# CDF Analyses with Photons

## Inclusive Photon Cross Section
## Search in Diphoton+Met
## Search in Photon+Jets

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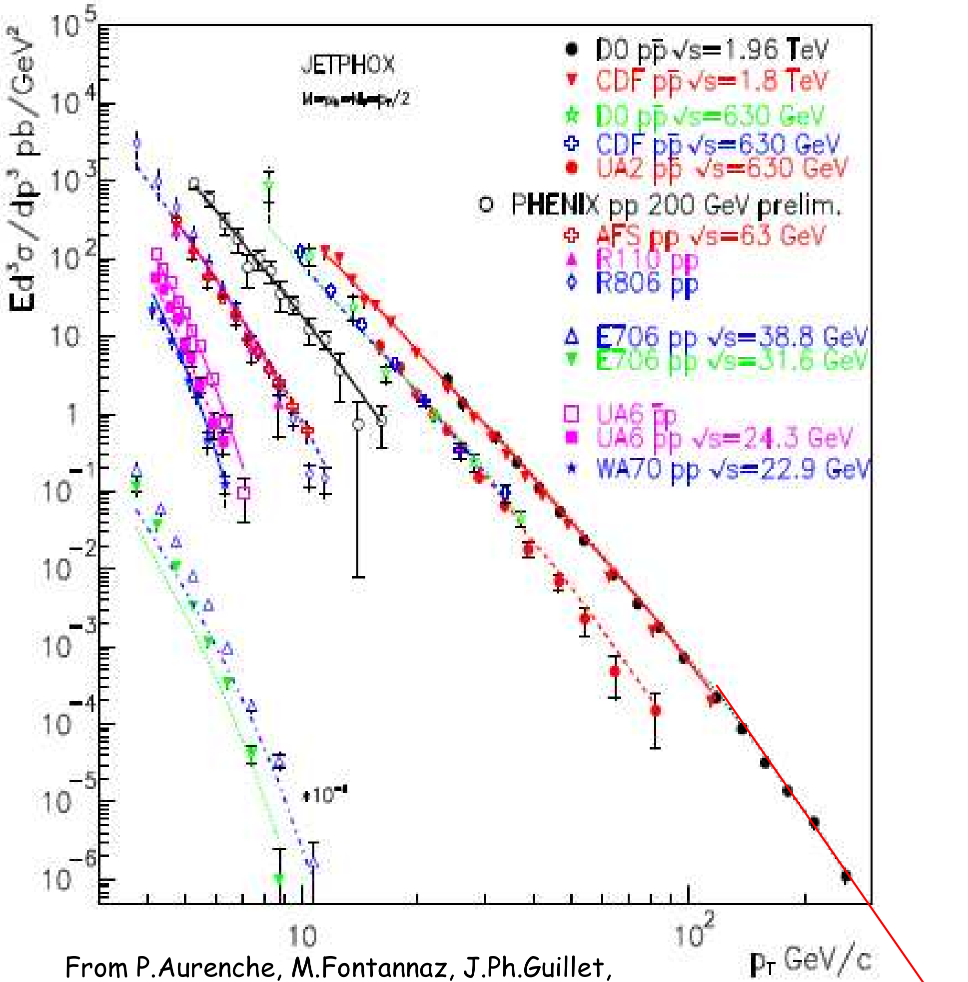
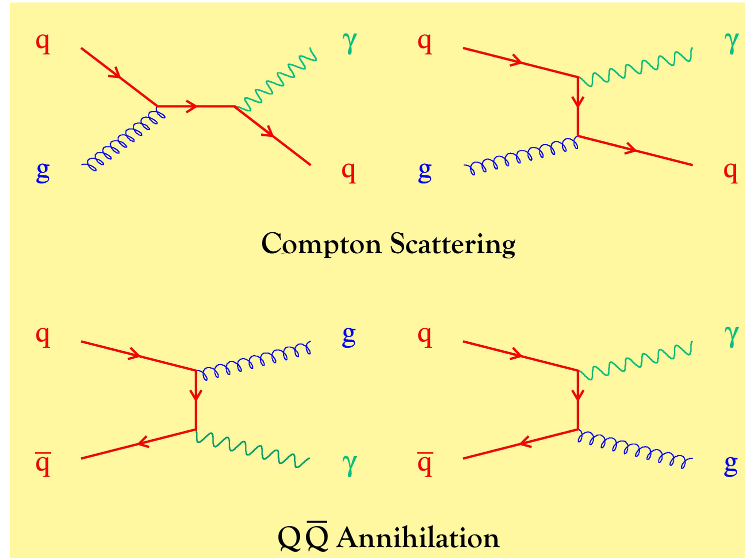
*for the CDF Collaboration*

# Inclusive Cross Section




From P.Aurenche, M.Fontannaz, J.Ph.Guillet, E.Pillon, M.Werlen (hep-ph/0602133), 2006




