Study of W+γ Production at the Tevatron

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for CDF collaboration
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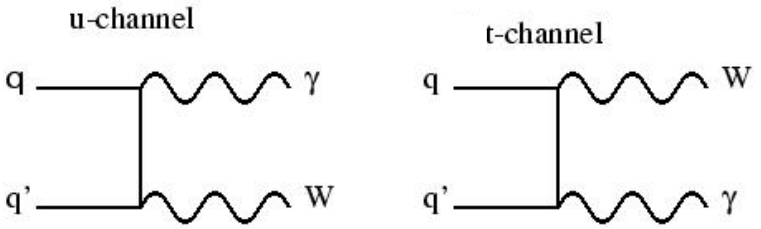
Outline

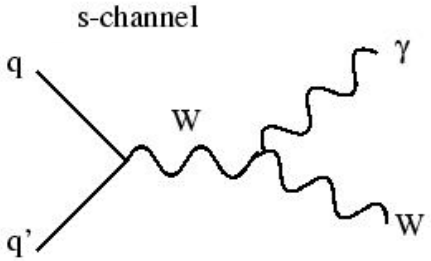
- Introduction
- Event Selection
- W cross section result
- W + γ cross section
- Conclusion

Introduction

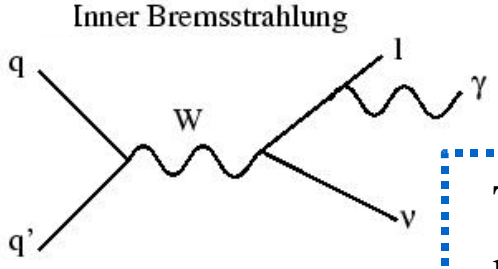
- measure W+ γ cross section
- The W+ γ kinematic distribution is sensitive to anomalous couplings
- Search for physics beyond standard model
  - excess in high photon E_T
  - excess in large $\Delta R(l,\gamma)$
- ISR and s-channel interfere each other. Radiation amplitude zero

The initial state radiation from an incoming quark





Photon is radiatied from W boson. interesting triple gauge coupling

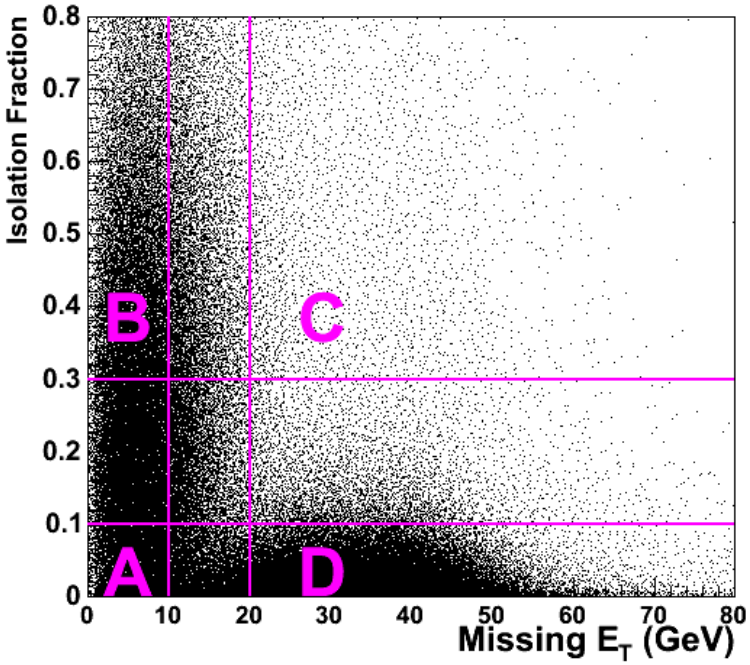


The final state radiation. photon is radiated from Bremsstrahlung process

W Event Selection

- High p_T muon Datasets 1/fb
- W Event Selection
  - one isolated high p_T muon : p_T > 20 GeV
  - neutrino observed as missing transverse energy : MET > 20 GeV
  - 30 GeV < M_T(W) < 120 GeV
  - Supress Z $\rightarrow\mu\mu$: no isolated track p_T > 10 GeV
  - Cosmic Ray veto
- Background
  - QCD background (0.87 %)
    - determined from Data
  - Z $\rightarrow\mu\mu$ background (7.74 %)
    - determiened from PYTHIA Monte Carlo
  - W$\rightarrow\tau\nu$ background (3.04 %)
    - determiened from PYTHIA Monte Carlo

The plane is divided into four region assuming no correlation between Isolation and MET. Region D is signal region.
(#of events in A)/(# in B) ×(# in C)

