Study of $W\gamma$ production with $W\rightarrow\mu\nu$ at CDF in Run II

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For the CDF collaboration

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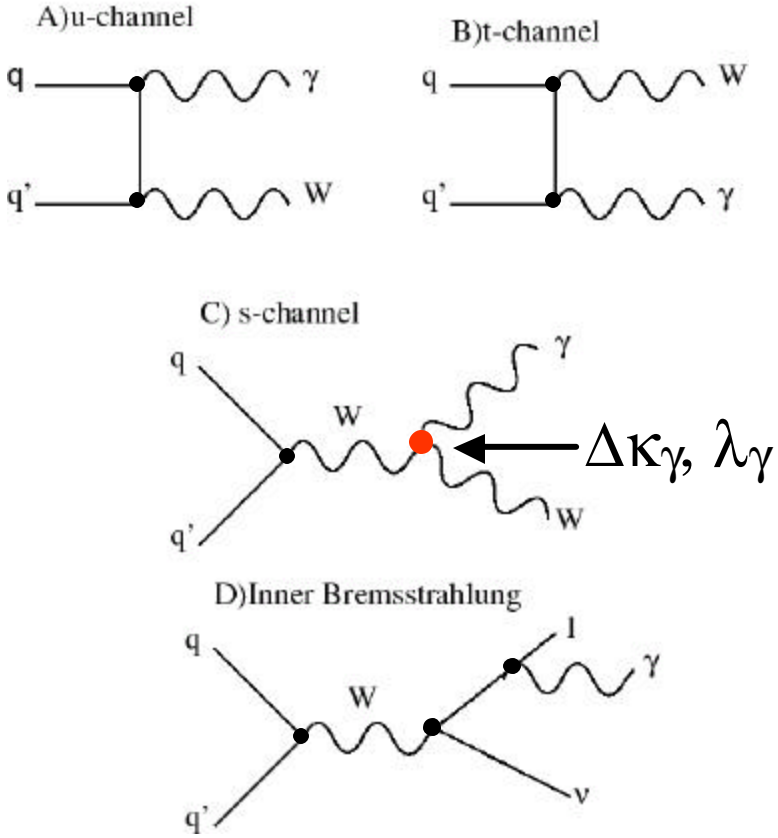
Theoretical motivation of W γ analysis