Leading Order Processes Yielding Direct Photons

Sensitive to

- ♦ gluon PDF
- ♦ new physics

Complementary to jets

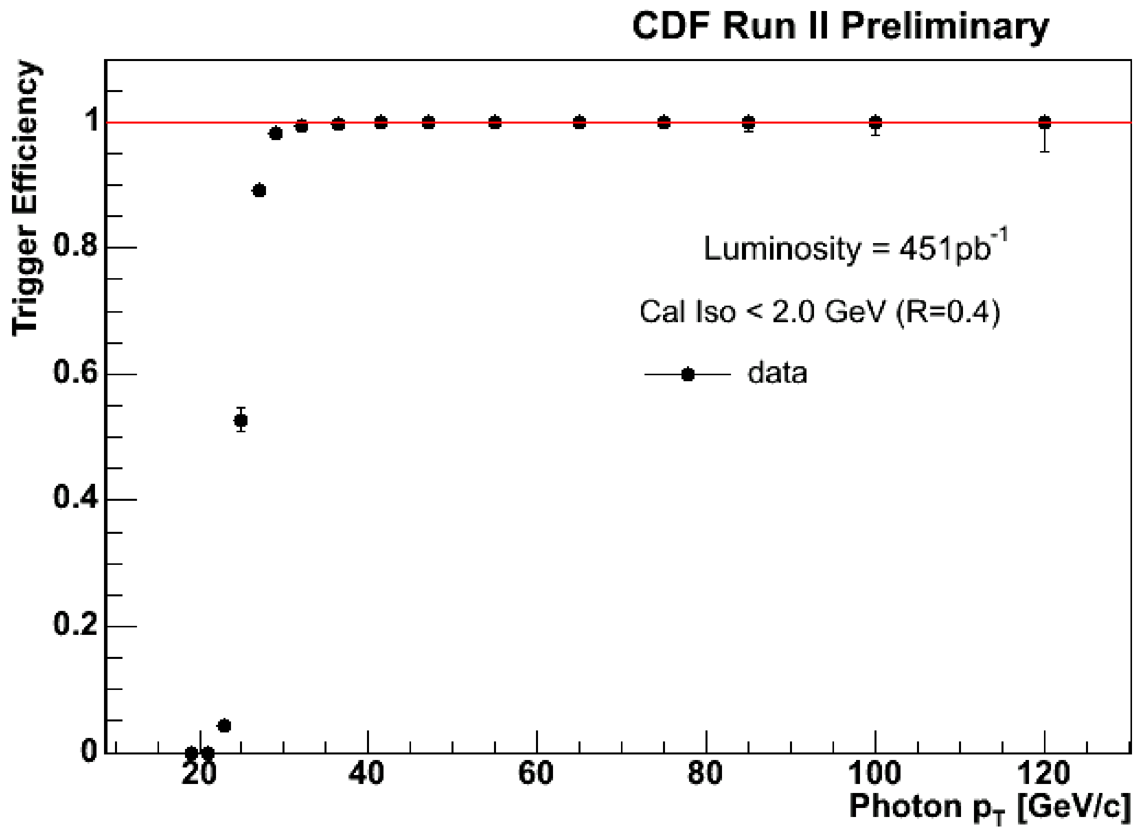
# Inclusive Cross Section

## Event Selection

- $E_T$>30 GeV, |η|<1
- calorimeter isolation < 2 GeV
- efficiency measured in Pythia+GEANT Monte Carlo, checked with data Z → ee

## Trigger Selection

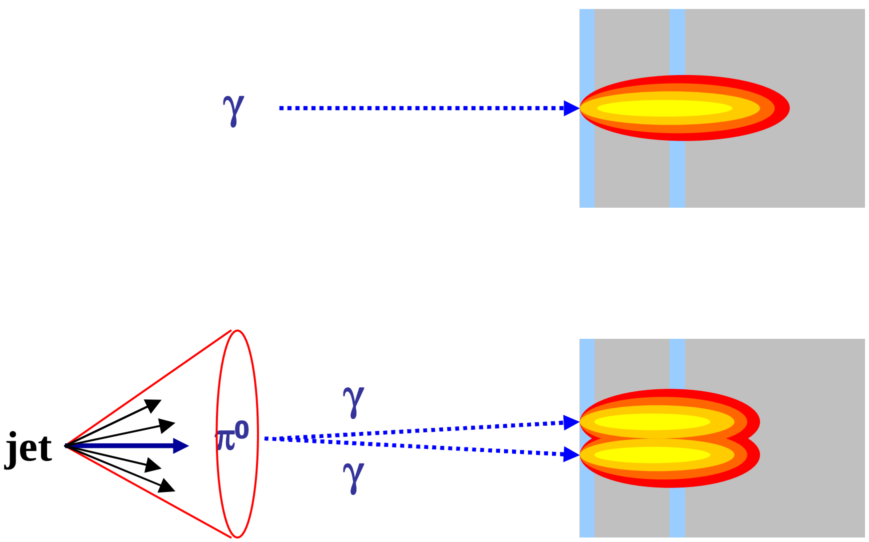
- $E_T$>25 GeV, calorimeter isolation< 10%
- efficiency measured using data Z → ee
- nearly 100% efficient