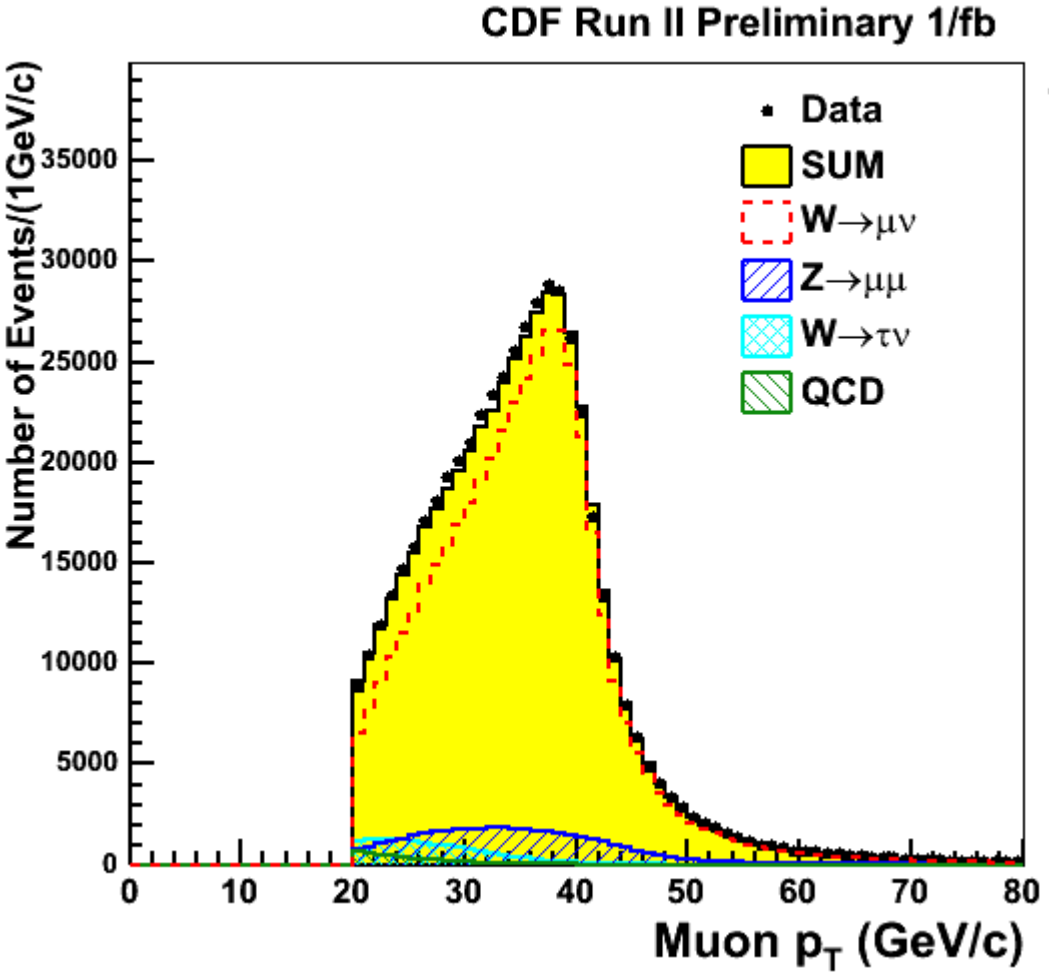


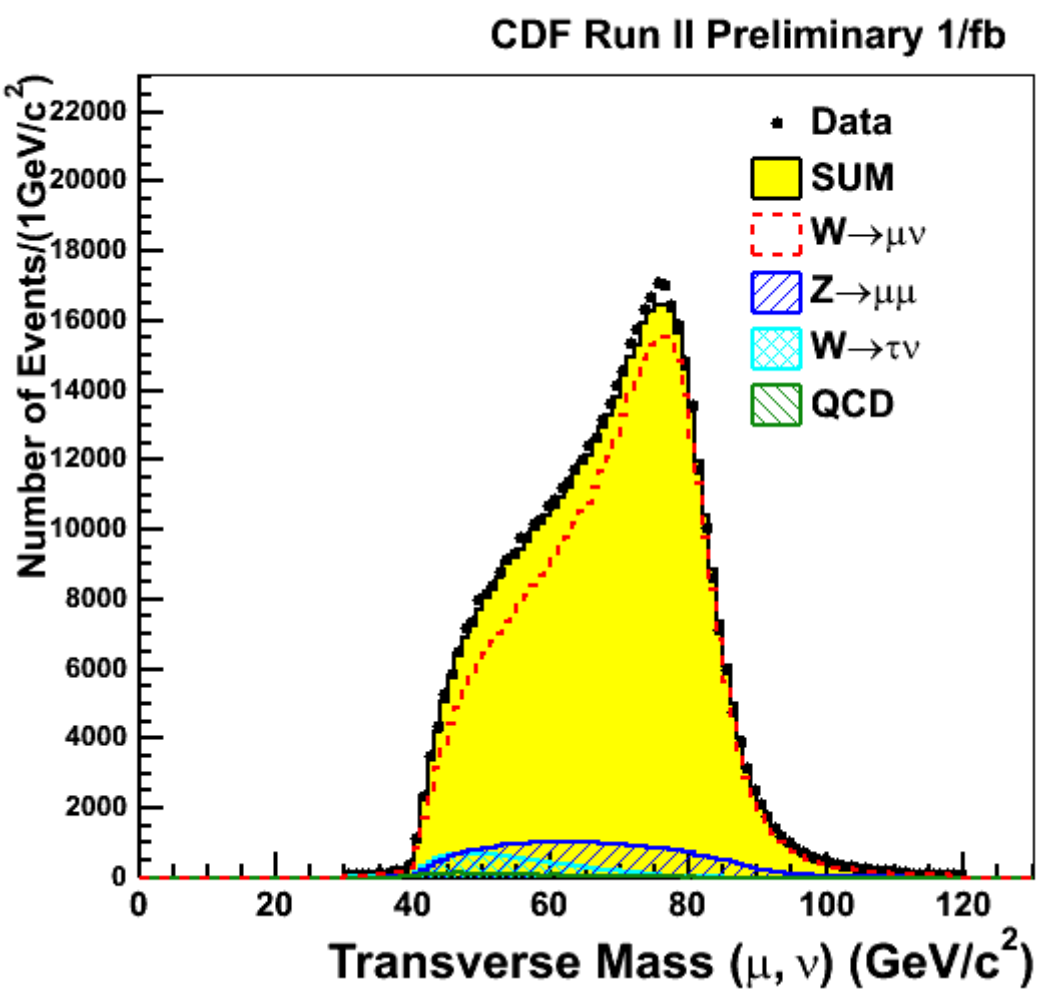
W cross section in Muon Channel as a cross check

	Number of Events
$W \to \mu\nu$	452811
QCD	4549
$Z \to \mu\mu$	40311
$W \to \tau\nu$	15807
Number of Total Expected	513478
Number of Observed	520818

- We observed 520818 W candidates in muon channel.
- σ (W $\to\mu\nu$)=2.78+-0.01(stat.)[nb]
- agree well with published result 72/pb PRL 94, 091803
  - 2.775+-0.01(stat.)+-0.053(sys.)+-0.167(lum.) [nb]