- At the Tevatron, W + γ are produced

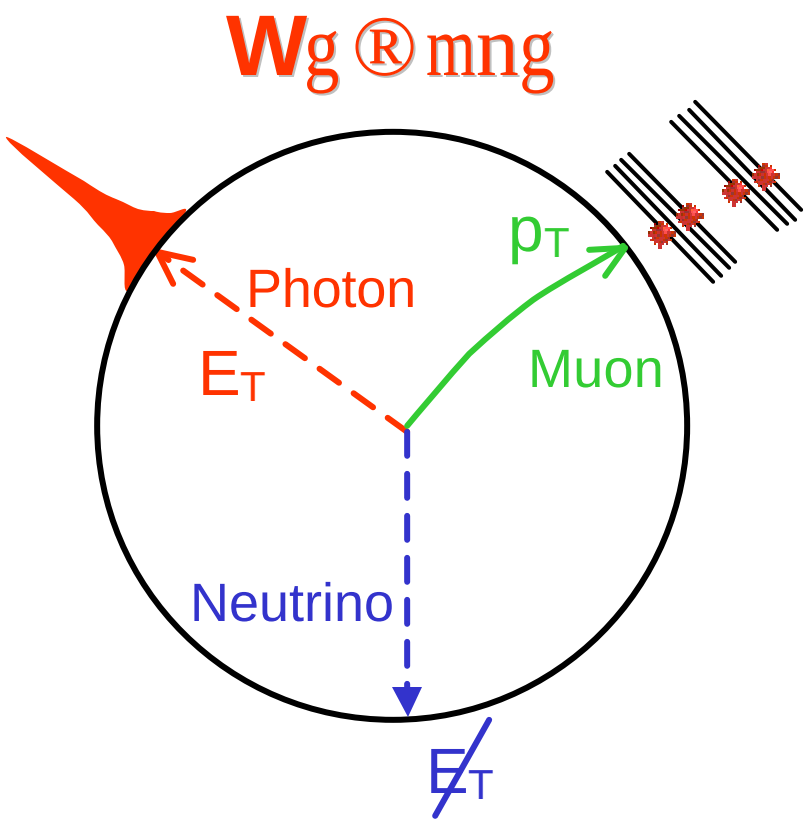


- Testing Gauge theory
  - $\Delta\kappa_\gamma$ and λ_γ can be related to electromagnetic dipole moment
  - In the SM, $\Delta\kappa_\gamma=0$ and $\lambda_\gamma=0$
  - Any deviation from SM enhance $\sigma(W\gamma)$
  - $E_T(\gamma)$, $\Delta R(\mu,\gamma)$ are sensitive to Trilinear Gauge Couplings
  - Anomalous couplings may indicate new physics or compositeness of W

$$\Delta R(\mu,\gamma) = \sqrt{(\Delta\phi)^2+(\Delta\eta)^2}$$

Event Topology

- Signature
  - $\mu\nu\gamma$ final state with $E_T(\gamma)>7$GeV and $\Delta R(\mu,\gamma)>0.7$



- Muon
  - Track matching to the hits in the muon chamber
- Neutrino
  - Observed as "missing" transverse energy ($-\Sigma\vec{p}_T$)
- Photon
  - EM calorimeter with no associated tracks
  - No significant energy in the hadron calorimeter

Event Selection

- Datasets ($\int \mathcal{L}\, dt = 72 pb^{-1}$)
  - High P_T Muon trigger
- W selection
  - Central muon with $P_T(\mu) > 20$ GeV
  - Large Missing E_T>20 GeV
- γ selection
  - Isolation, $E_T(\gamma) > 7$GeV, $|\eta| < 1$
  - Quality cuts to reject π^0 BG
- Wγ selection (Increase s-channel diagram contribution)
  - $\Delta R(\mu,\gamma)>0.7$

Backgrounds

- Fake photon: W+jets, jets fakes to photon
- Zγ, Z$\rightarrow\mu\mu$: One muon missed
- Wγ, W$\rightarrow\tau\nu$, $\tau\rightarrow\mu\nu\nu$

Looking at Run II data 72pb^{-1}

Signal MC	25.5 ± 3.0
Jet→ γ (data)	5.6 ± 1.7
One leg Zγ (MC)	5.1 ± 0.7
Wγ→τνγ (MC)	0.7 ± 0.1
Sum of BG	11.3 ± 1.8
Signal MC+BG	36.9 ± 3.5
DATA	38

- $\sigma(W\gamma)=(N_S-N_B)/(\varepsilon * A * \int \mathcal{L}\, dt)$
  - N_S=38 : Observed events
  - N_B=11.3 ± 1.8
    : sum of backgrounds
  - ε : efficiency
  - $\int \mathcal{L}\, dt$: Luminosity
  - A : acceptance

*Error includes stat., sys. and lum.

CDF Run II preliminary results

$\sigma(W\gamma)*BR(W\rightarrow\mu\nu)$ =19.5 ± 4.5(stat.) ± 2.4(sys.) ± 1.2(lum.)[pb]