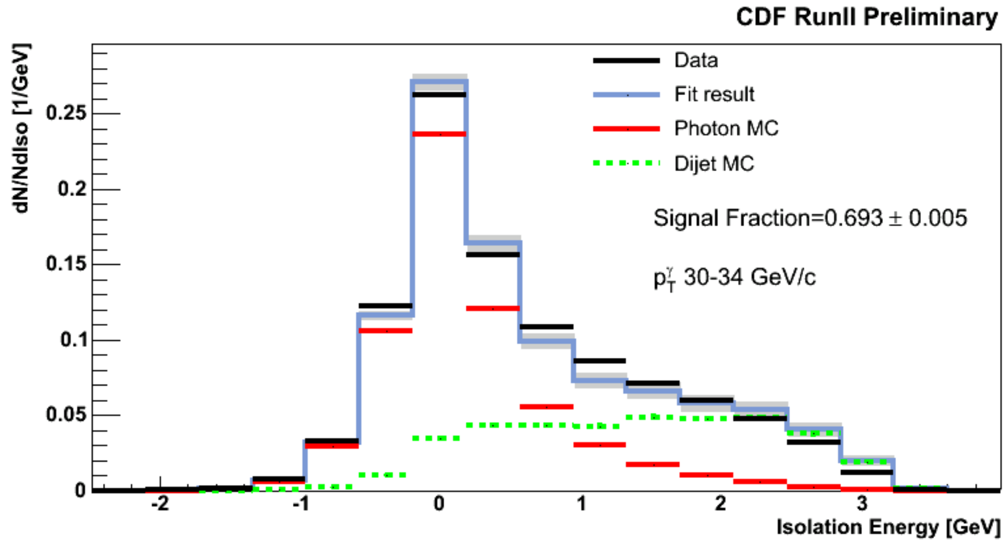


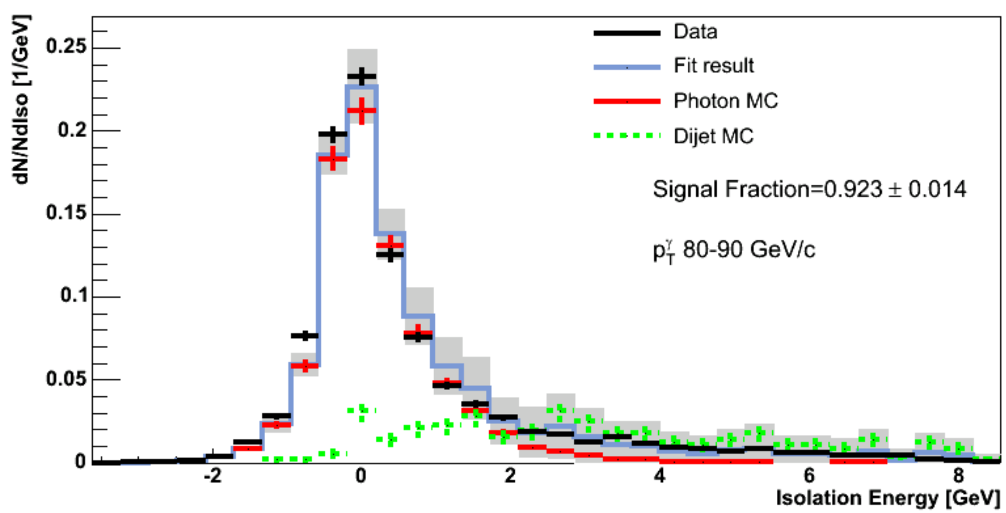
# Inclusive Cross Section

Largest issue:

separate backgrounds
from jets faking photons



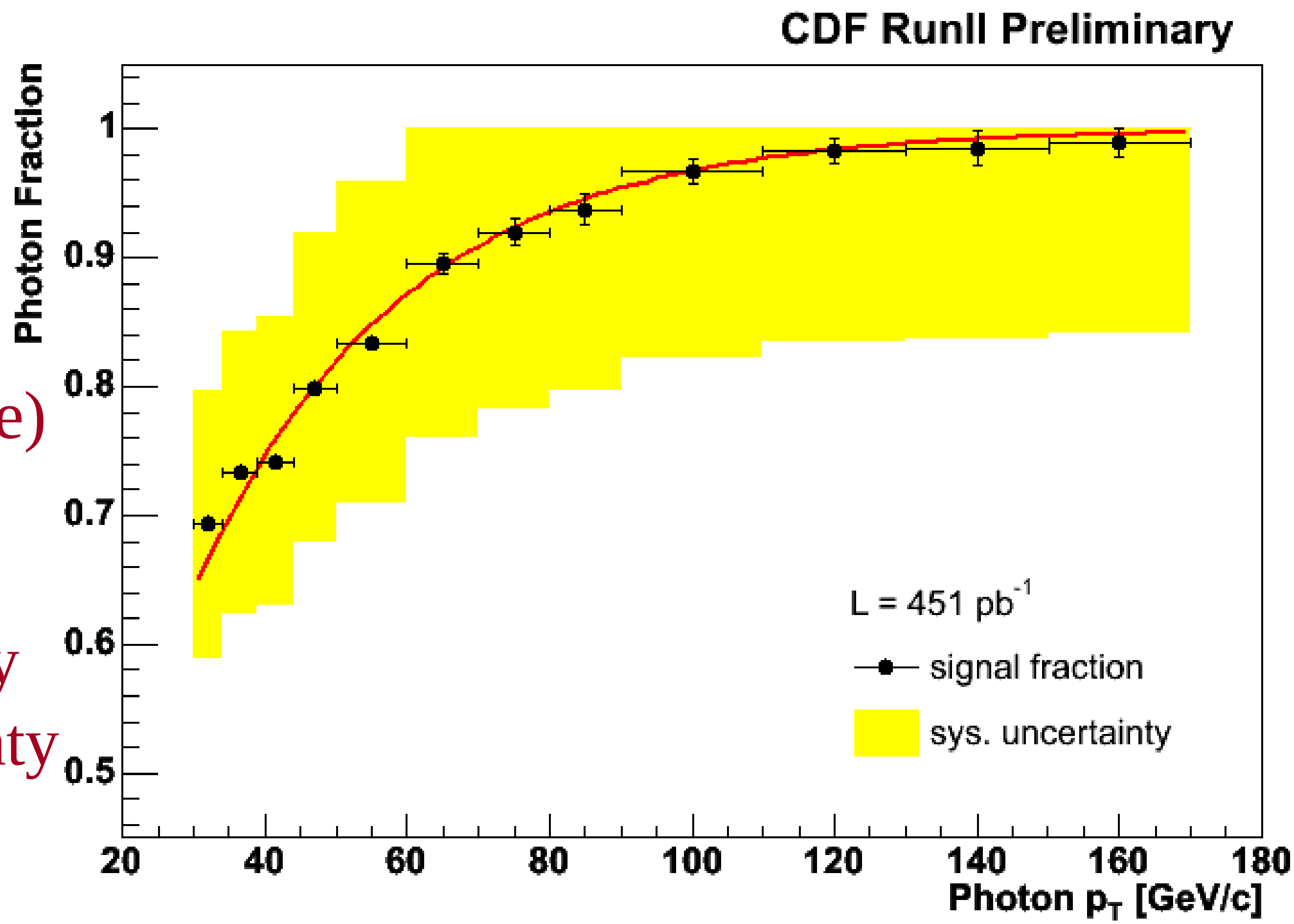

Method:

