Updates on electron to photon fakes

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Motivation

- As we've seen before we have a large background from $Z \rightarrow ee$ in the electron channel
- This background is dominated by electrons that fake photons
- Although we can use some kinematic cuts to remove a large portion of this background, the remaining events are non-negligible
- In addition, the MC estimate suffers from low statistics
- A fake factor method will improve statisics and provide a data-driven check of photon fakes

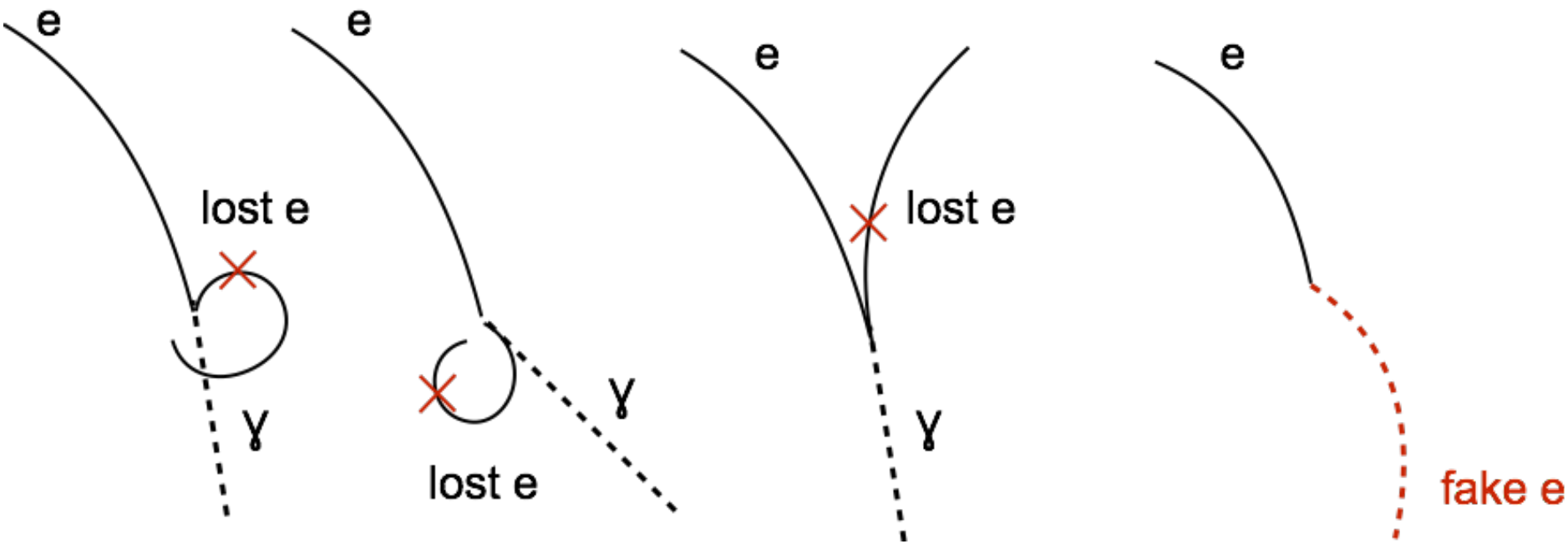
Composition of $Z \rightarrow ee$ background, $e + \gamma$ events