- Thus we can move on to W+γ analysis

W kinematic distributions





- Data agree with Standard model prediction

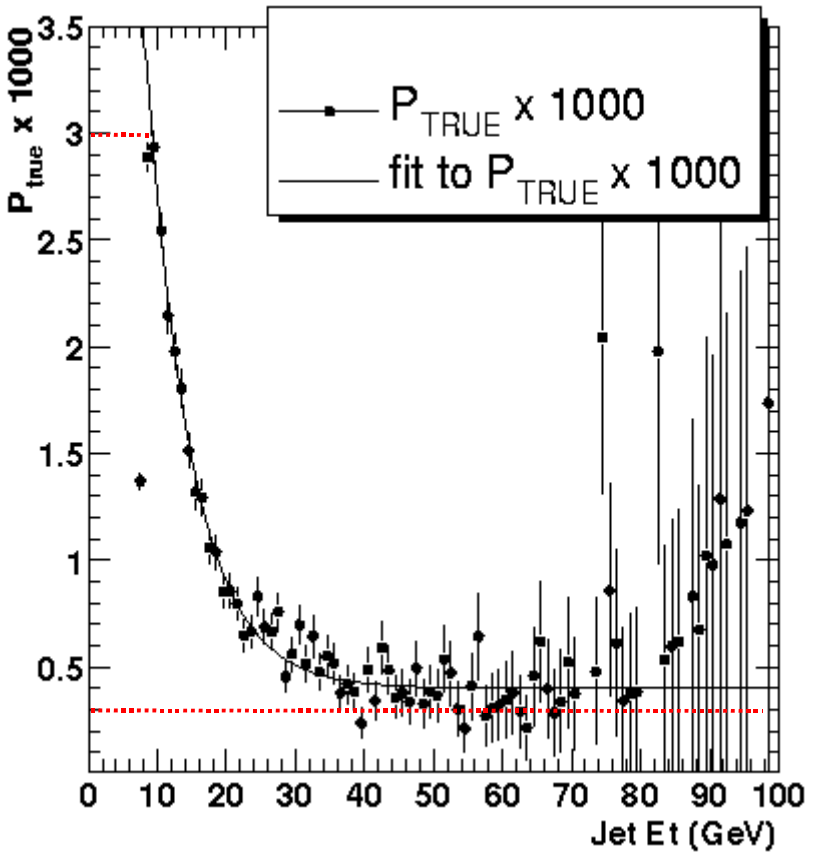
W+γ Event Selection in Muon Channel

- After inclusive W selection then add photon selection.
- W+γ process
  - simulated by Monte Carlo program by U. Baur
  - It contains initial and final state photon radiation and the trilinear gauge coupling process.
- Photon ID
  - $E_T > 7$ GeV
  - $|\eta| < 1.0$
- W+γ Selection
  - ΔR (lepton,photon) > 0.7