- fit calorimeter isolation shape
- templates from Pythia+GEANT

# Inclusive Cross Section

Photon Fraction

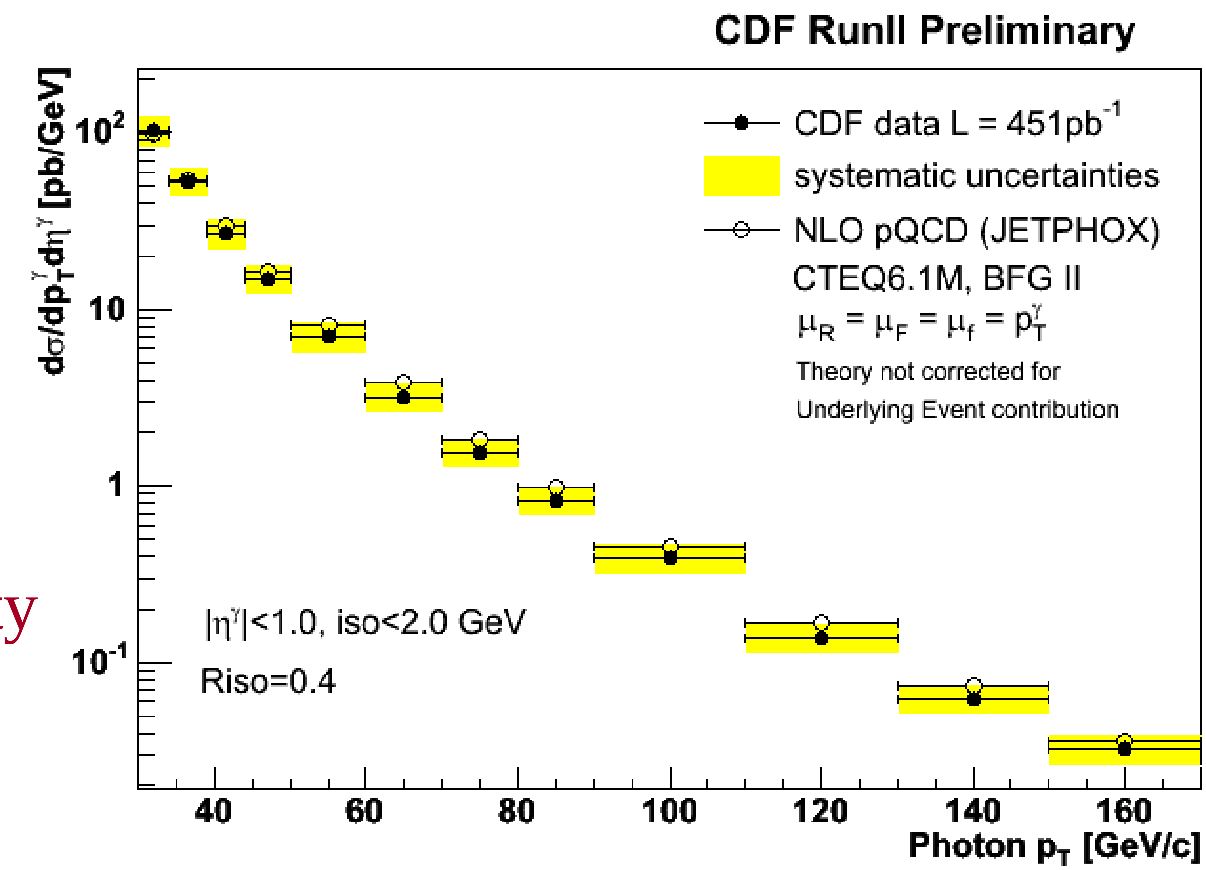
- Result of isolation fit
- Systematic variations in templates
  - Z data (limited $E_T$ range)
  - several other variations
- Currently, use a conservative, preliminary 15% systematic uncertainty



# Inclusive Cross Section

Results

- ♦ unfolded - corrects for E resolution
- ♦ 1% E scale uncertainty = 5% on cross section
- ♦ not corrected for underlying event - additional 10% uncertainty
- ♦ Compares well to NLO calculation JETPHOX (*JHEP 0205:028,2002*)
- ♦ 451 $pb^{-1}$




- ♦ plans: increase to 3 $fb^{-1}$, $E_T$ range to 300 GeV, reduce systematics

# Search for Diphoton and MET

## Model independent

- explore the kinematic distributions, looking for anomalies

## Complex background mix

- Non-collision
  - beam halo
  - cosmics
  - data-based prediction
- QCD
  - real and fake photons
  - data-based Met resolution model
- True MET
  - W or Z
  - $\gamma$, $e \to \gamma$, $j \to \gamma$ or $\tau \to \gamma$
  - data-based prediction

## Selection

- Two photons
  - Et > 13 GeV
  - $|\eta| < 1$
- Targeted cuts
  - beam halo
  - cosmics
  - $e \to \gamma$

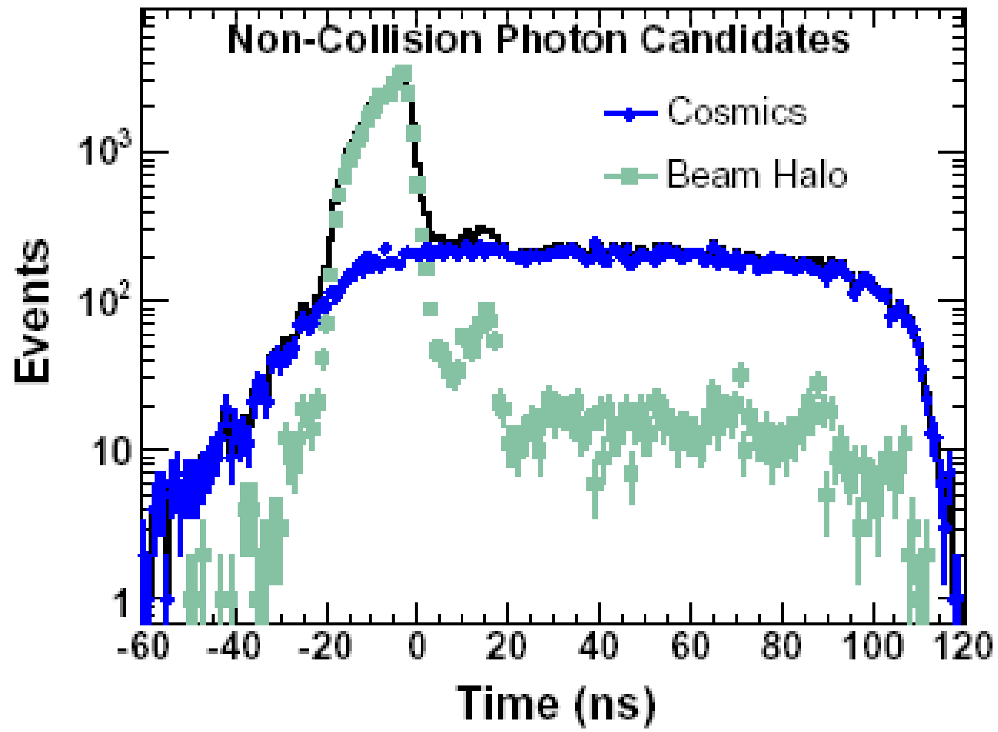
2.0 $fb^{-1}$

# Search for Diphoton and MET

## 1) Non-collision Background

Cosmics

- ♦ reduce with
  - ○ no muon stubs (early data)
  - ○ EM in time (later data)
- ♦ data for counts, MET template