ISR + lepton boosted to low p_T

FSR, lepton falls bellow p_T cut

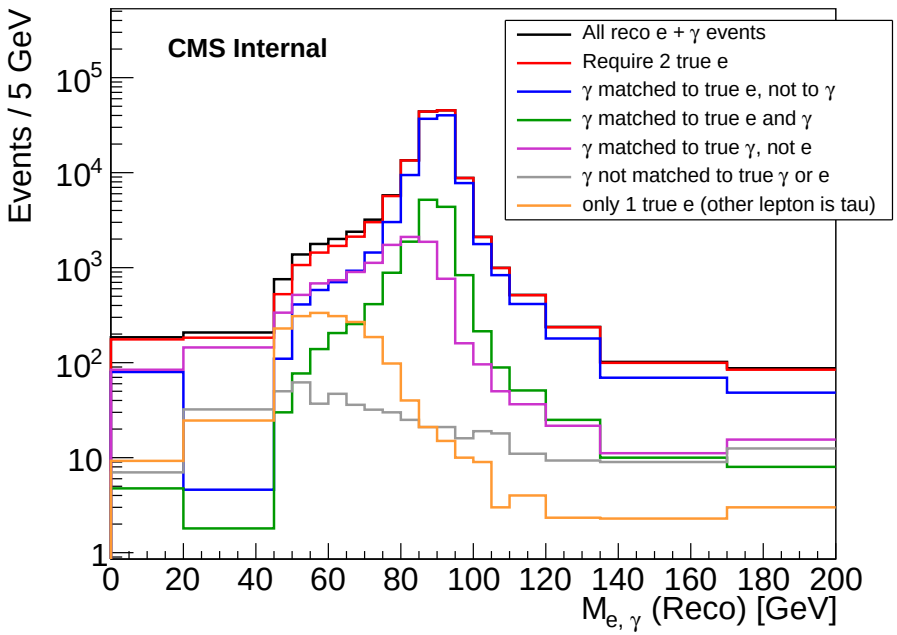
ISR, lepton lost (η, PID)

Electron fakes photon

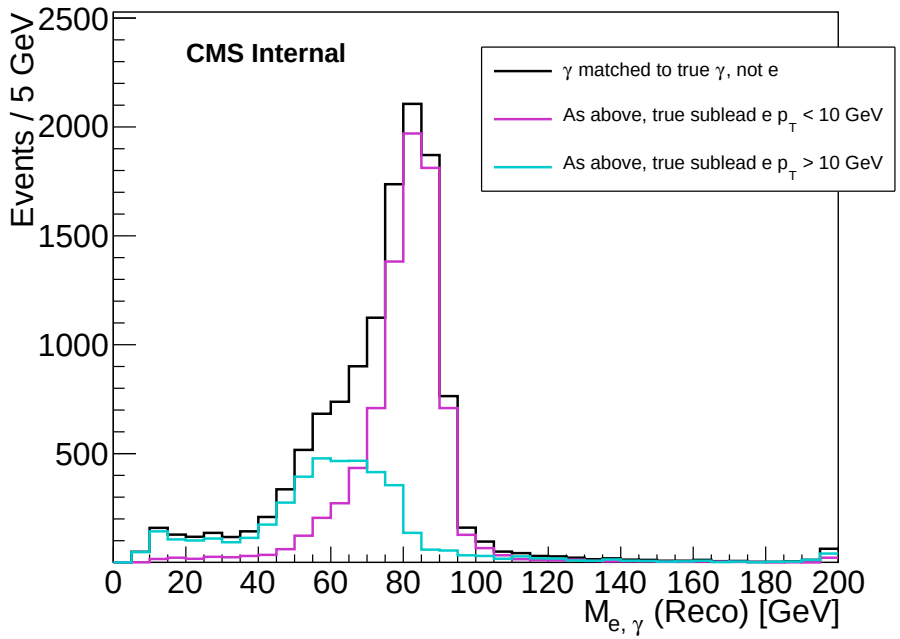


Composition of $Z \to ee$ background, $e + \gamma$ events

- Select events having 1 electron and 1 photon (reco)
- Split these events by their truth content