W+γ Background contributions

- W+jet is the largest background. 22.7%
  - Jet misidentified as photon
  - determined from data
  - measure the photon fakerates versus jet E_T
- $Z+\gamma \rightarrow \mu\mu\gamma$ 13.1 %
  - one muon not identified
  - determined from Monte Carlo
- $W+\gamma \rightarrow \tau\nu\gamma$ 1.5 %
  - determined from Monte Carlo

0.3 % at photon E_T=7GeV
0.03% at photon E_T>50GeV



W+γ cross secion CDF preliminary results with 1/fb

- The W+γ cross section in the kinematic range of $\Delta R(\mu,\gamma) > 0.7$ and photon $E_T > 7$ GeV using photon $|\eta| < 1.0$

	Number of Events
$W\gamma$	541.7±4.02(stat.)±1.57(sys.)
W+jet	194.3±0.15(stat.)±66.91(sys.)
$Z\gamma$	112.0±0.39(stat.)±0.32(sys.)
$W\gamma(\tau)$	12.4±0.60(stat.)±0.04(sys.)
Number of Total	860.4±29.25(stat.)±66.95(sys.)
Number of Observed	855

$$\sigma(W\gamma \rightarrow \mu\nu\gamma) = 19.11 \pm 1.04(\text{stat.}) \pm 2.40(\text{sys.}) \pm 1.11(\text{lumi.})\,[\text{pb}]$$

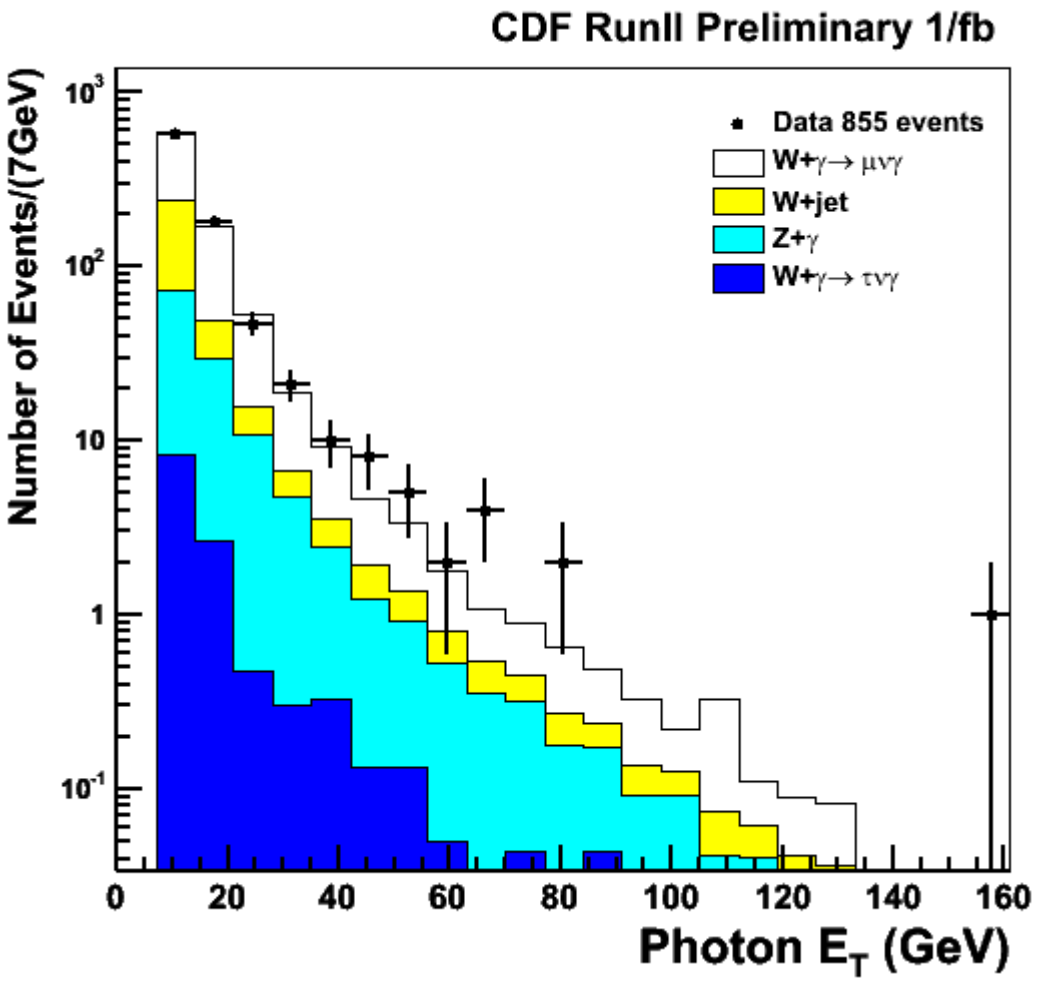
theoretical NLO cross section : 19.3+-1.4 pb