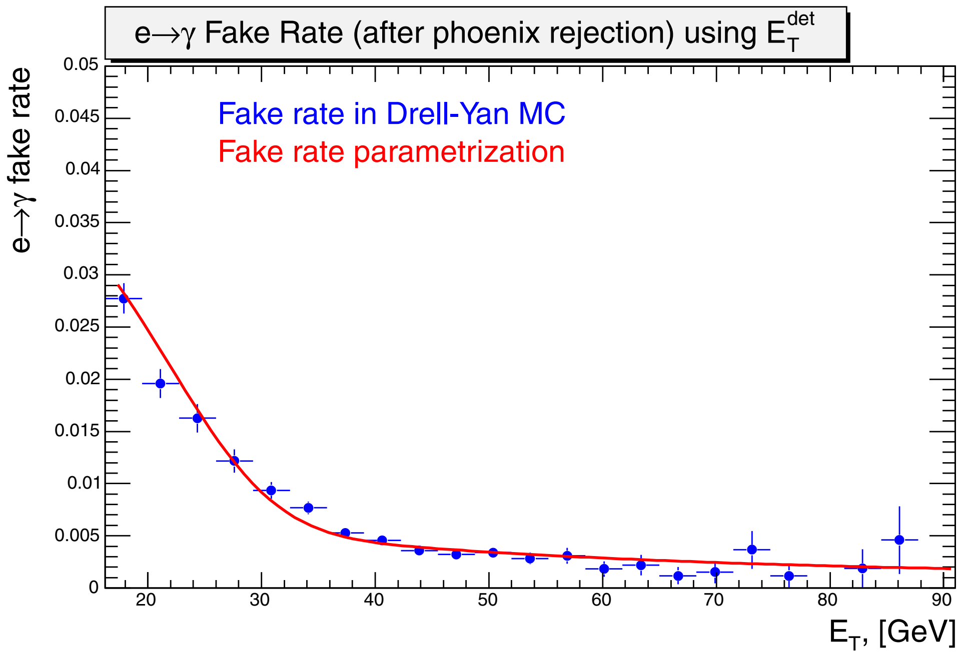

Beam Halo

- ♦ muons travelling with beam
- ♦ cuts on E along muon path
- ♦ data for counts, Met template

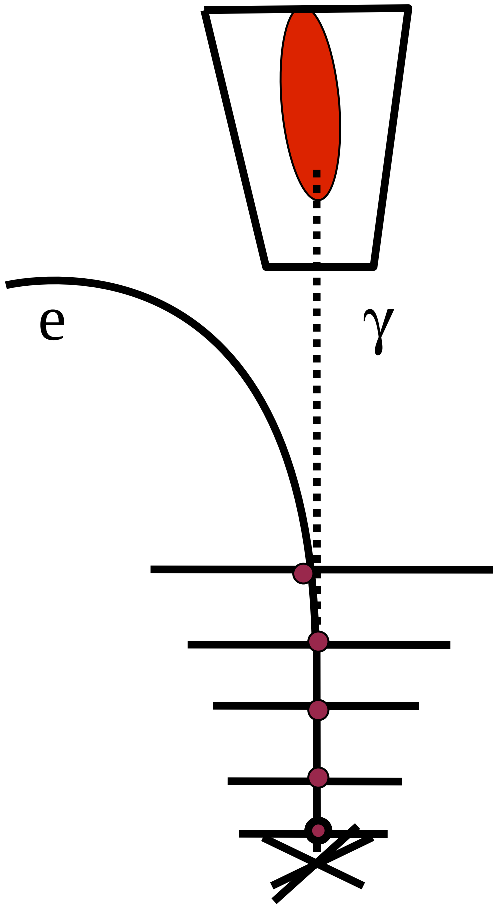
# Search for Diphoton and MET

## 2) Electroweak backgrounds

- Reject e→γ with "Phoenix"
- Remaining eγ events * P(e→γ)
- Correct with MC(γγ)/MC(eγ)
  - FSR γ, τ→γ
- MET template same method




