Rejecting e→γ Fakes in the Exclusive γ+MET Final State

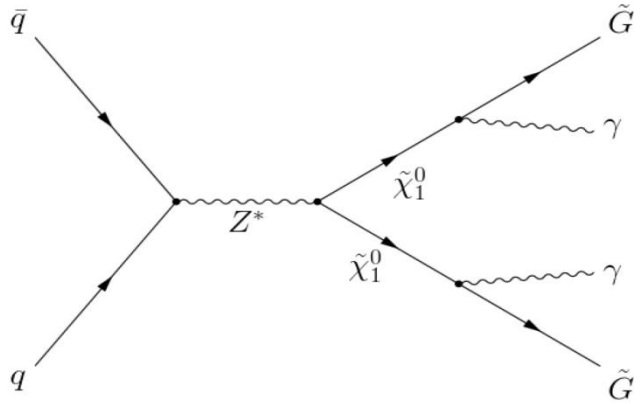
Jonathan Asaadi, Adam Aurisano, Daniel Goldin, Jason Nett, David Toback
(Texas A&M University)

Outline

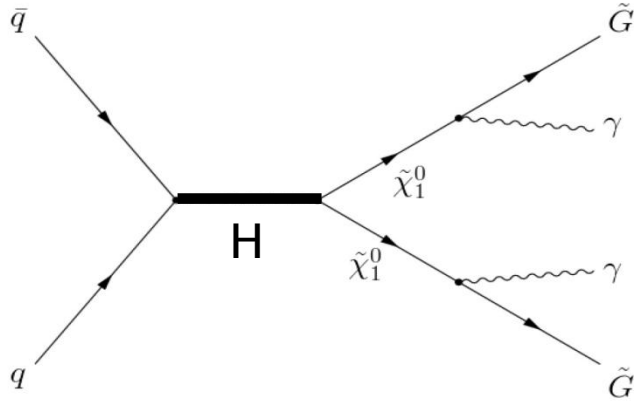
- Overview of the delayed photon analysis
- $W \rightarrow e\nu \rightarrow \gamma_{fake}$+MET Backgrounds in the Exclusive γ+Met final state
- Motivation for this method
- Data samples used
- Description of $e \rightarrow \gamma_{fake}$ rejection algorithm
- Final cut and results

Overview of Delayed Photon Analysis

- In some GMSB models the next-to-lightest stable particle (NLSP) has comparatively long lifetime (~ few ns) before decaying to a photon and lightest stable particle (LSP).

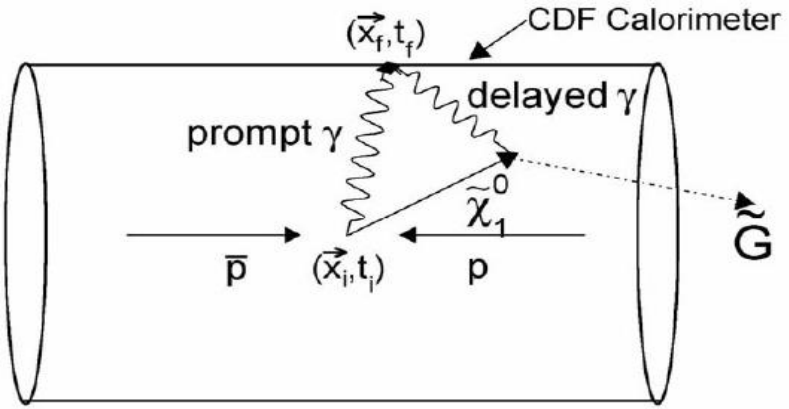


OR



- For direct χ_1^0 production consider the exclusive $\gamma_{delayed}$+MET final state.

[Toback and Wagner, Phys. Rev. D 70, 114032 (2004)]



Exclusive γ+MET Selection Cuts

- Photon ET > 45 GeV
- MET > 45 GeV
- Veto Jet/electron/tau ET > 15 GeV
- Veto muon PT > 10 GeV
- Reject isolated tracks with PT > 10 GeV
- Trigger: W_NOTRACK OR SuperPhoton70 OR UltraPhoton50
- Beam halo rejection cuts
- Cosmic ray rejection cuts

Not used in MC

Backgrounds for this Analysis

$W \rightarrow e\nu \rightarrow \gamma_{fake}\nu$

$W \rightarrow \mu\nu \rightarrow \gamma_{fake}\nu$

$W \rightarrow \tau\nu \rightarrow \gamma_{fake}\nu$

$W\gamma \rightarrow \gamma\nu$ *(lost lepton)*

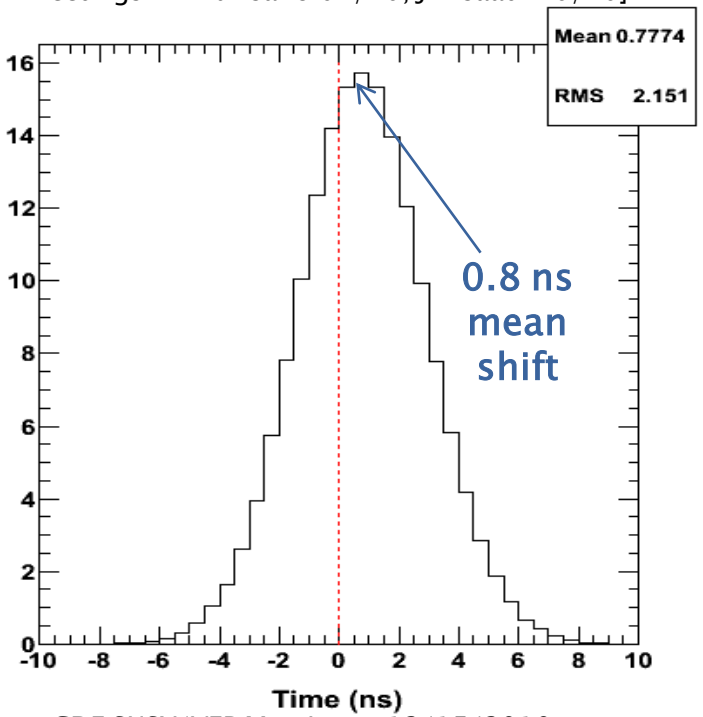
$Z\gamma \rightarrow \gamma\nu\nu \rightarrow \gamma$ MET