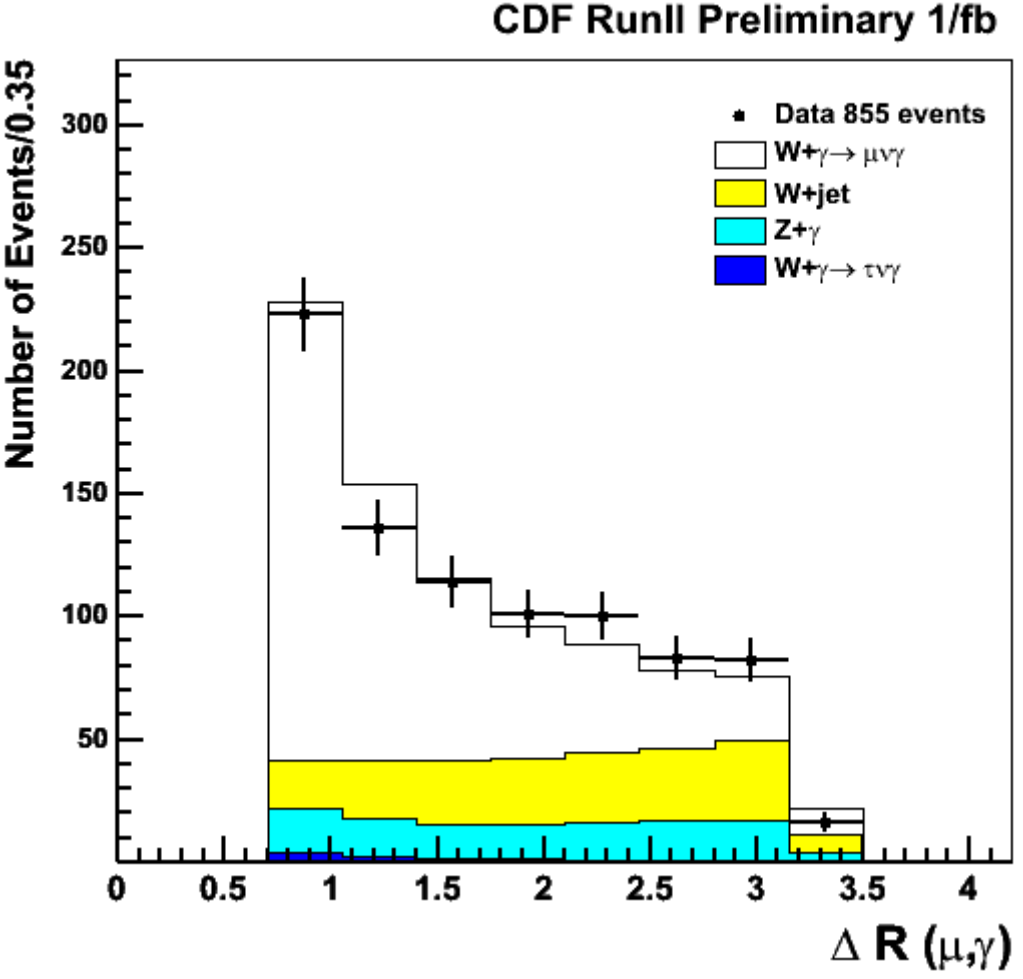
Systematic Uncertainties

Source	% effect on σ
Luminosity	5.8
Jet Fake	10.1
Trigger Efficiency	0.5
Tracking Efficiency	0.2
Muon ID	0.6
Muon Momentum Scale	0.2
Photon Energy scale	1.0
Photon ID	3.0
Z vertex cut efficiency	0.2
Cosmic rejection	0.01
Conversion	2.0
Acceptance	3.0
Total (excluding Luminosity)	12.6

- The photon fake rate uncertainty yields the dominant uncertainty on the cross section.