EM-seeded "Phoenix" rejection



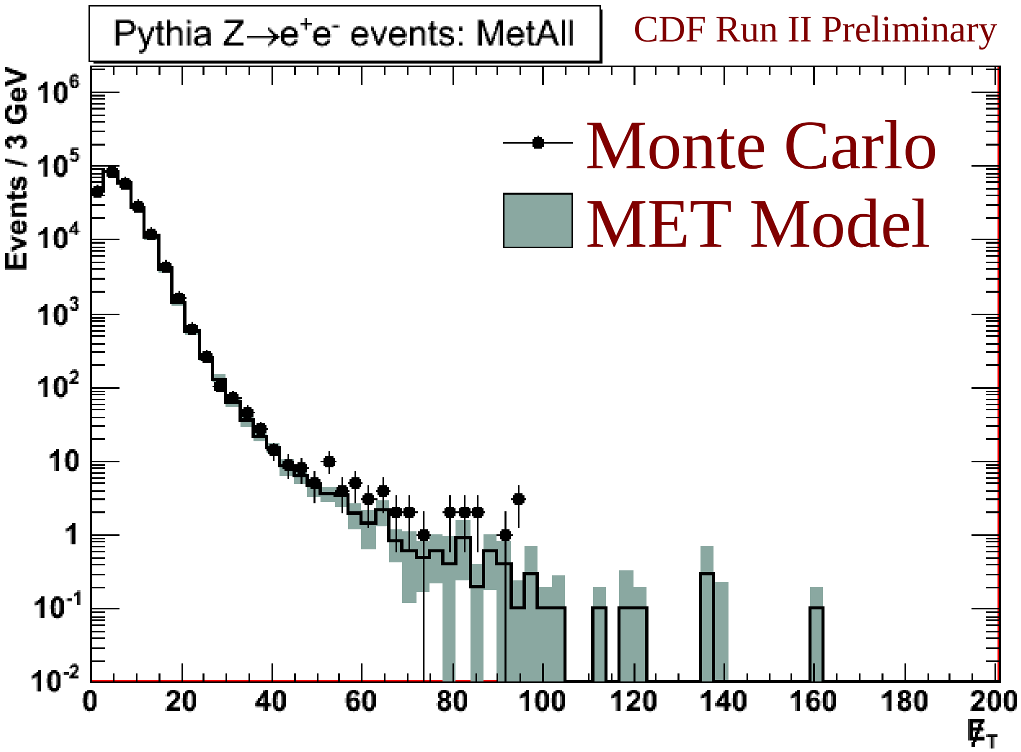
# Search for Diphoton and MET

## 3) QCD – real or fake photons plus jets

MET Model

- ♦ make MET distribution prediction based on observed jets in the event
- ♦ jet resolution parameterized from dijet MC, including tails
- ♦ validate resolution on data
- ♦ for each event, smear jets with $E_T$>3 GeV
- ♦ if $E_T$>15, use jet corrections
- ♦ include unclustered E resolution
- ♦ integrate over smearings
- ♦ define significance, "METSig": -LOG10( P(MET fluctuation>MET observed) )

Test on Z Monte Carlo:

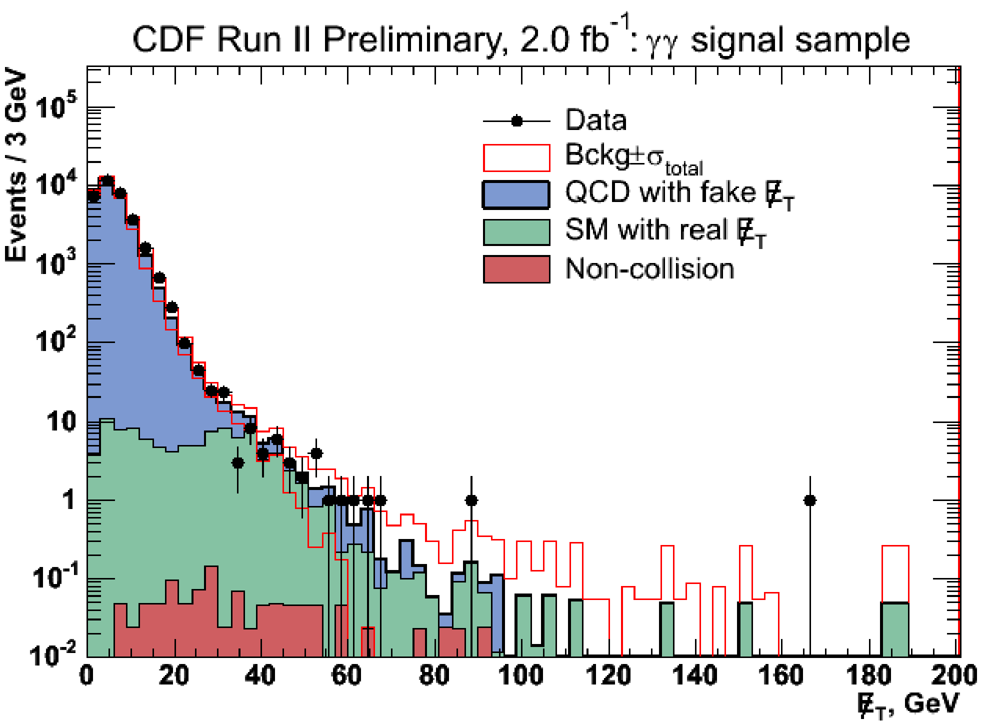


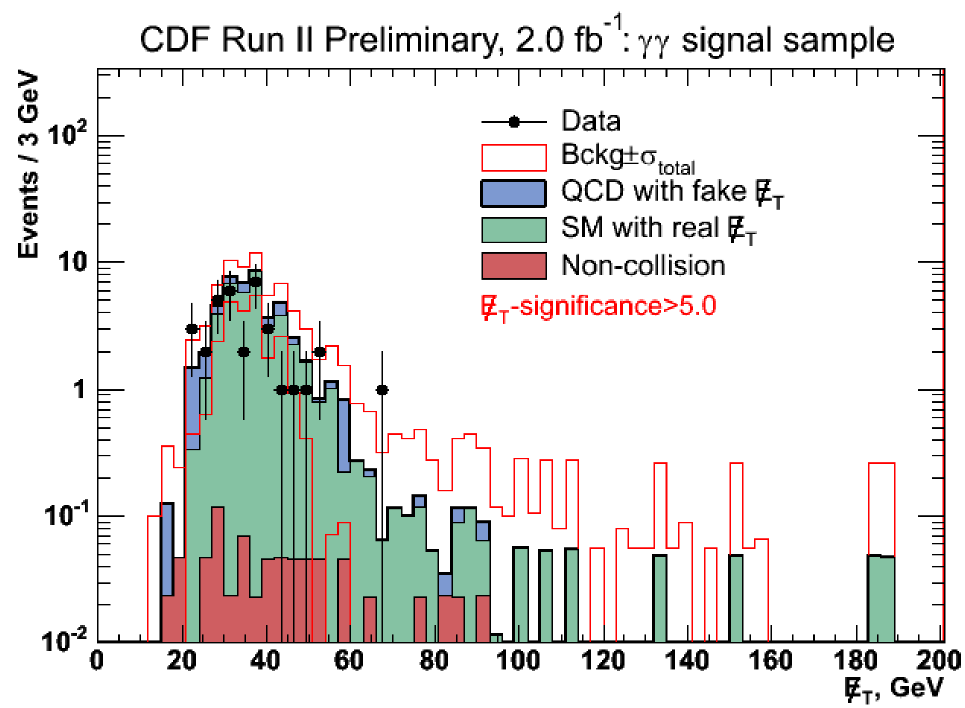
# Search for Diphoton and MET

Signal region results

METSig>5.0:
probability of MET fluctuation < $10^{-5}$

| | |
|---|---|
| Non-collision | 0.80 ± 0.27 |
| Fake Met | 3.0 ± 1.8 |
| SM with real MET | 41.6 ± 7.0 |
| Total | 45.4 ± 7.2 |
| Observed | 34 |