$\gamma\gamma, \gamma$ lost $\rightarrow \gamma$ MET

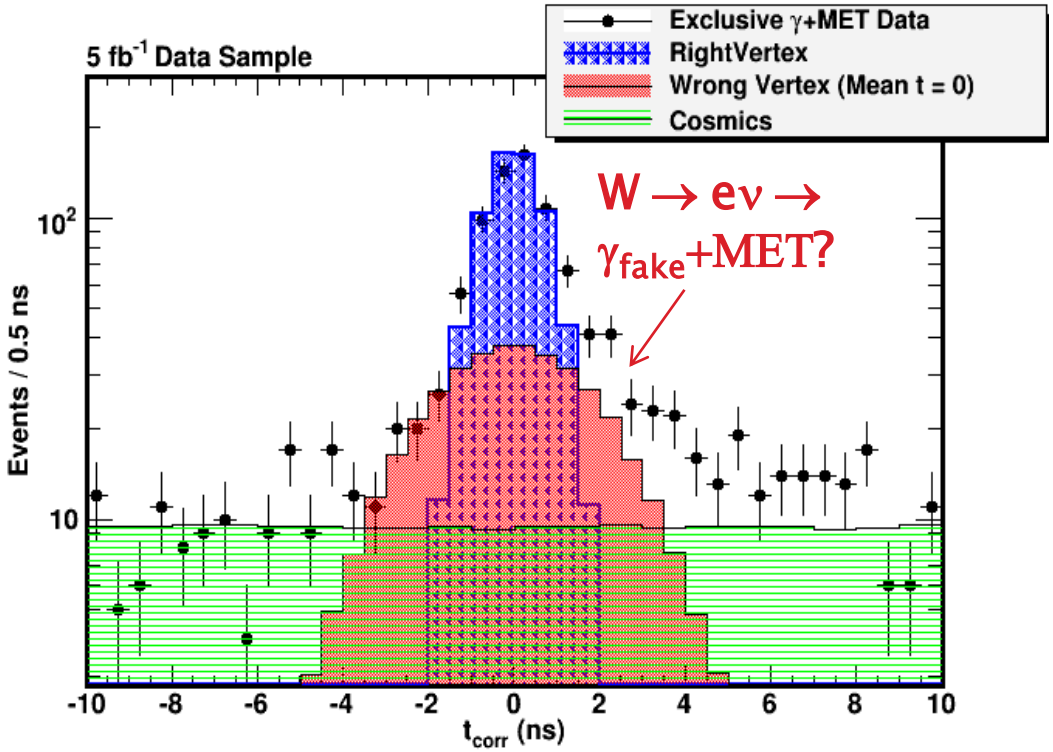
γ + jet$_{lost} \rightarrow \gamma$ MET

Non-Collision Background

- SM backgrounds to Exclusive γ + MET have shifted timing distributions
  [SUSY Meetings: Asaadi (10/09) and Aurisano (09/09)]
- One of the most worrisome is $W \rightarrow e\nu \rightarrow \gamma_{fake}$+MET
  - large rate and the largest timing shift
    [SUSY Meetings: A. Aurisano 04/10, J. Asaadi 10/10].



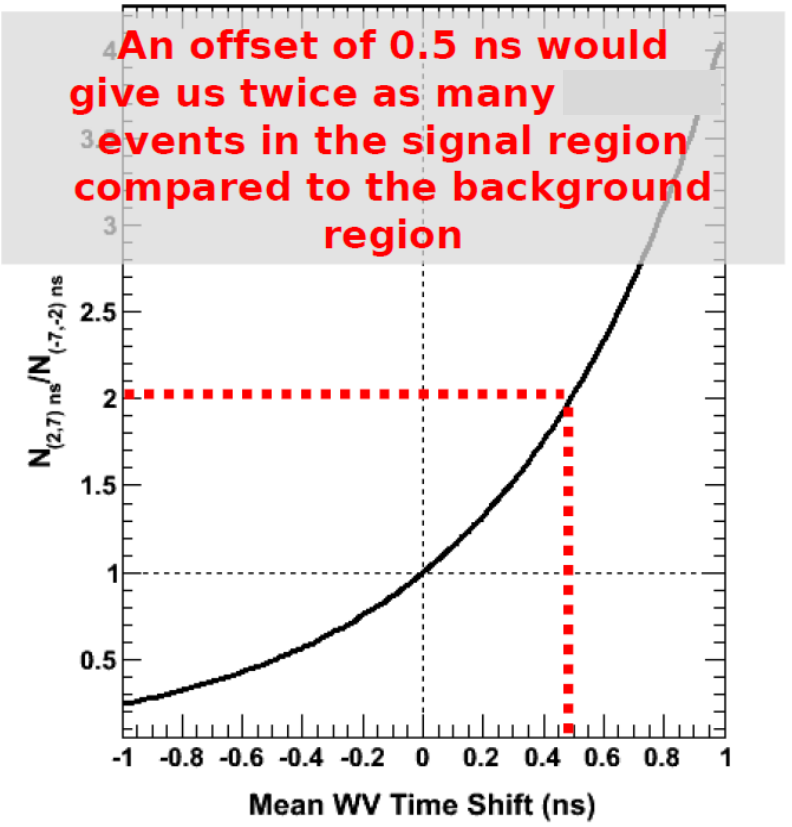
Why Understanding $W \rightarrow e\nu \rightarrow \gamma_{fake}$+MET is Important



Σ(Signal Region (2,7)) : 198 events (100 cosmics)

Σ(Control Region (−7,−2)) : 129 events (100 cosmics)