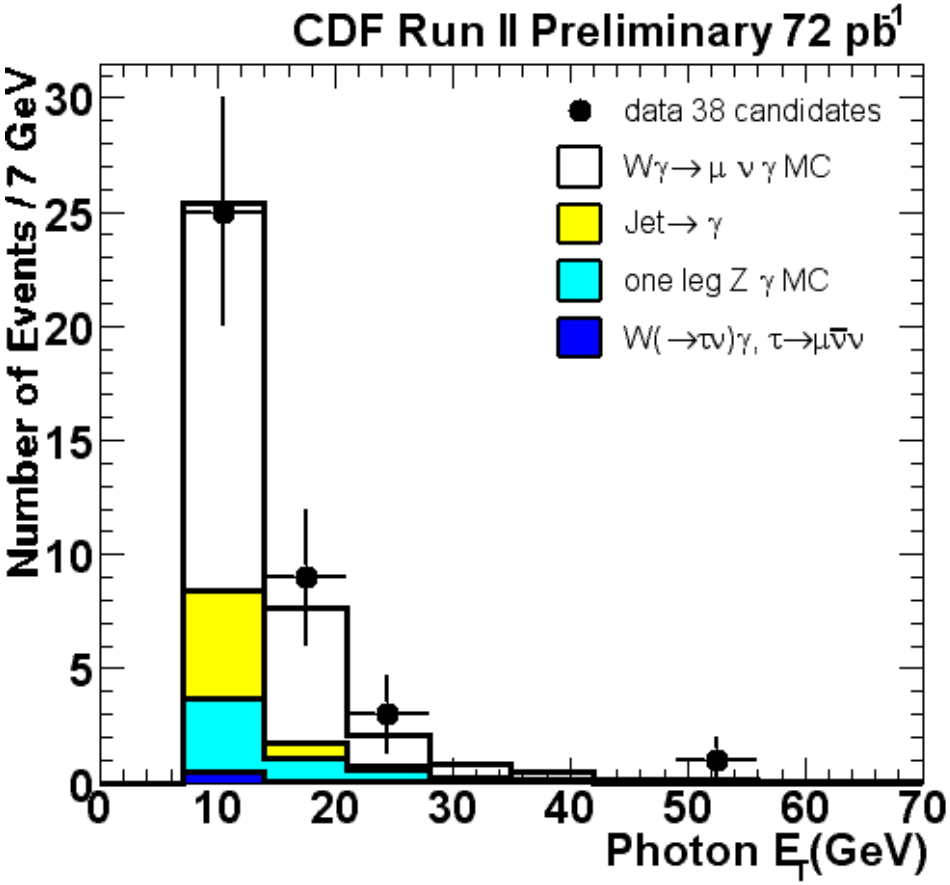
WGAMMA MC

$\sigma^{SM}(W\gamma)*BR(W\rightarrow\mu\nu)$ =18.7 ± 1.3 [pb]

