT_Mu15 trigger object within a cone size of 0.015 with $|\eta| < 2.1$.
- The muon should have:
  - Associated silicon track hits $\geq$ 12.
  - Normailized $\chi^2/ndf < 5$.

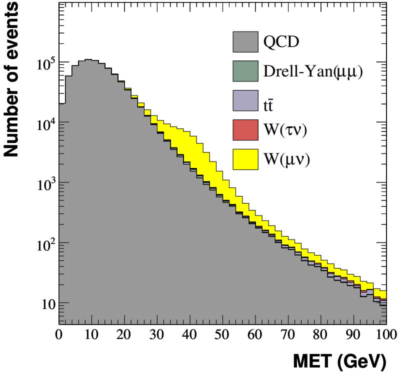




Isolation and the Minning E_t

- Iso $= \sum_{R(caloTower^i, muon)<0.3} E_T^{caloTower^i}$, where the sum of the transverse energy of all the calo towers within a cone of radius 0.3 around the muon direction is made, $(P_t^{\mu} + Iso) > 25$ GeV.
- The isolation cut ::z < 0.05, defined by $z = 1 - \frac{p_T}{p_T + Iso}$, where p_T is the transverse momentum of the muon candidate (weakly correlated with $\not{E}_T$).
- Missing $E_t > 20$ GeV.





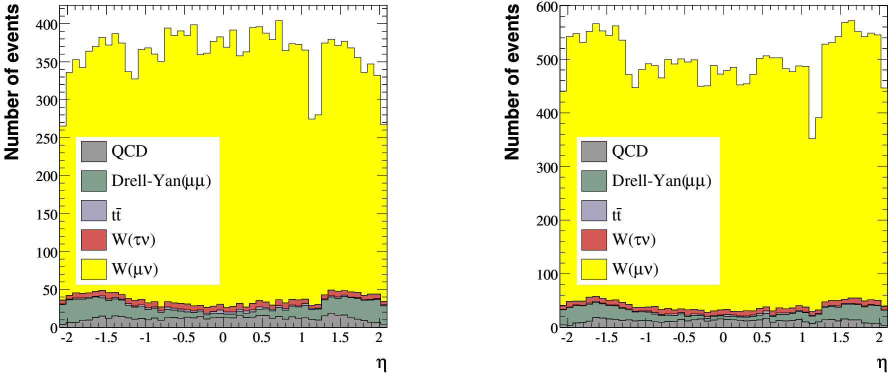
Selection efficiency and event yeild

Selection	$W^+ \to \mu^+\nu$		$W^- \to \mu^-\nu$	
	Events	Efficiency	Events	Efficiency
Generated Events	571787		356714	
HLT-matched (($\|\eta\|$ <2.1)	440982	0.771±0.001	291833	0.818±0.002
Muon p_T + Iso >25 GeV	343180	0.778±0.001	240533	0.824±0.002
z <0.05	317012	0.924±0.002	222029	0.923±0.002
MET > 20 GeV	305367	0.963±0.002	216045	0.973±0.002
Total Efficiency		0.534±0.001		0.606±0.001

Data Type	Events/pb	Fraction (%)	Events/pb	Fraction(%)
$W \to \mu\nu$	2294.3±4.2	91.9±0.2	1623.2±3.5	89.8±0.2
$W \to \tau\nu$	43.1±0.7	1.7±0.03	32.9±0.6	0.018±0.03
$t\bar{t}$	9.9±0.4	0.4±0.02	10.1±0.4	0.006±0.02
Drell-Yan	89.4±0.4	3.6±0.02	81.6±0.4	0.045±0.02
QCD	60.0±1.0	2.4±0.04	59.6±1.0	0.033±0.06

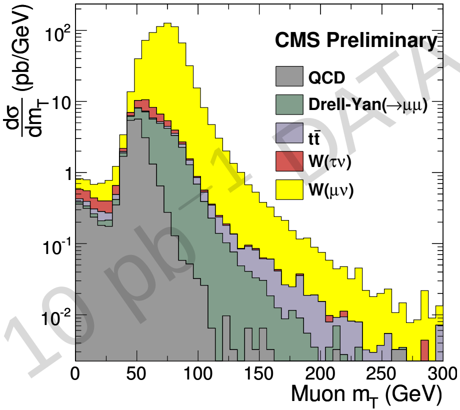
Pseudorapidity distribution after all the selection criteria

- The muon pseudorapidity distribution after all event selection criteria have been applied. Left :: μ^-, Right :: μ^+.



Transverse Mass Distribution

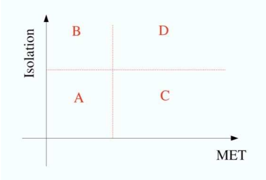
- $m_T = \sqrt{2 \cdot p_T \cdot \not{E}_T \cdot (1 - cos(\phi))}$, ϕ is the angle between muon p_T and $\not{E}_T$.