Photon E_T, $\Delta R(l,\gamma)$ distribution



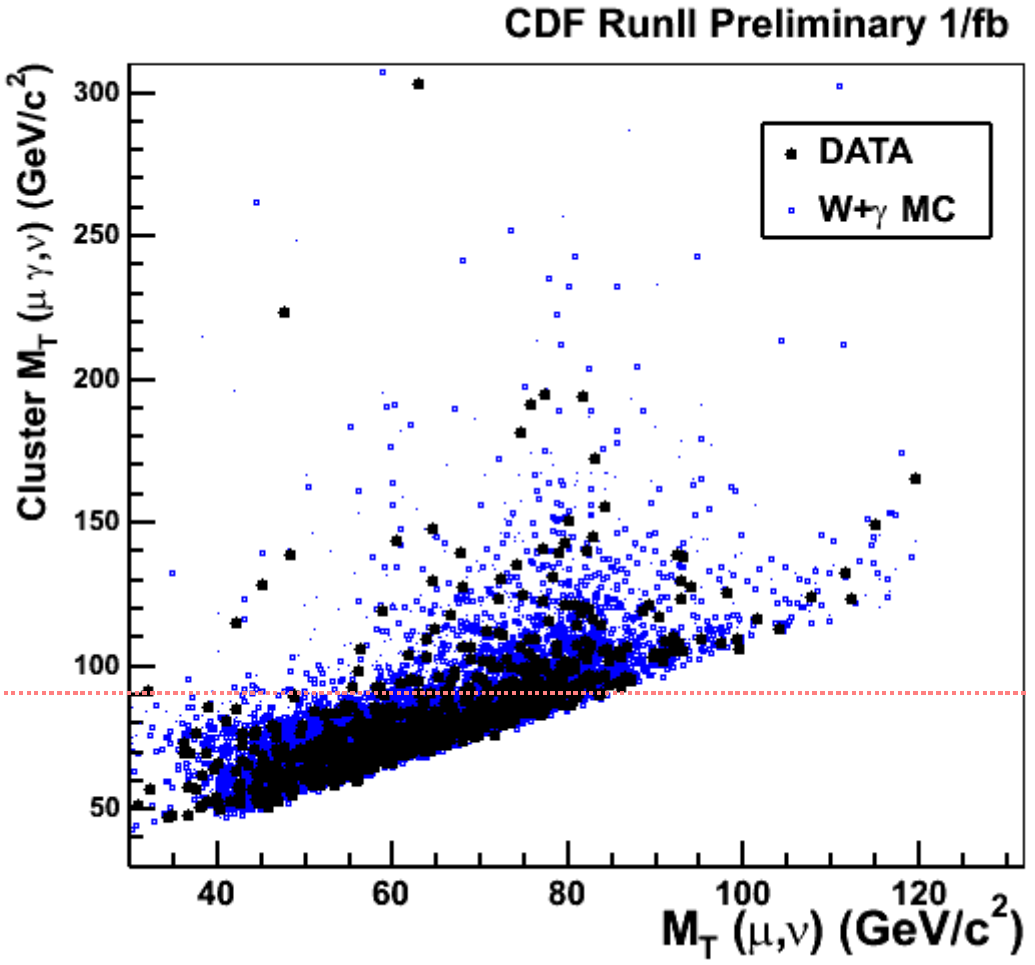


Data agree well with Standard Model prediction

Transverse Mass (μ,ν) vs Cluster MT(μγ,ν)

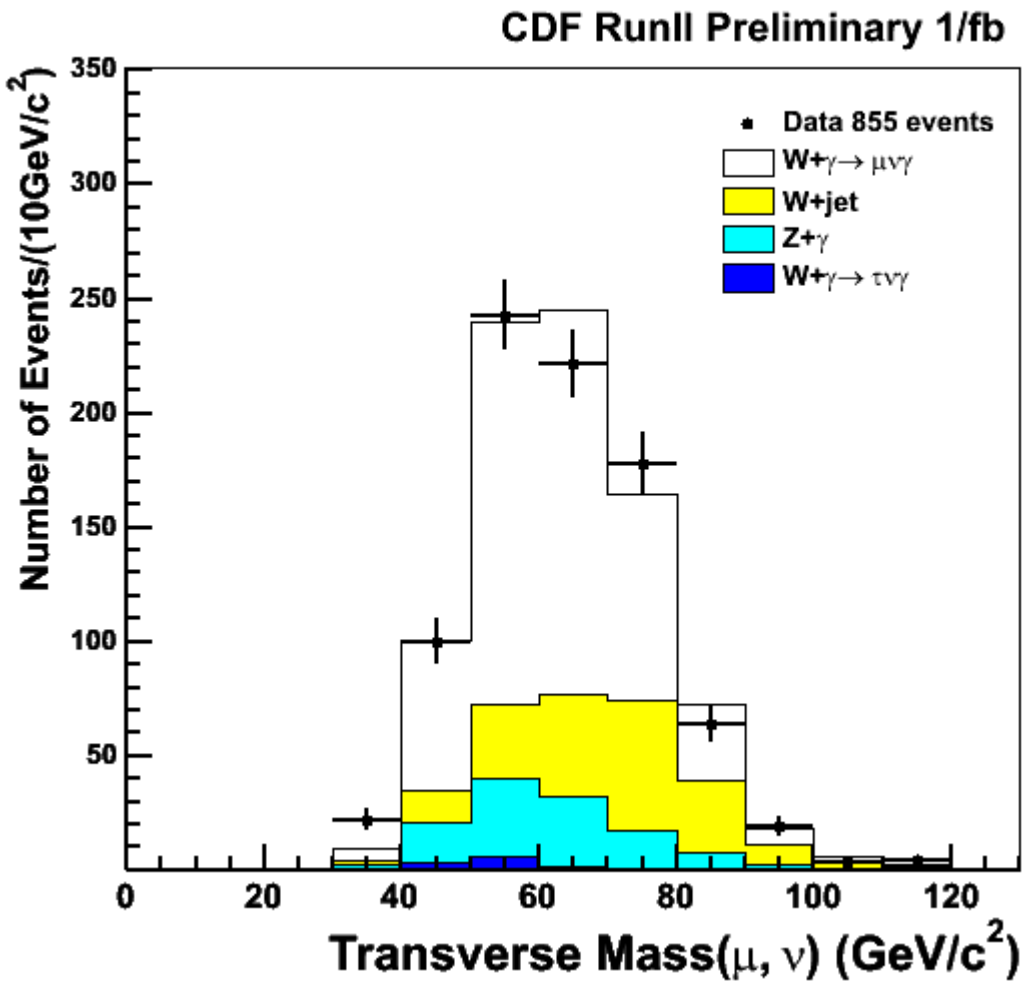
- ISR, s-channel Event
  - Invariant Mass(μ,ν) = Mw
  - cluster MT(μγ,ν) > Mw
- FSR Event
  - Invariant Mass(μ,ν) < Mw
  - cluster MT(μγ,ν) ~ Mw