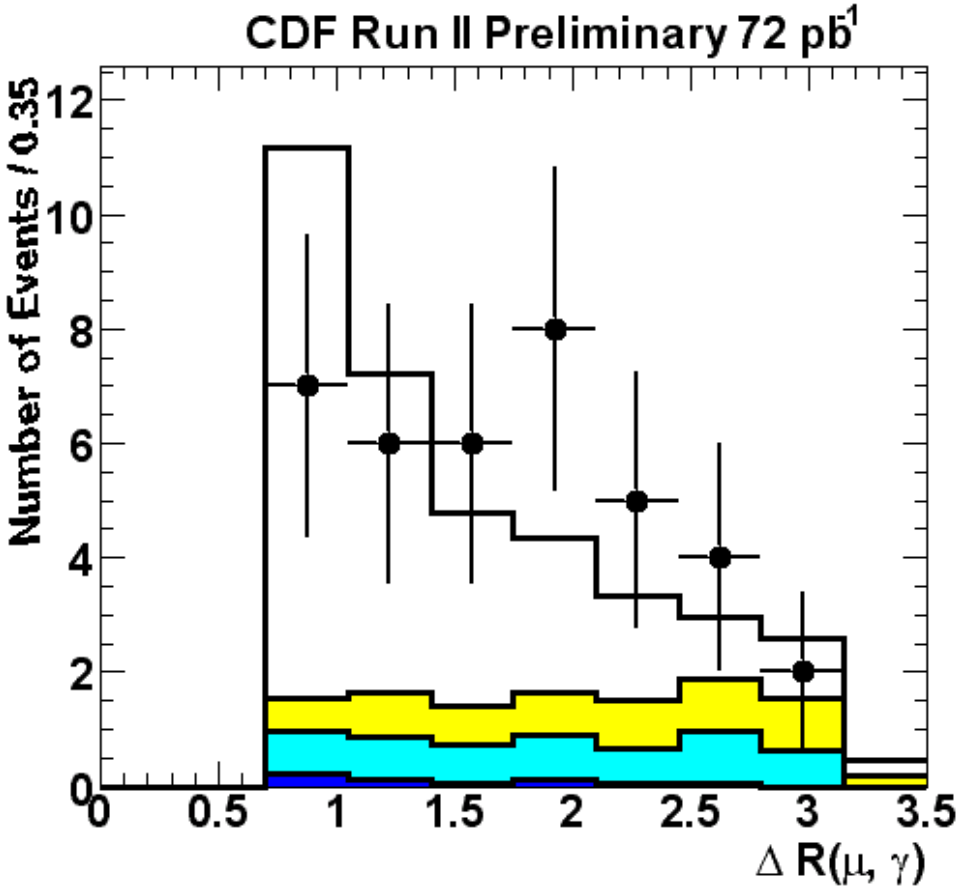
at $E_T(\gamma)$ > 7 GeV, ΔR > 0.7

Photon E_T and $\Delta R(\mu,\gamma)$