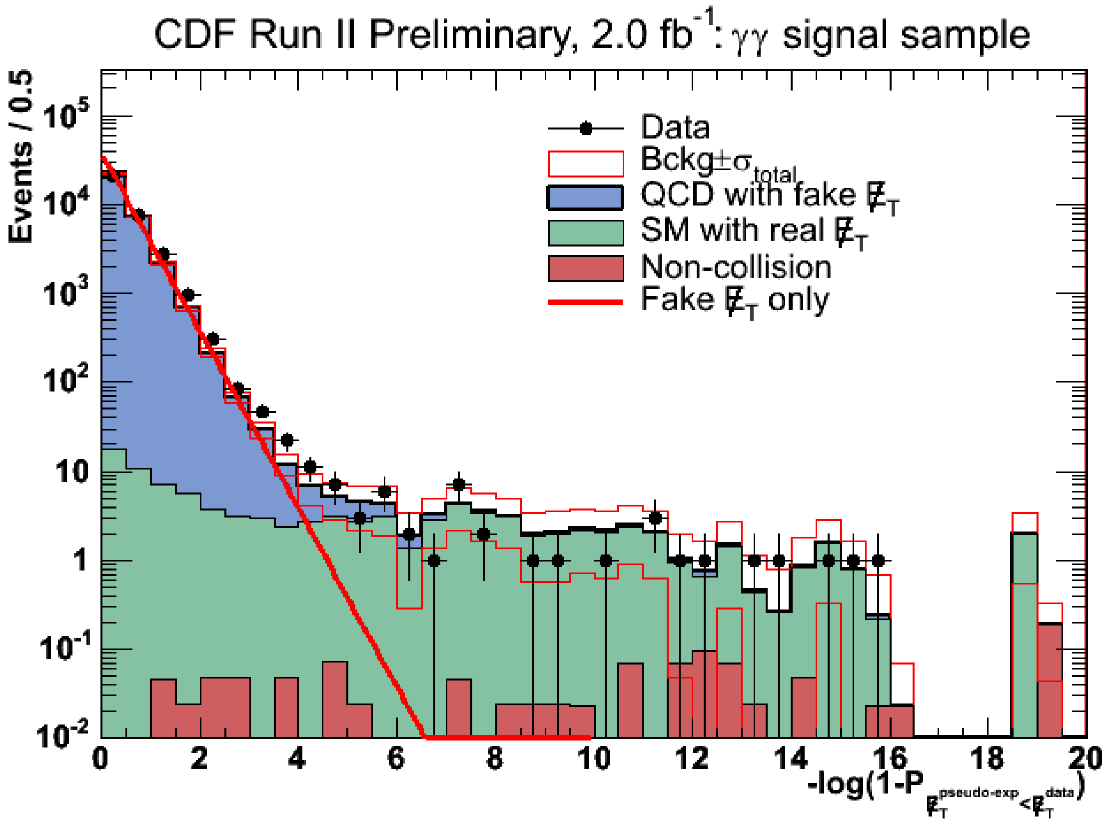


# Search for Diphoton and MET

## Signal region results

| | METSig>3.0 | METSig>4.0 | METSig>5.0 |
|---|---|---|---|
| QCD rejection | $10^3$ | $10^4$ | $10^5$ |
| Efficiency for $W\gamma \rightarrow e\nu\gamma$ (%) | 84 | 79 | 72 |



# Search for Photon and Jets

## Model Independent

- explore the kinematic distributions, looking for anomalies

## Background mix

- QCD (dominant!)
  - inclusive photon
  - jets faking photons
- Electroweak
  - W or Z
  - $\gamma$, $e \to \gamma$, $j \to \gamma$ or $\tau \to \gamma$
- Non-collision
  - beam halo
  - cosmics

## Selection

- One photon
  - $E_T > 30$ GeV
  - $|\eta| < 1$
- >=1 jet
  - Corrected $E_T > 15$
  - $|\eta| < 3$
- Targeted cuts
  - beam halo
  - cosmics
  - $e \to \gamma$ (Phoenix)
  - events with isolated tracks

*Currently only examining 10% of 2 $fb^{-1}$ (test sample)!*

# Search for Photon and Jets

Two background methods

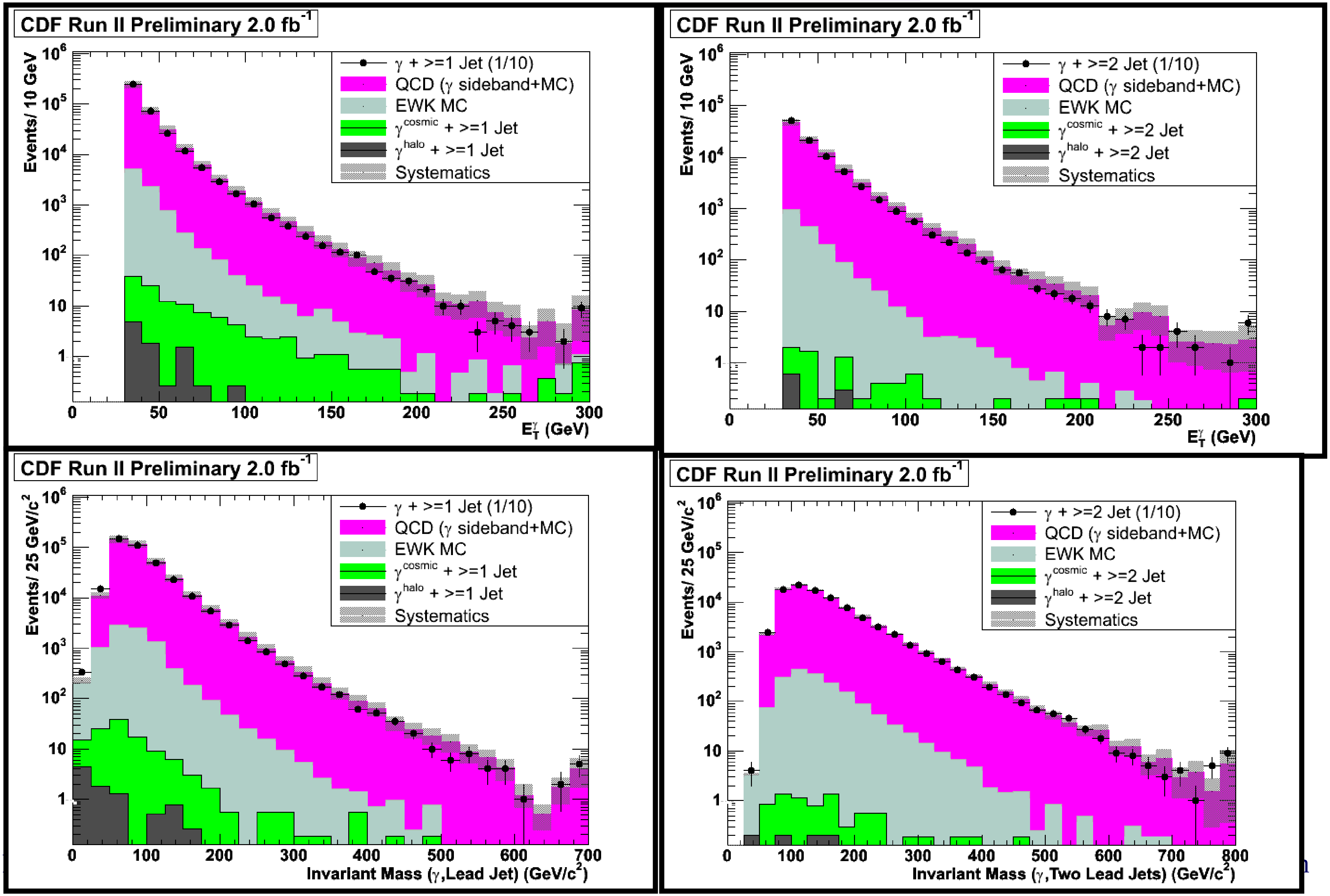
- For kinematic distributions very sensitive to photon $E_T$
  - use Pythia photon Monte Carlo for real photon template
  - use loose photon sample for fake photon template
  - combine using 70% overall inclusive photon fraction
  - normalize total to data total