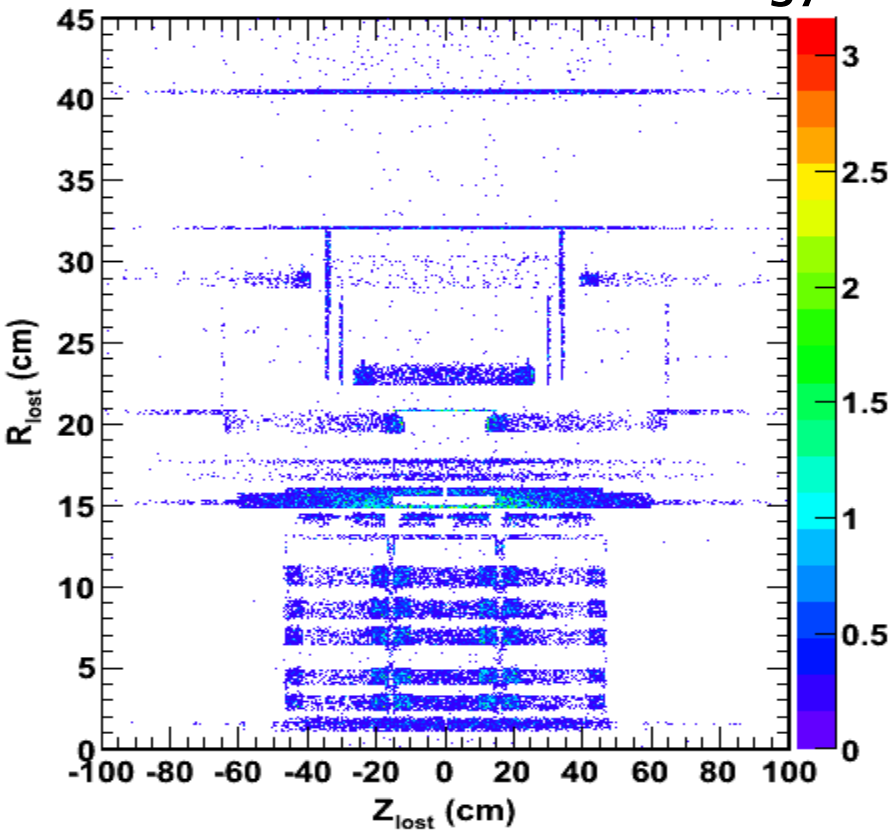
$$\frac{\#\ \text{of Events}^{(2,7\ \text{ns})}_{\text{Signal Region}}}{\#\ \text{of Events}^{(-7,-2\ \text{ns})}_{\text{Control Region}}}\ \text{vs Mean Time Shift}$$



Goal: Identify and Reject $e \rightarrow \gamma_{fake}$ Events

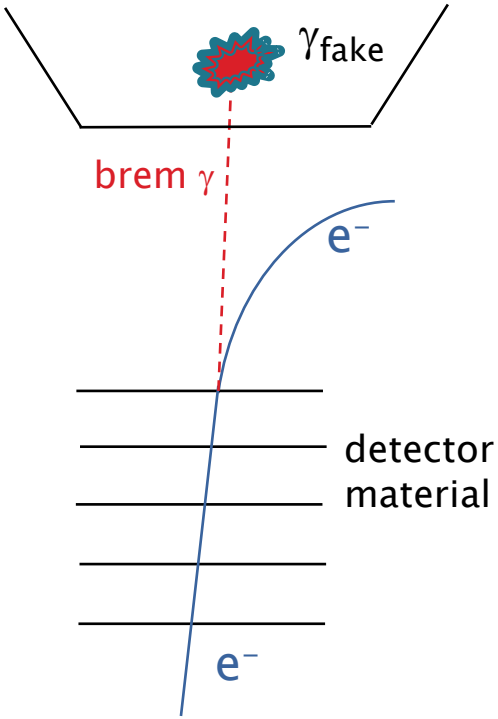
- Previous studies: Fakes not due to tracking failures, but interactions where a photon takes most of initial electron's energy.
- Phoenix tracking would be great, except 50% of $W \rightarrow e\nu \rightarrow \gamma_{fake}+\mathrm{MET}$ events do not produce a vertex.
  - NB: when electron *does* produce a vertex, detection efficiency is ~2/3 (CDF Note 8220).

"X-ray" plot of brem points where e^- lost ≥ ½ initial energy



Rejecting e → γ_{fake}: Method

- Look for any track topologically close to the identified photon candidate.
- Primary variable of interest: ΔR between photon candidate and track, but taking into account resolutions in $\Delta\eta$ and $\Delta\phi$.
- Select a cut and measure its power to reject fakes as well as its efficiency to accept $Z\gamma \rightarrow \nu\nu\gamma$ events.