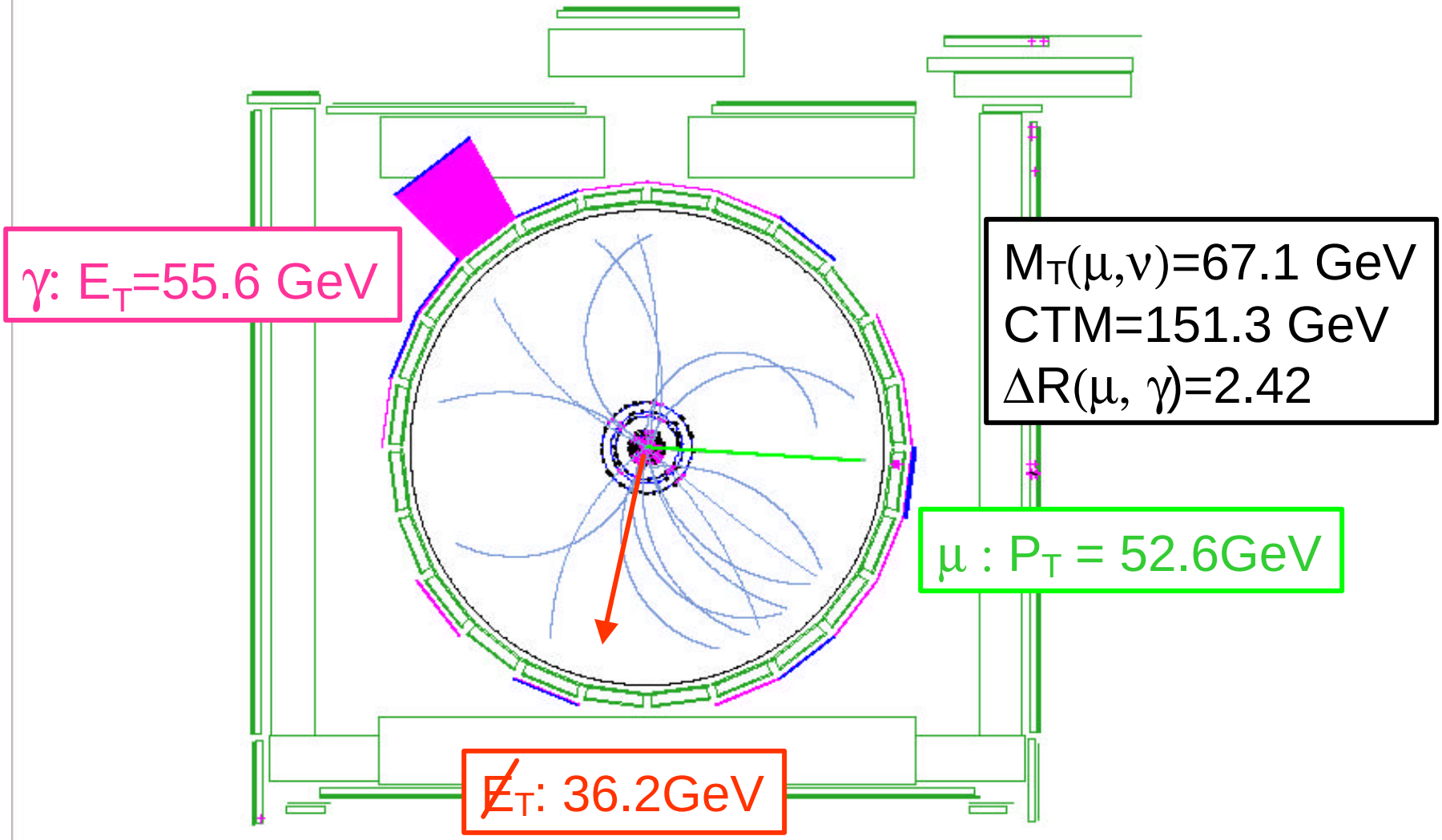
Photon E_T



$\Delta R(\mu,\gamma)$