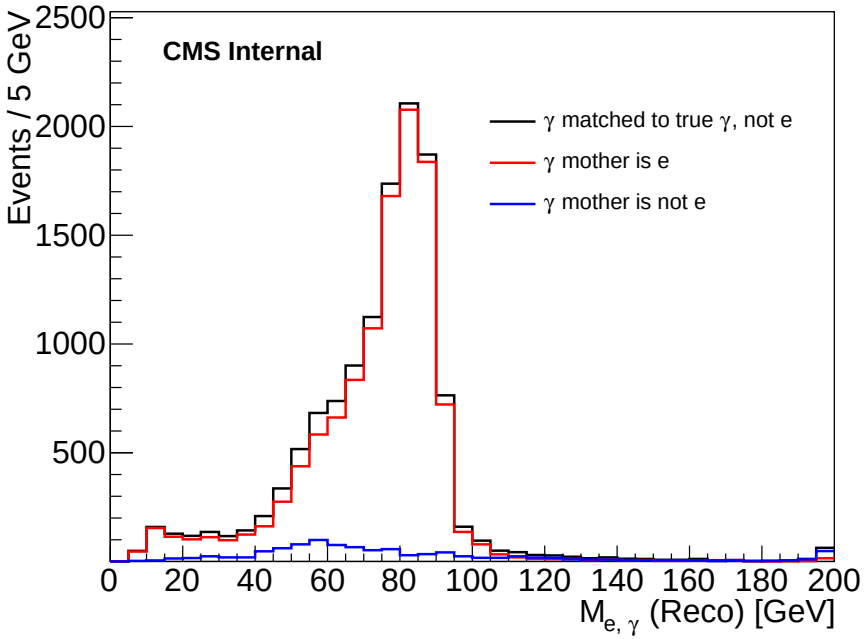
Photon matched to true photon, break down by p_T of subleading truth lepton



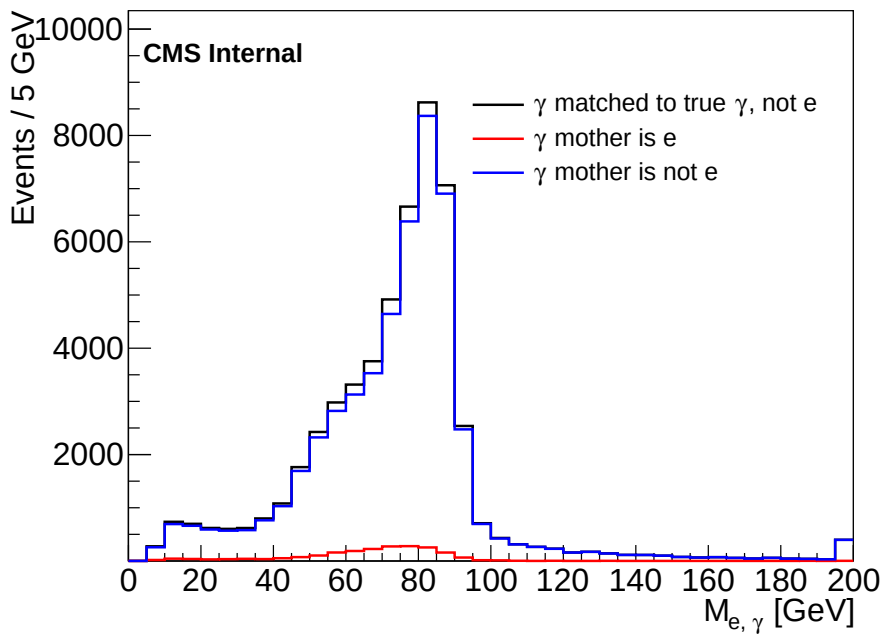
Composition of $Z \to ee$ background, $e + \gamma$ events

- Look at events as in the previous slide where the reco photon is matched to a true photon
- Split by the mother of the true photon