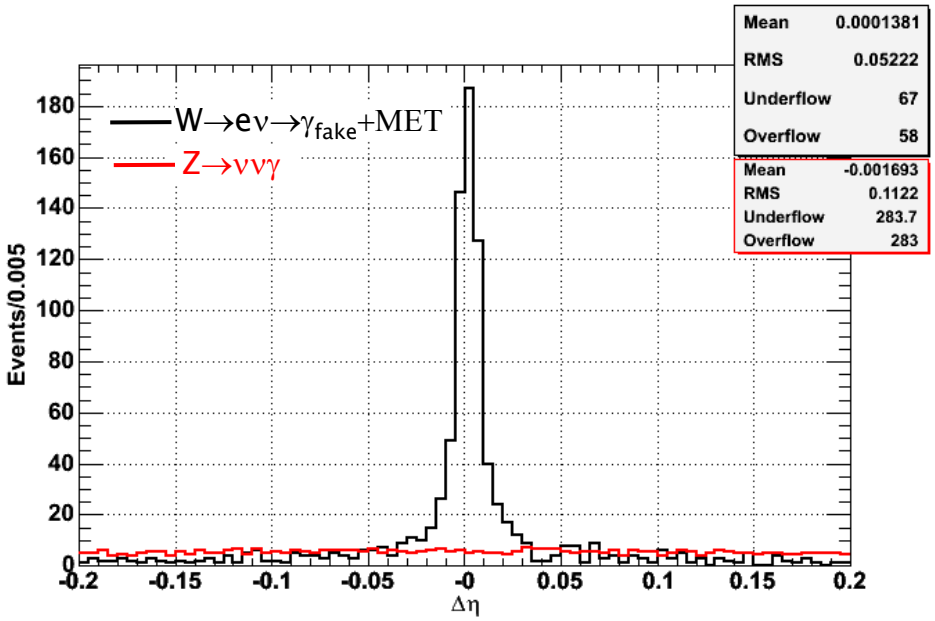
Notes on Fake Events

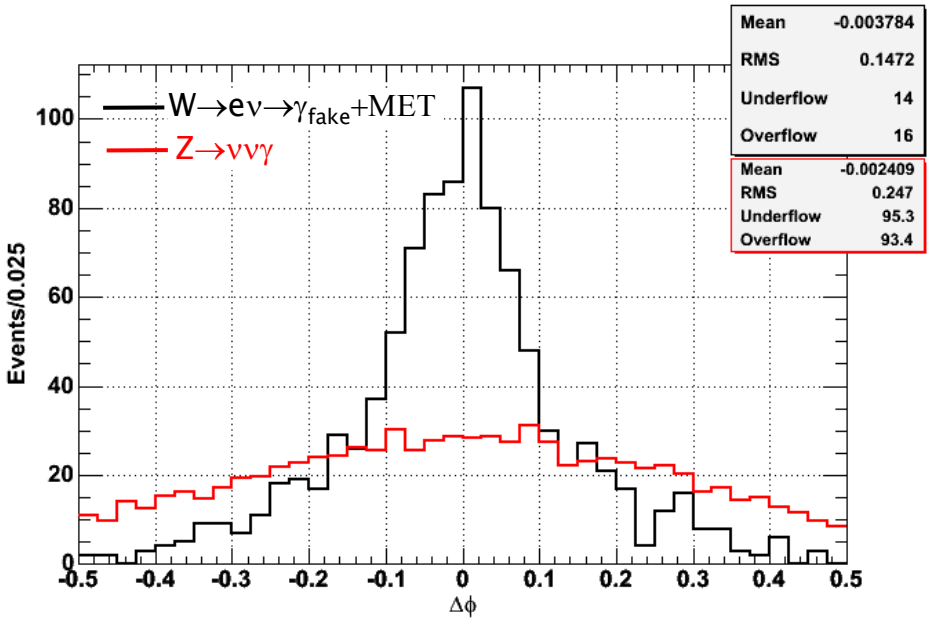
- Track will often exist.
- Likely to be a poorly measured track because tracking algorithm assumes a helical path.
- Resolution in ϕ is likely to be bad.
- Also, should be very efficient for real photons because we've already required the standard photon ID cuts which reject a track, and require track isolation.

MC Samples

- Generate **subsample of γ_{fakes}** from MC $W \rightarrow e\nu \rightarrow \gamma_{fake}+MET$
  - Passing exclusive γ+MET cuts
  - Require only generator-level electrons identified as photons
  - Sample of 1,000 events
- Use $Z\gamma \rightarrow \nu\nu\gamma$ events as **control sample** to model extra tracks in GMSB pair production $\chi_1^0 \rightarrow \gamma\tilde{G}$
  - Must pass the same offline γ+MET requirements
  - Sample of 10,000 events

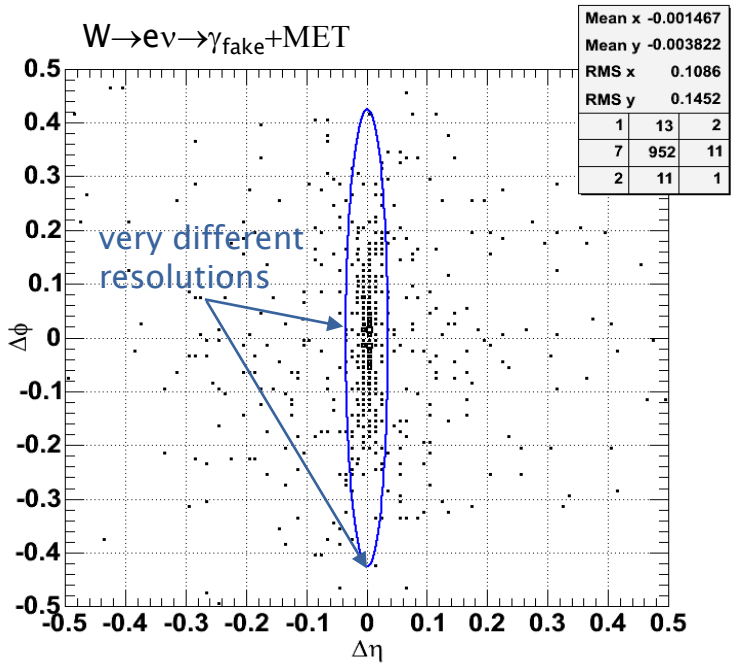
Photon Candidate-Closest Track Matching for MC events

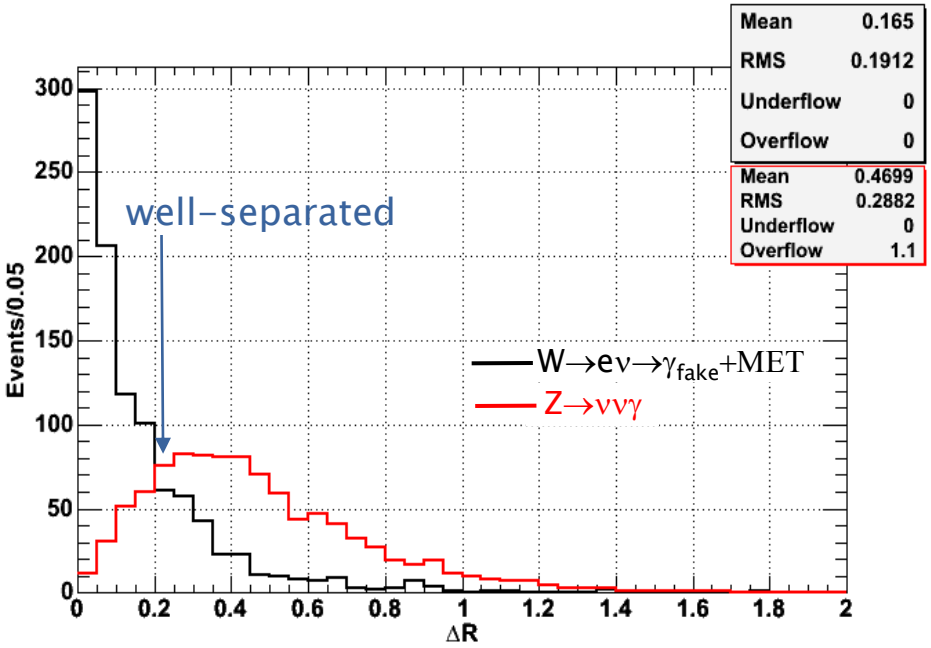




- For $W \rightarrow e\nu \rightarrow \gamma_{fake}$, photon candidates have tracks nearby, as expected.