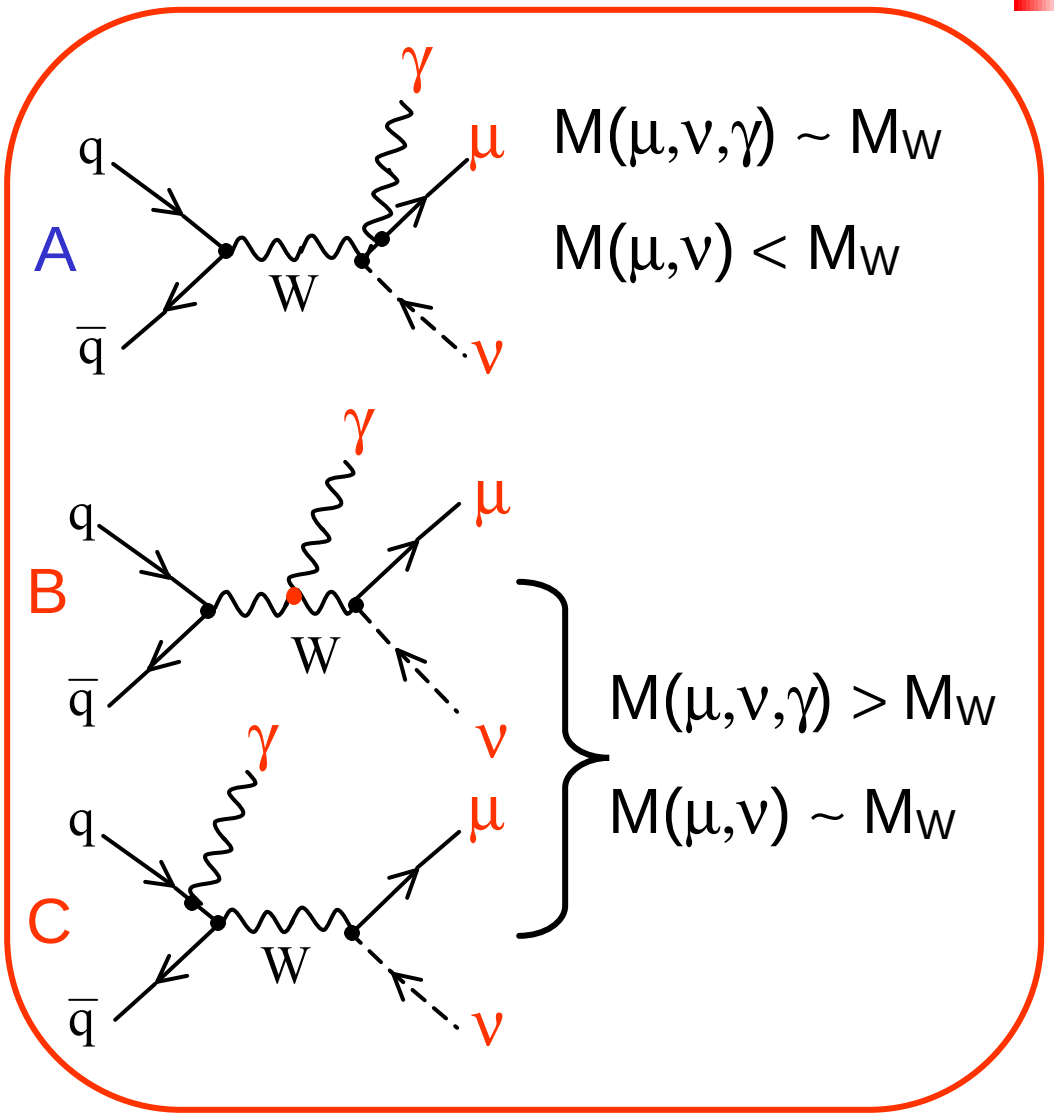


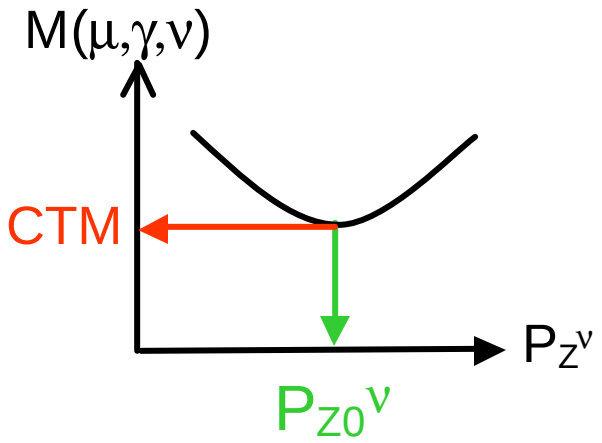
Event display of Wγ: highest $E_T(\gamma)$