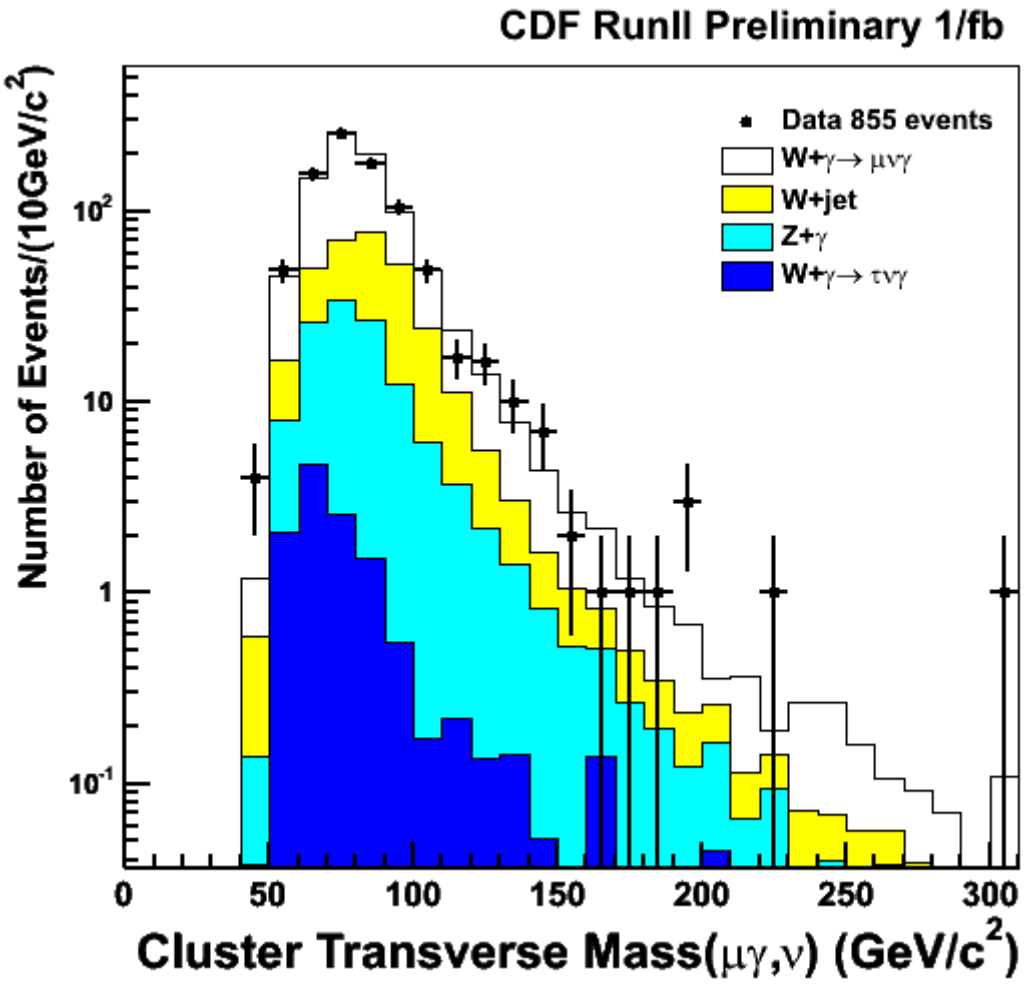
cluster MT(μγ,ν) = 90



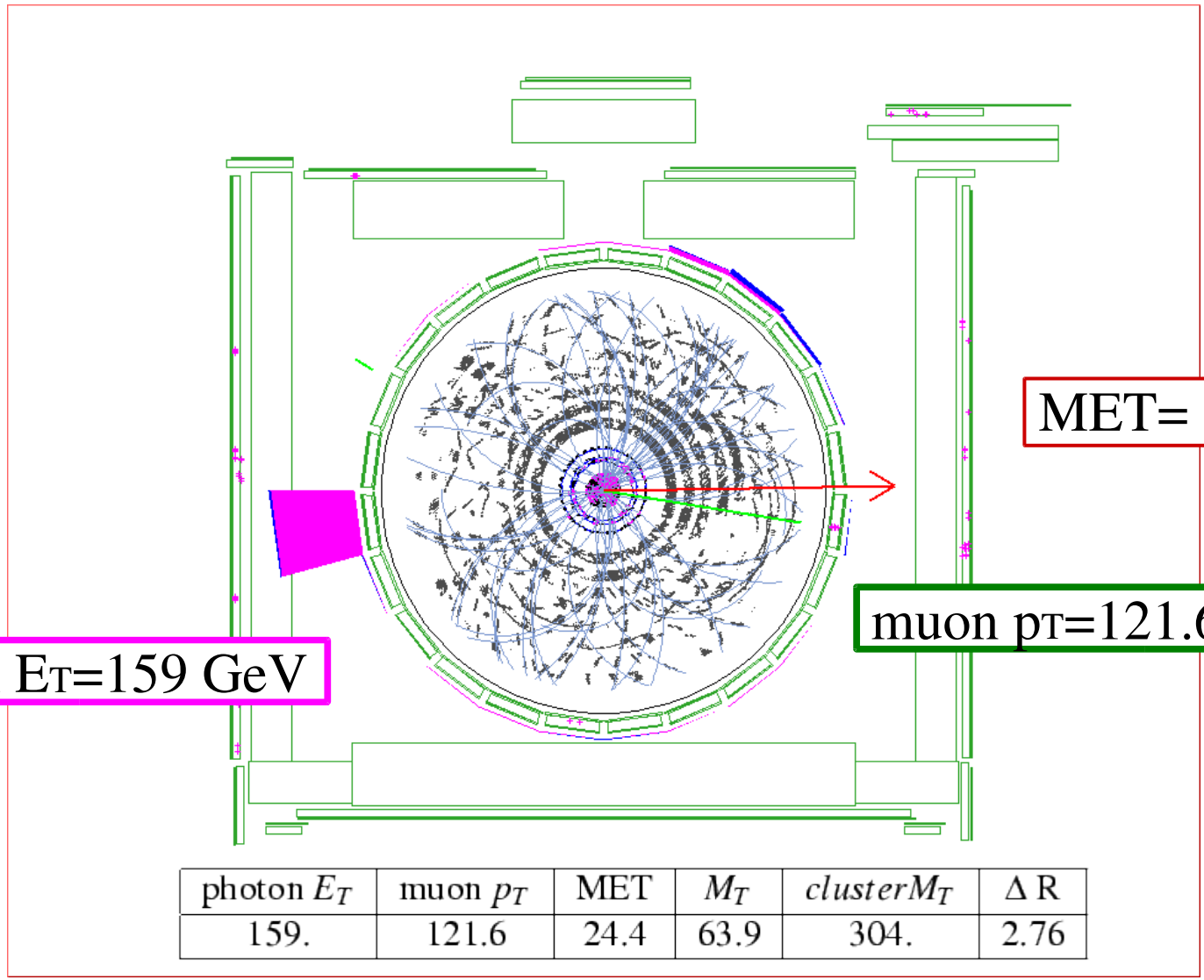
In future plan, we can separate ISR, s-channel Events from FSR with cluster MT(μγ,ν) > 90 GeV cut.

Mass distributions





W+γ Candidate Event Display



photon E_T	muon p_T	MET	M_T	$clusterM_T$	Δ R
159.	121.6	24.4	63.9	304.	2.76

Conclusion

- W+γ cross section measured in 1/fb
  - σ BR(W$\rightarrow\mu\nu$) 19.11+-1.04 (stat.) +-2.40 (sys.) +- 1.11(lumi.) [pb]
  - theoretical NLO cross section 19.3+-1.4 pb
- very good agreement with standard model prediction.
- Plan
  - extract anomalous couplings
  - study radiation amplitude zero