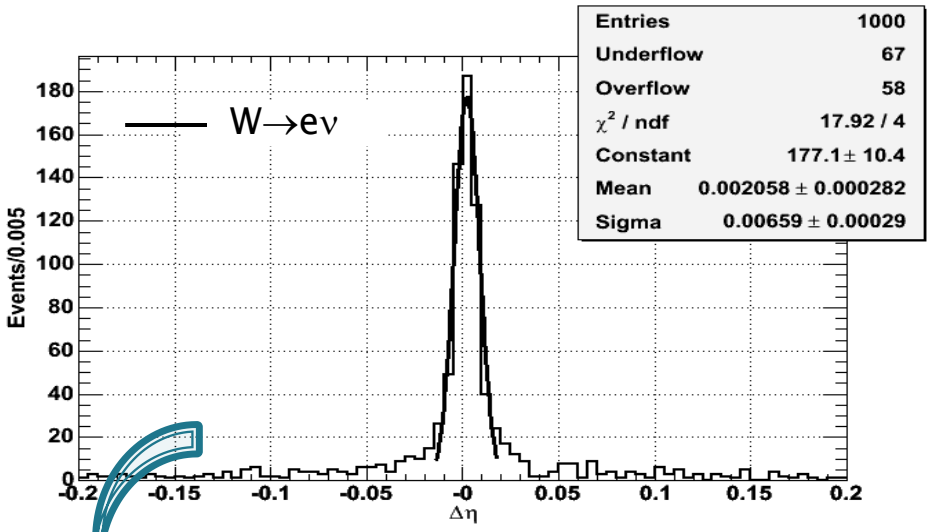
$\Delta\phi$ vs. $\Delta\eta$ and ΔR



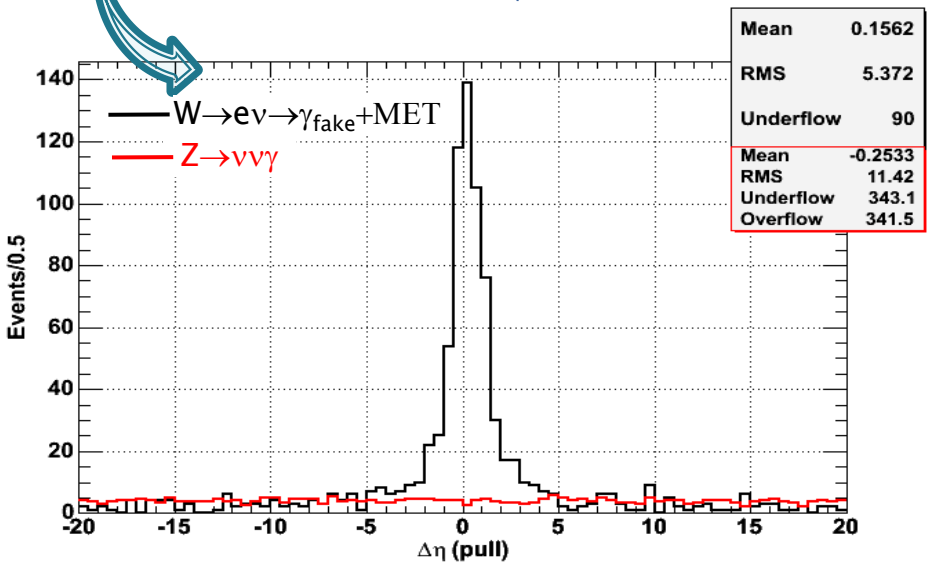


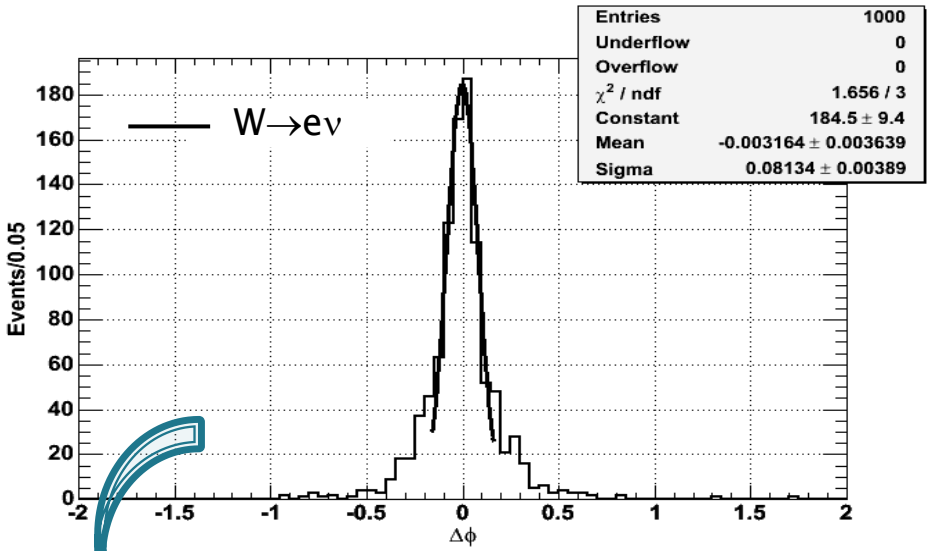
- ΔR already provides significant rejection.
- ϕ resolution worse, as expected
- Can do better by taking into account the difference in resolutions