DYJetsToLL sample – most events are FSR



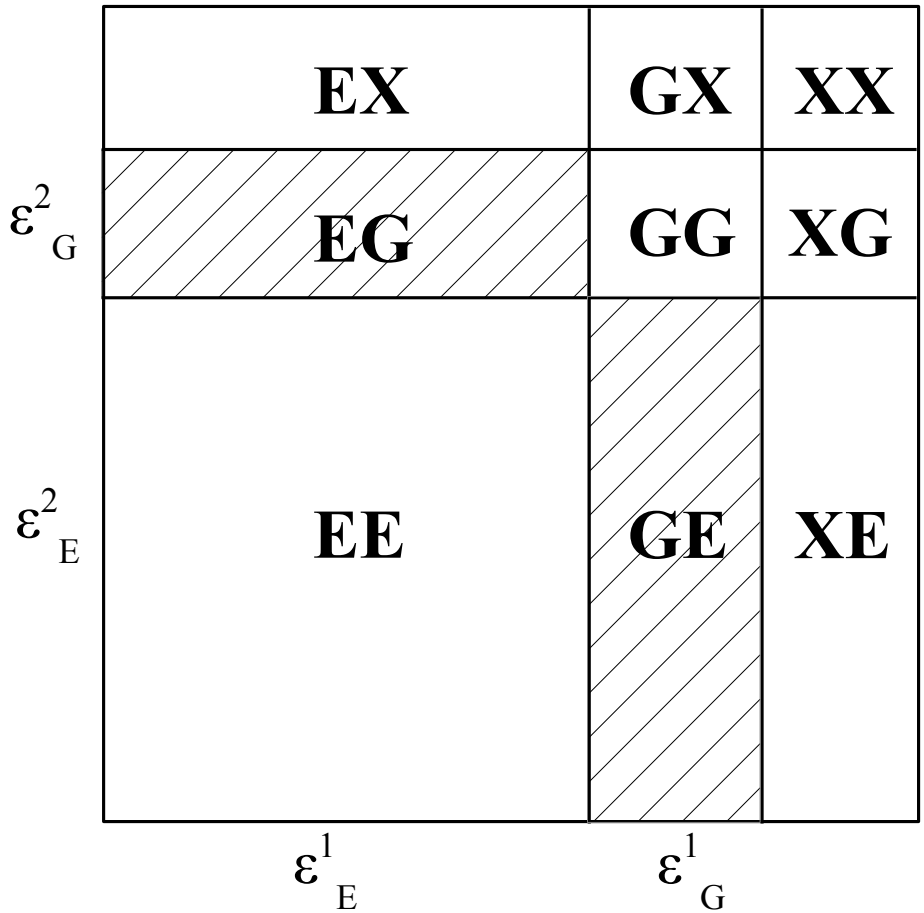
Zg sample – most events are ISR



Estimating $Z \rightarrow ee$ background

- Derive a relative fake factor using $Z \rightarrow ee$ events where the electron passes the nominal ID, or passes the photon ID (mutually exclusive)

  For all true $Z \rightarrow ee$ events the possible reonstructed states are



Probability to reconstruct a photon fake

- $\epsilon^i_{E,G}$ represents the rate to reconstruct an electron or photon (E, G) for true electron i
- ϵ may depend on kinematic variables (p_T, η, ...). Keep ϵ^1 and ϵ^2 separate for this reason

The number of electron plus photon events is given by,

$$N_{EG} = N_Z \left(\epsilon^1_E \epsilon^2_G + \epsilon^1_G \epsilon^2_E\right) \tag{1}$$

And the number of two electron events is,

$$N_{EE} = N_Z \epsilon^1_E \epsilon^2_E \tag{2}$$

Plug in to remove N_Z

$$\frac{N_{EG}}{N_{EE}} = \frac{\epsilon^1_G}{\epsilon^1_E} + \frac{\epsilon^2_G}{\epsilon^2_E} \tag{3}$$