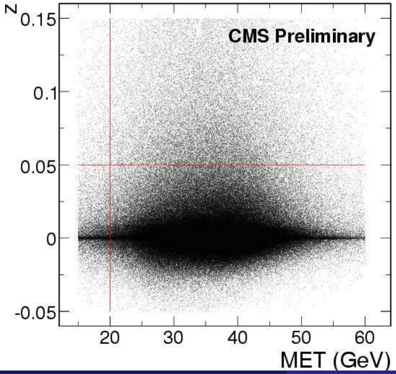


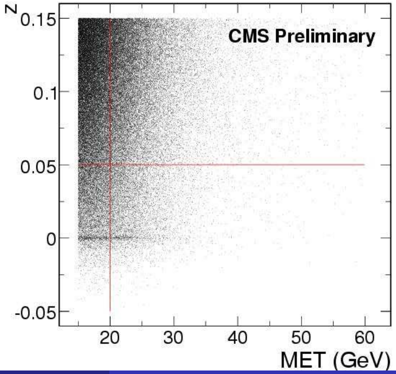
- Drell-Yan background dominates ($\sim$ 4 %).
- Electro-weak background ($\sim$ 2 %).
- QCD dijet background is at 2-3% level, large uncertainty in MC predictions.
- Overall signal to background ratio $\sim$ 10.

Background estimation

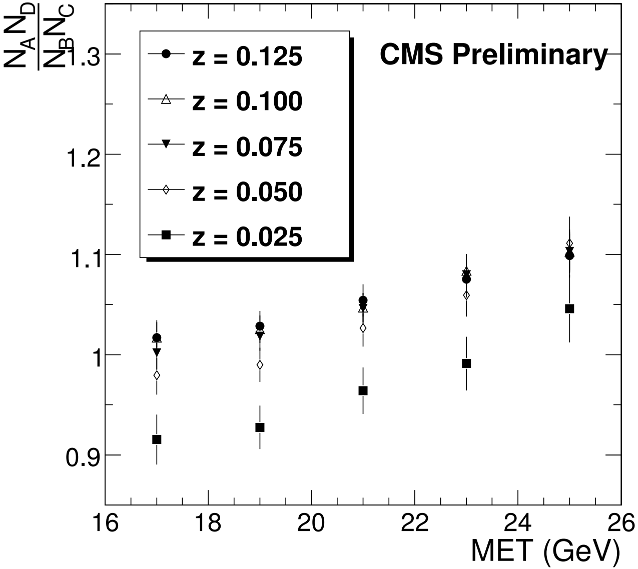
If the MET and z variables are uncorrelated then the numbers of events in the signal and sidebands should be in the ratio,
$r = \frac{N_A N_D}{N_B N_C} = 1.$







The ratio

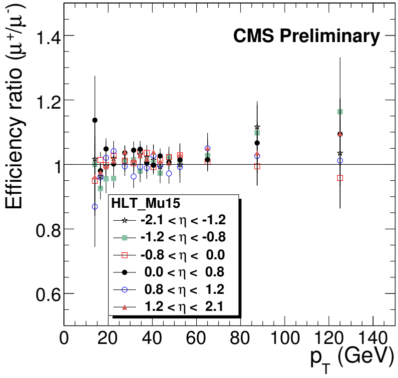


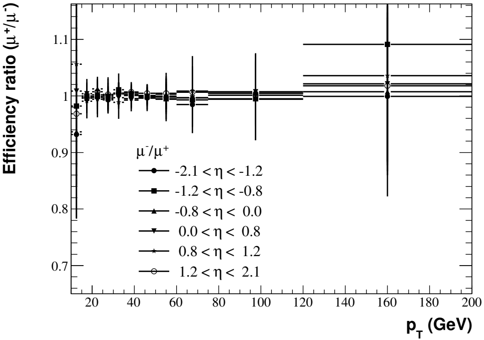
$\frac{N_A N_D}{N_B N_C}$
1.3
1.2
1.1
1
0.9
16
18
20
22
24
26
MET (GeV)
z = 0.125
z = 0.100
z = 0.075
z = 0.050
z = 0.025
CMS Preliminary

Charge asymmetry results

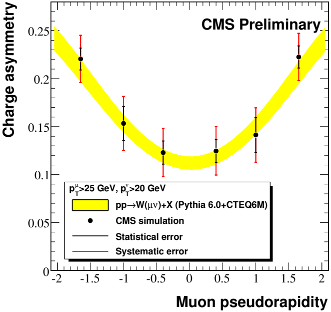
Efficiency ratio between μ^+ and μ^-

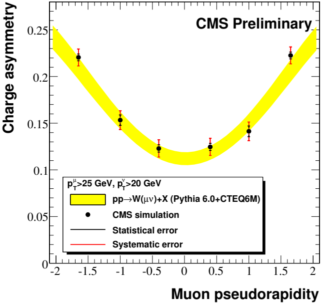
$$\frac{dN}{d\eta} = \mathcal{L} \cdot \frac{d\sigma}{d\eta} \cdot \epsilon_{HLT} \cdot \epsilon_{offline} \cdot \epsilon_{acceptance} \cdot$$





The measured charge asymmetry at 10 pb^{-1} and 100 pb^{-1} of LHC luminosity

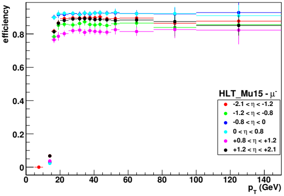


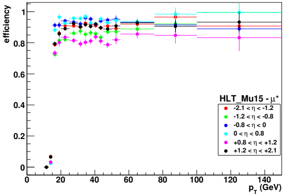


Statistical error : 4%; Acceptance : 4%; Goes down to 1.3% with 100 pb^{-1} of LHC luminosity.