Determining "Pull" Values

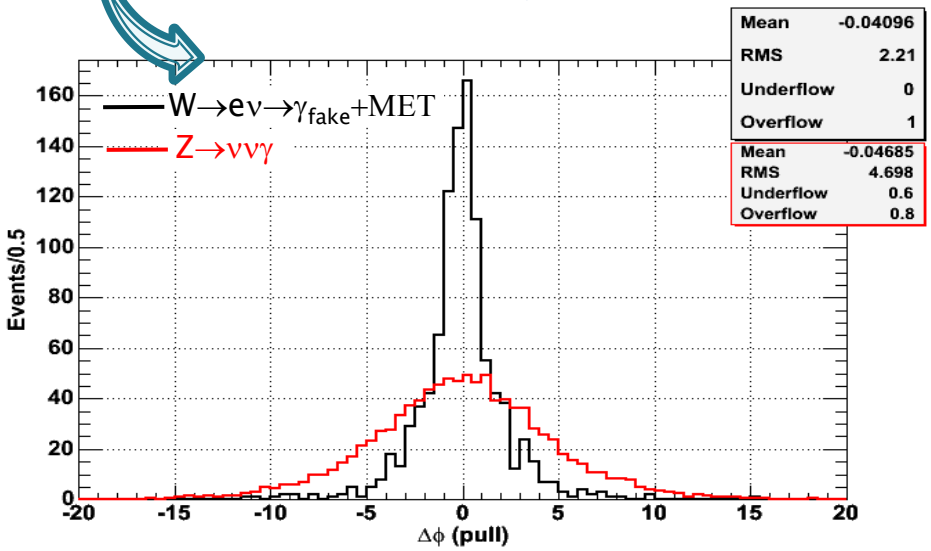


"pull" $\Delta\eta = \Delta\eta/\text{Sigma}_{\eta}$

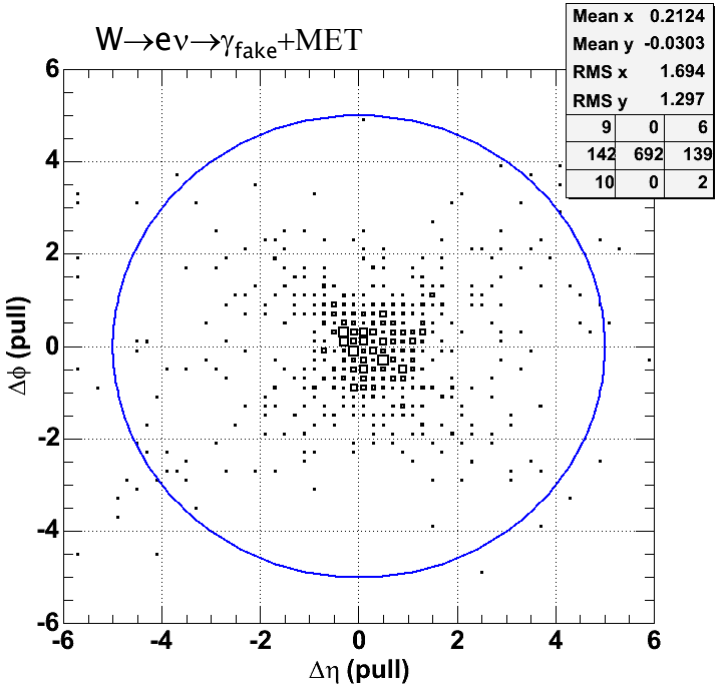


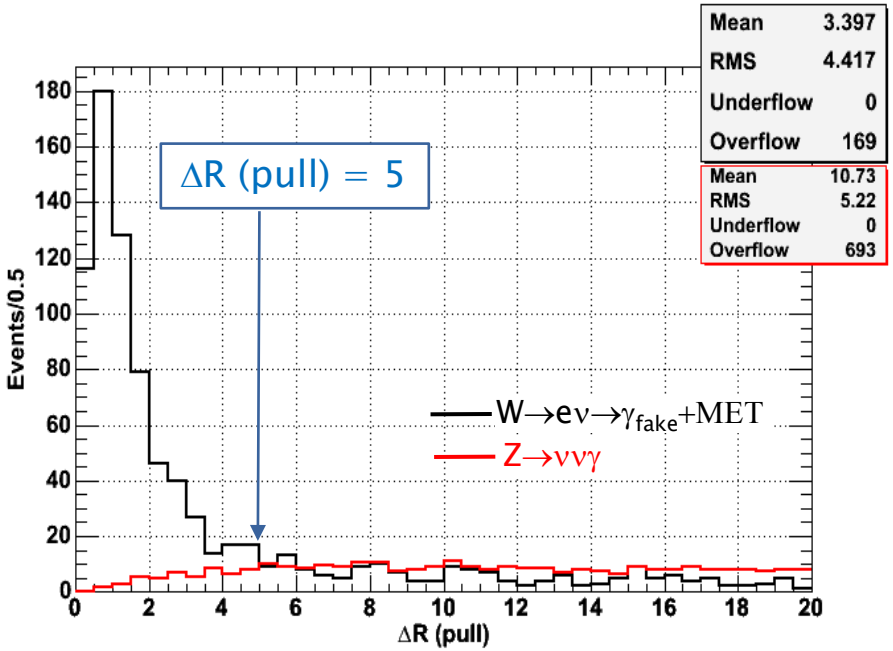


"pull" $\Delta\phi = \Delta\phi/\text{Sigma}_{\phi}$



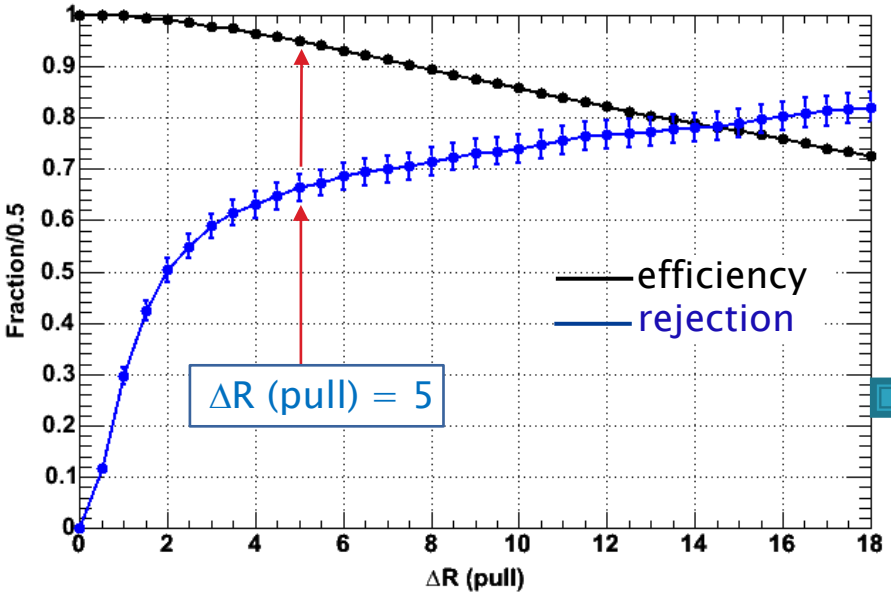
Δϕ (pull) vs. Δη (pull) and ΔR (pull)

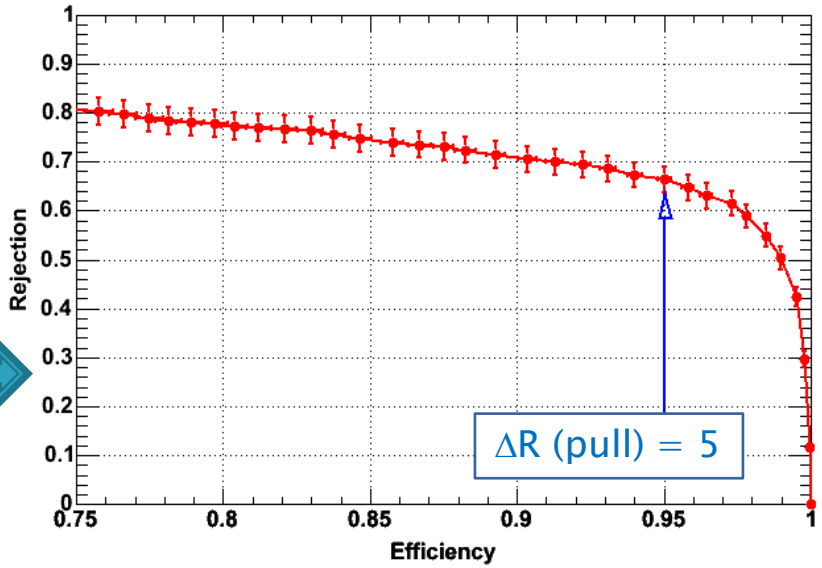




- Our mapping makes the distributions fairly symmetric and provides better rejection power than cutting on ΔR.