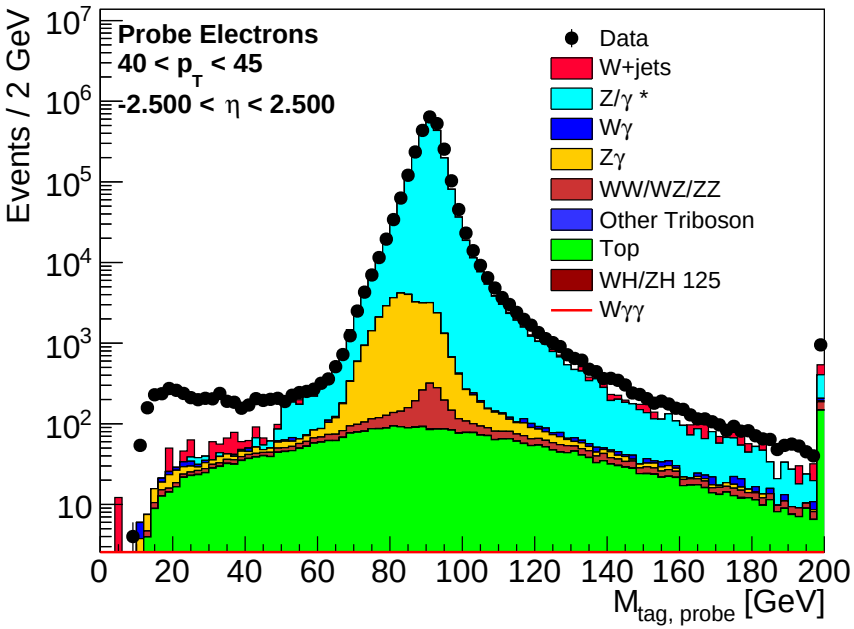
We therefore need N_{EE} and the ratio of the electron reconstruction efficiency to the photon reconstruction efficiency (fake factor)

Fake factor determination

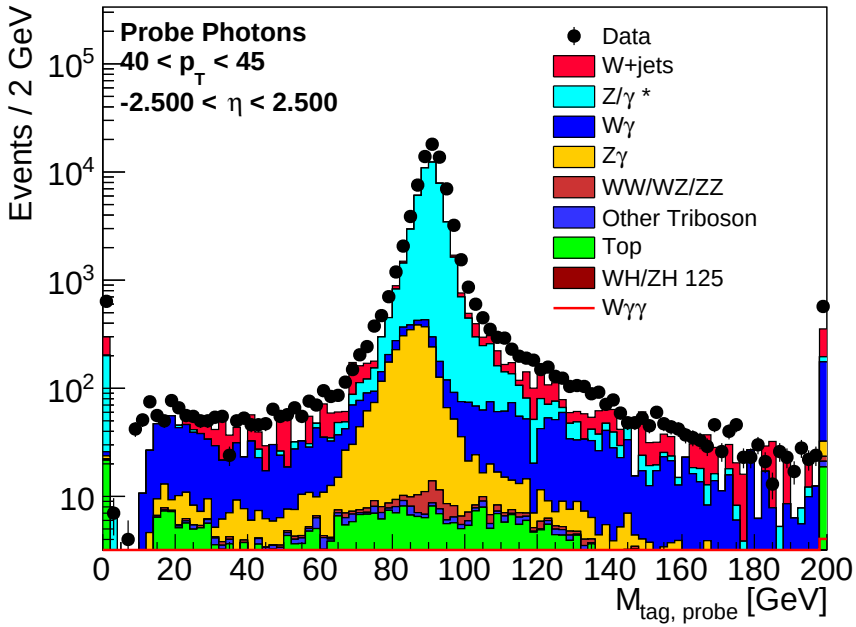
- Select events with at least one tag electron
  - $p_T > 30$ GeV, trigger matched, pass trigger MVA ID
- Probes are electrons passing the MVA ID or photons that pass the nominal loose ID
- In di-electron events both electrons are used if they both pass the tag selection
  - Electrons : $p_T > 15$ GeV, pass MVA ID
  - Photons : $p_T > 15$ GeV, pass loose ID
- Require the di-object mass to be within 5 GeV of the Z mass
- apply additional electron veto (MVA ID, $p_T > 10$ GeV)
- fake factor is the ratio of the number of probe photons to probe electrons (binned in p_T, η)