- For kinematic distributions more sensitive to jet configuration
  - use loose photon sample for fake photon template
  - normalize total to data total

normalization scheme implies we are only sensitive to shapes, and excesses in the low statistics regions

# Search for Photon and Jets

10% of 2.0 $fb^{-1}$

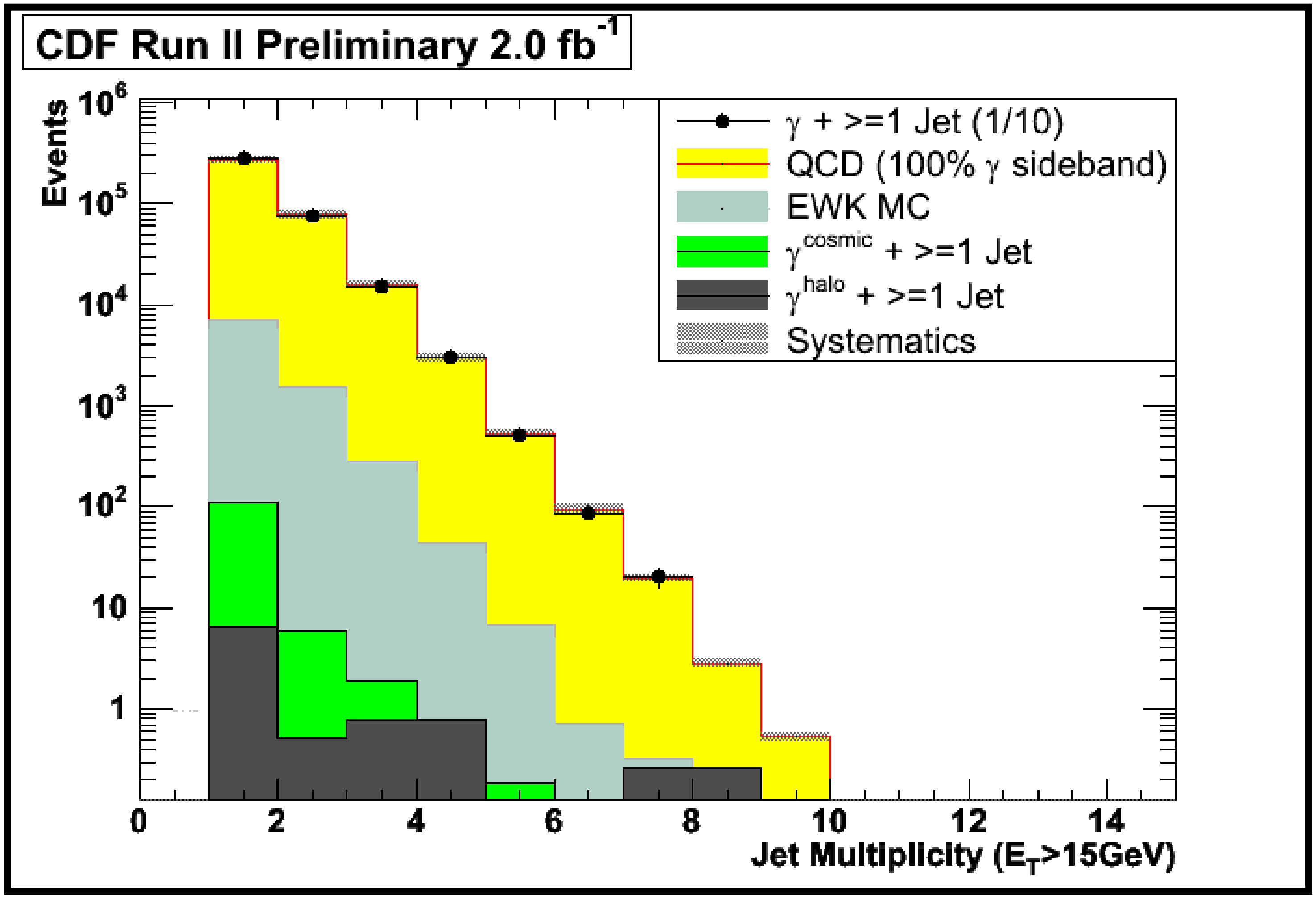


# Search for Photon and Jets

10% of 2.0 $fb^{-1}$

Jet multiplicity distribution

QCD background: 100% loose photons



# The search continues…

# Search for Diphoton and MEt

Control region results

♦ loose photon cuts, dominated by fake photons