Efficiency and Rejection





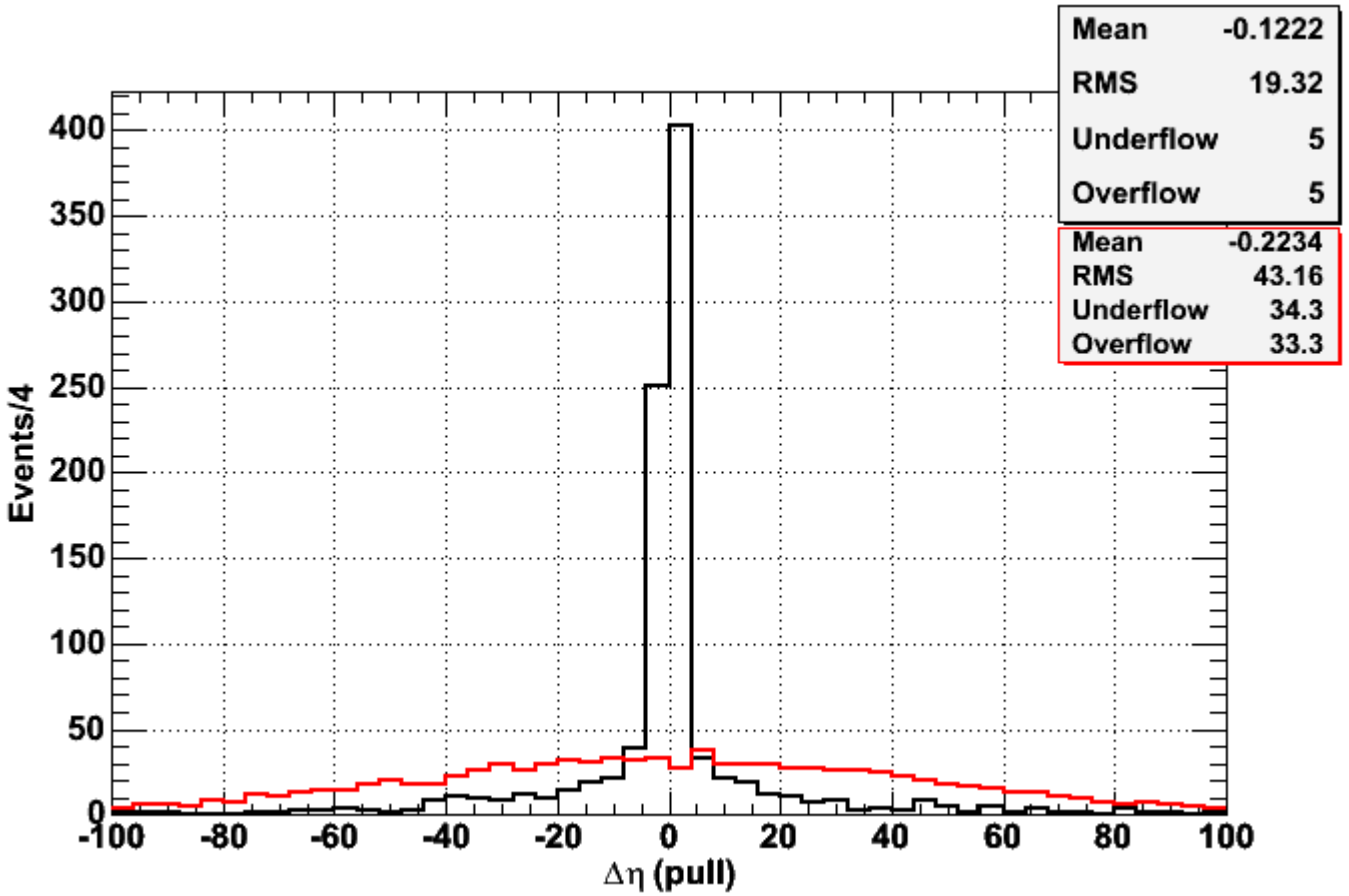
- By cutting at $\Delta R = 5$ we get rejection of about 2/3
  - Compares well with Phoenix expectations for rejection
- ~95% efficient