Example – mid p_T

Probe electrons



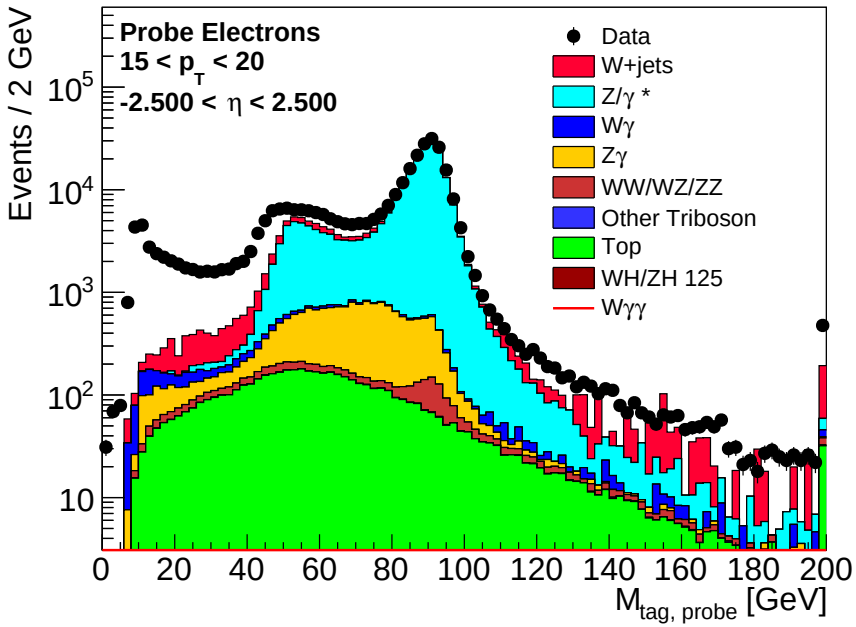
Probe photons



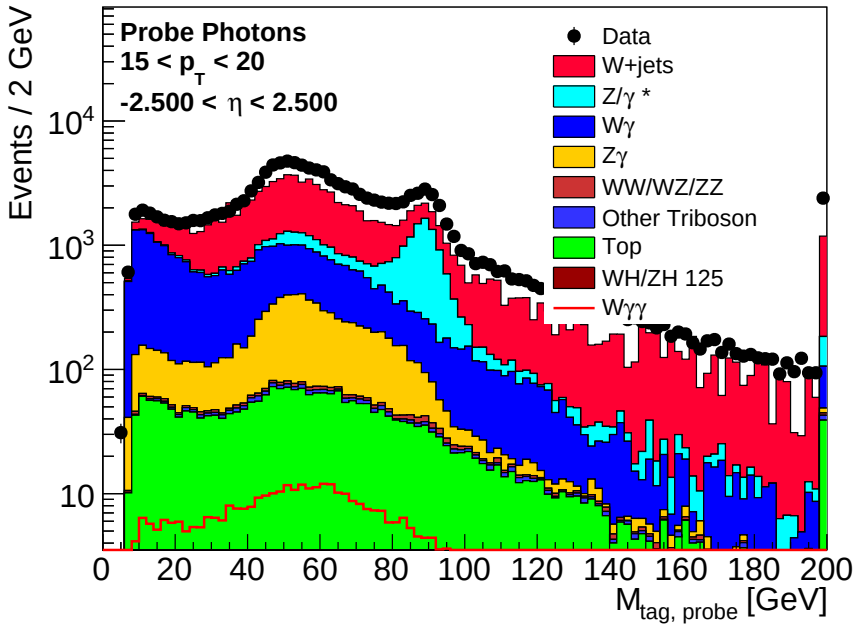
Example – low p_T

- W background is an issue in the electron + photon selecton at low pt
- MC subtraction may not be sufficient because statistics are poor in the W MC