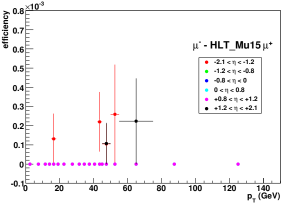
Error due to background subtraction can be improved with increased luminosity.

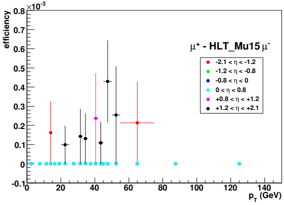
Systematic uncertainty due to trigger efficiency and charge mis-identification for muons from monte-carlo





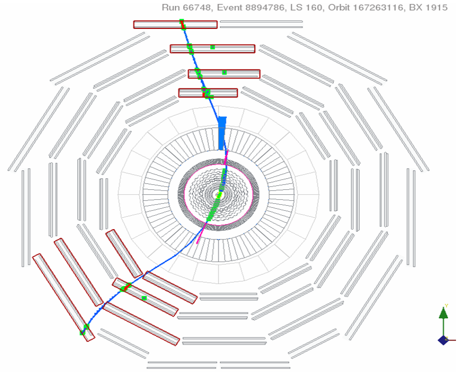
The matching criteria used : $\Delta R(gen\ \mu, HLT\ \ object) < 0.015$.





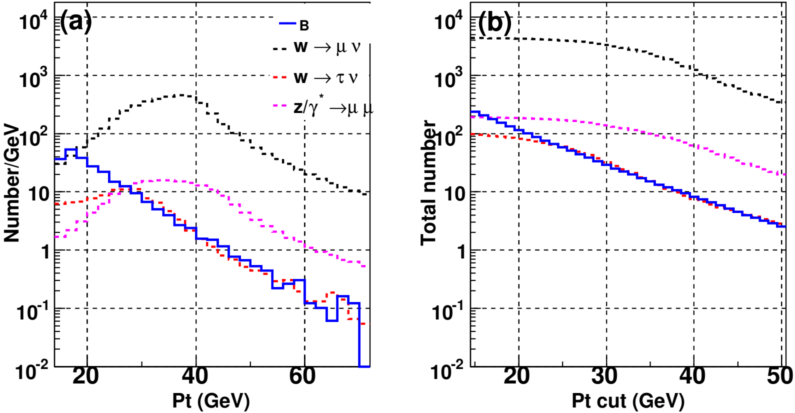
The mis-identification is less than 0.1% in for muons coming from W.

CMS detector in transverse plane, showing a cosmic muon event



We can do the trigger efficiency and charge mis-identification using cosmic muon events.

Decay-in-flight background after the $\not{E}_T$ criteria



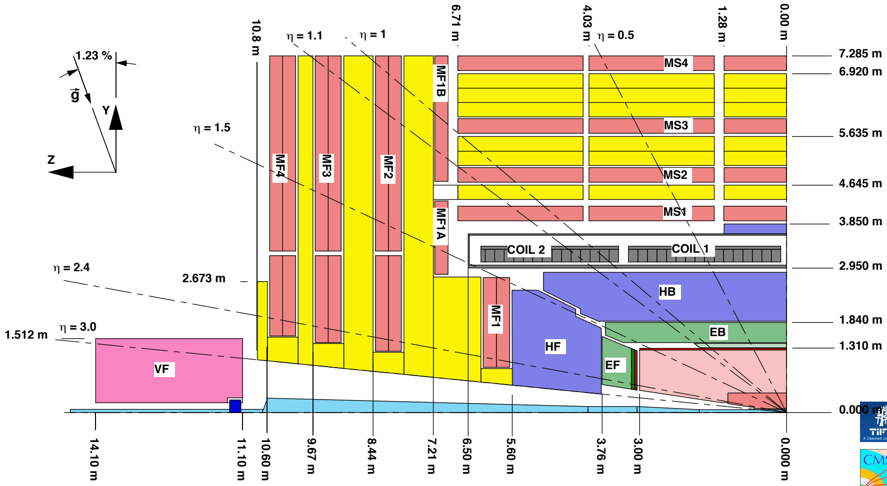
After Muon transverse momentum criteria the Drell-Yan is the most dominant background.

Conclusion

1. With 100 pb^{-1} data, the total uncertainty is comparable to the PDF error set and therefore may begin to provide constraints on different PDF sets.
2. The background coming from pion/kaon decay-in-flight is small , but not negligible (2.5%) in comparison with other background for $W \rightarrow \mu\nu$ event.
3. We can do estimation of trigger efficiency and charge mis-identification using cosmic muon events.

Back-up slides

CMS detector in longitudinal plane



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