Conclusions and Outlook

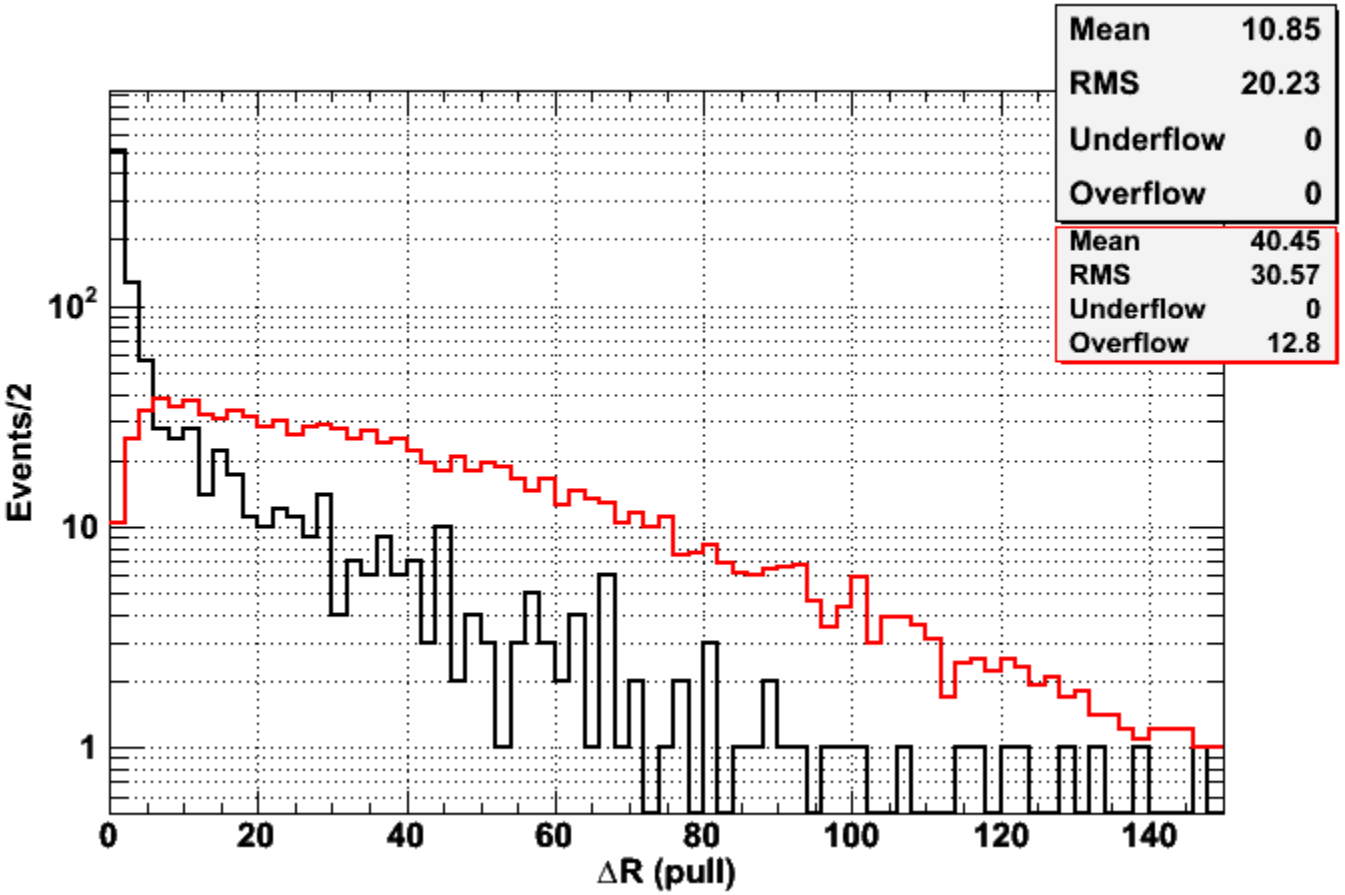
- Developed a vertex-independent method to reject e $\rightarrow \gamma_{fake}$ events
- Defined a new variable, ΔR "pull", that allows us to reject ~67% of e $\rightarrow \gamma_{fake}$ events, while retaining ~95% of real γ's.
- Next step: apply the cut to the Exclusive γ+MET data:
  - Does the excess in the signal region completely disappear?
  - Study the remaining e $\rightarrow \gamma_{fake}$ events.

Backup

Δη "pull" (blowup)

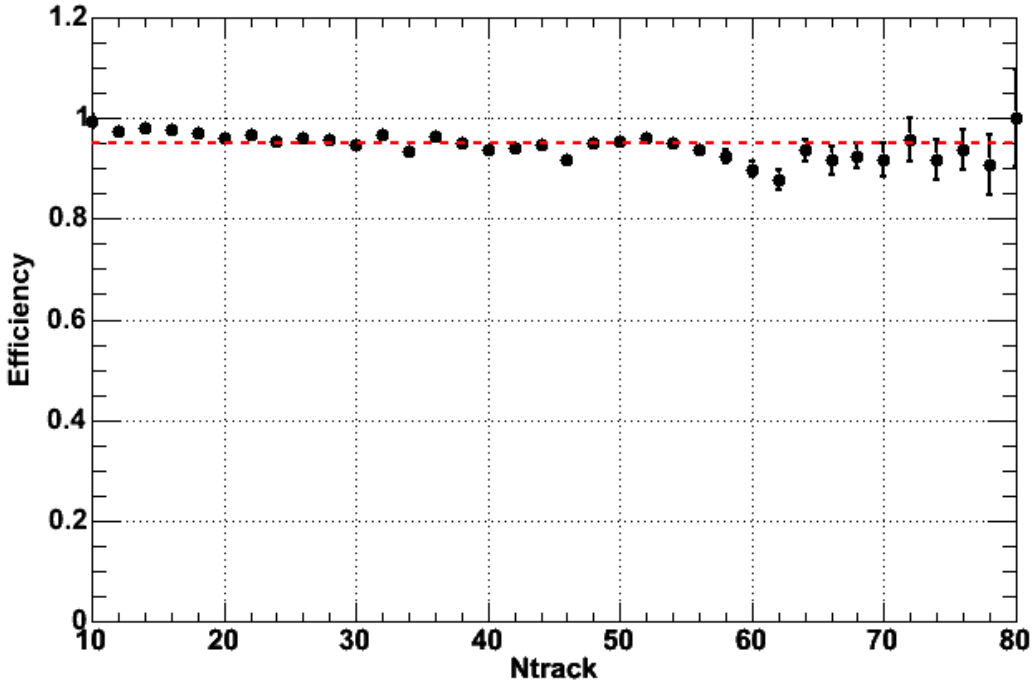


ΔR "pull" (blowup)



Efficiency vs. Number of Tracks

- Efficiency doesn't change much with higher track multiplicity. So the method may be used for other analyses with a Tight Photon requirement.



Background Studies for Exclusive γ+MeT

Backgrounds Scaled for 5 fb^{-1}	# of Photons	# of Events in the Signal Region *(2,7) ns*	# of Events in the Control Region *(-2,-7) ns*	SR-CR
$W \rightarrow e\nu$	693 ± 26	72 ± 8	25 ± 5	48 ± 10
γ inclusive	752 ± 27	21 ± 5	10 ± 3	11 ± 6
$W \rightarrow \mu\nu$	266 ± 16	14 ± 4	10 ± 3	4 ± 4
$W \rightarrow \tau\nu$	310 ± 18	15 ± 4	13 ± 4	2 ± 2
$Z\gamma$	409 ± 20	18 ± 4	17 ± 4	1 ± 0.4
Cosmics	140 ± 5	50 ± 2	50 ± 2	0 ± 2
Totals	**2570 ± 51**	**190± 14**	**124± 11**	**66± 18**
Previous Analysis Scaled to $5fb^{-1}$	N/A	**203**	**97**	**106**

$W \rightarrow e\nu \rightarrow \gamma_{fake}$+MET remains the dominant background and requires closer study to understand the source of the bias

No naïve scaling of Monte Carlo can account for the previously observed excess in data