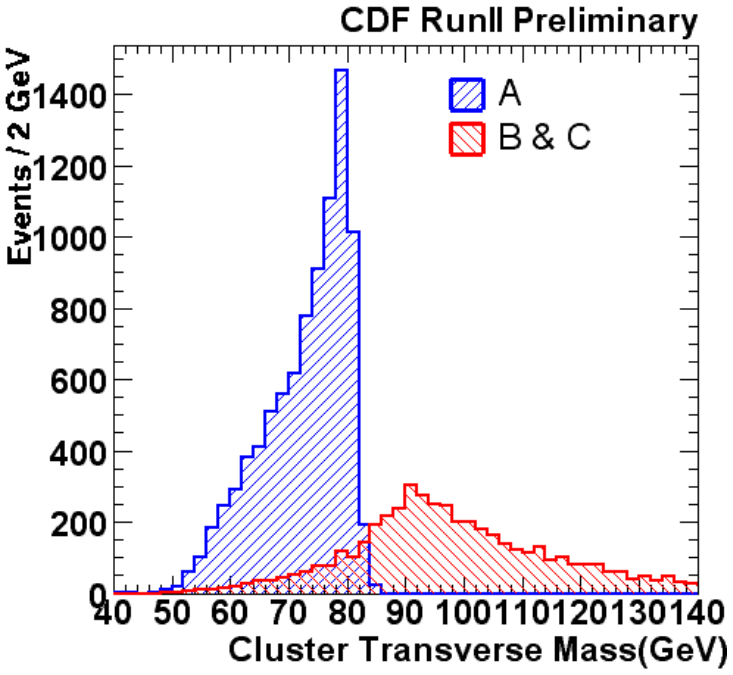


Cluster transverse mass

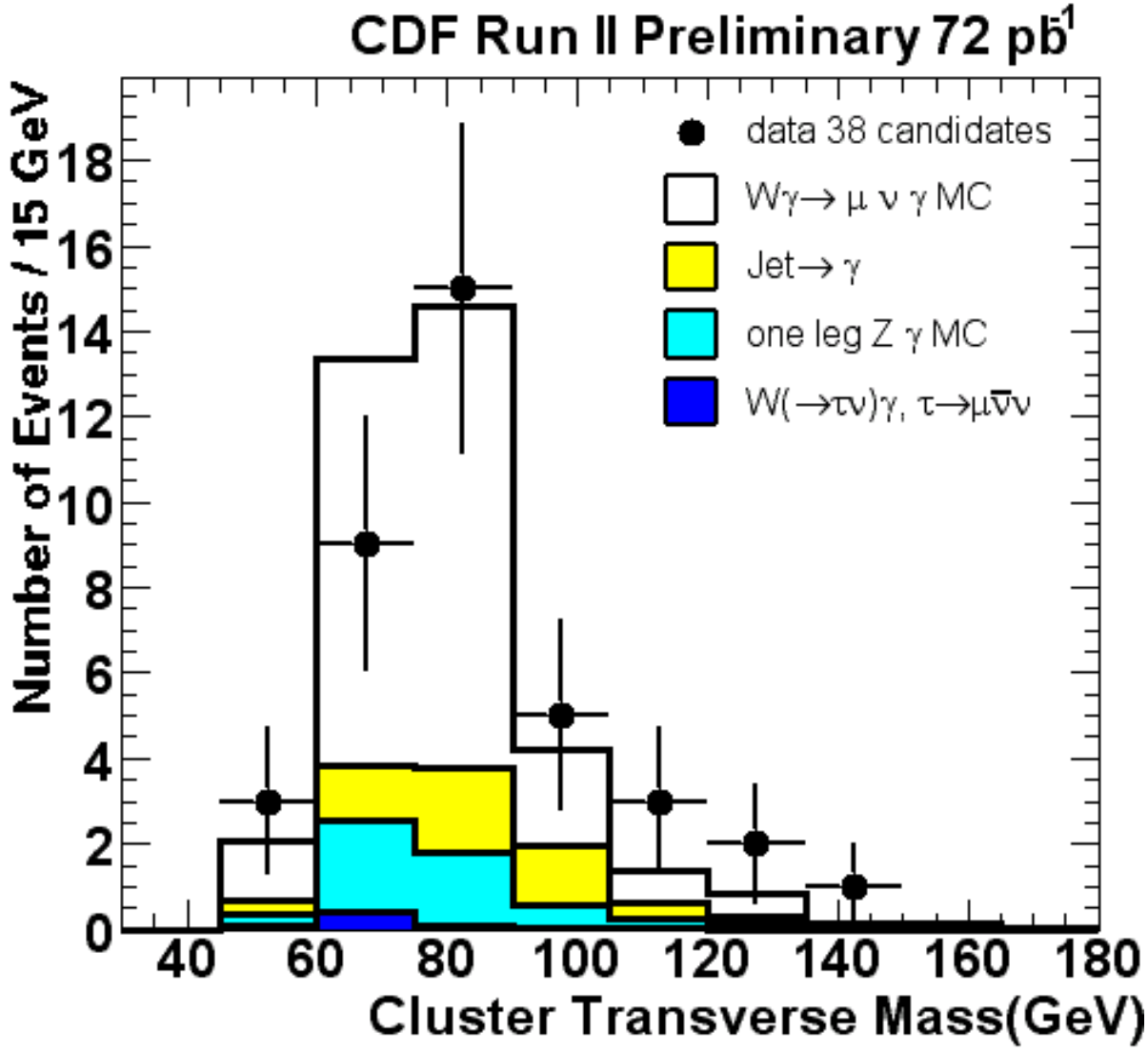
- $dM(\mu, \gamma, \nu)/dP_Z^{\nu}=0$ at P_{Z0}^{ν}







Cluster transverse mass



Conclusions

- The process $W\gamma \rightarrow \mu\nu\gamma$ is measured
- Using 72.0 pb^{-1} data, we observed 38 $W\gamma$ candidates
- From these events, we derived the cross section for $E_T(\gamma) > 7$ GeV and $\Delta R(\mu,\gamma)>0.7$

$\sigma(W\gamma)*BR(W\rightarrow\mu\nu) = 19.5 \pm 4.5(stat.)\pm 2.4(sys.) \pm 1.2(lum.)[pb]$

$\sigma^{SM}(W\gamma)*BR(W\rightarrow\mu\nu) = 18.7 \pm 1.3\ (theo.)\ [pb]$

Agree very well

- Future plan
  - Adding photons in high eta region
  - Set limits to anomalous couplings

Z gamma results

Zγ results	e (sys)	μ (sys)
Signal MC	10.3 ±1.3	11.9 ±1.7
Jet→ γ	0.5 ±0.1	0.5 ±0.4
Signal MC+BG	10.8 ±1.3	12.4 ±1.7
DATA	11	12

- e : $\sigma(Z\gamma) = 5.5 \pm 1.7(\text{stat.}) \pm 0.6\ (\text{sys.}) \pm 0.3(\text{lum.})$ [pb]
- μ : $\sigma(Z\gamma) = 6.0 \pm 1.6\ (\text{stat.}) \pm 0.7(\text{sys.}) \pm 0.4(\text{lum.})$ [pb]
- $\sigma^{SM}(Z\gamma) = 5.3 \pm 0.4\ (\text{theo.})$ [pb] (ZGAMMA MC)