Probe electrons



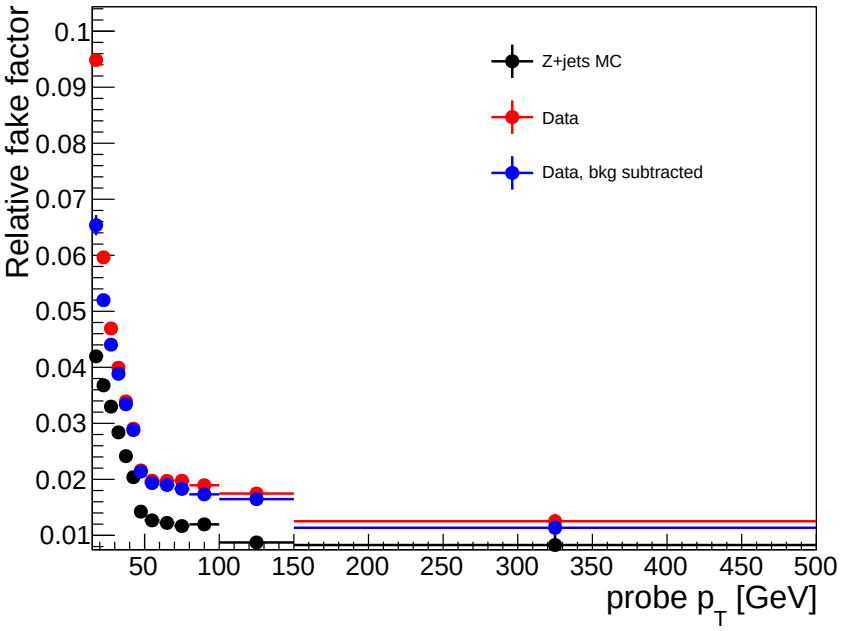
Probe photons



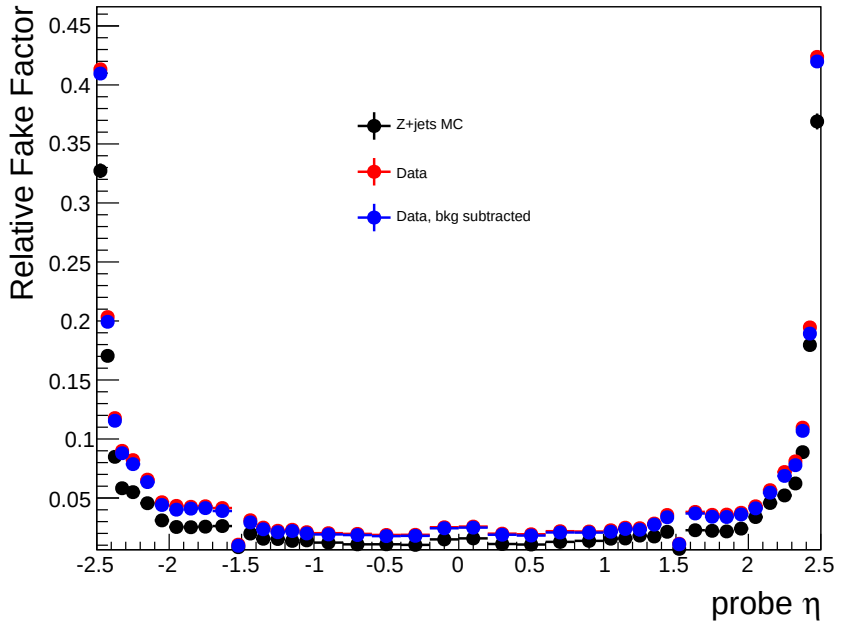
1D p_T, η results

Observe a large difference between simulation and data. Needs to be checked.

Fake factor vs p_T

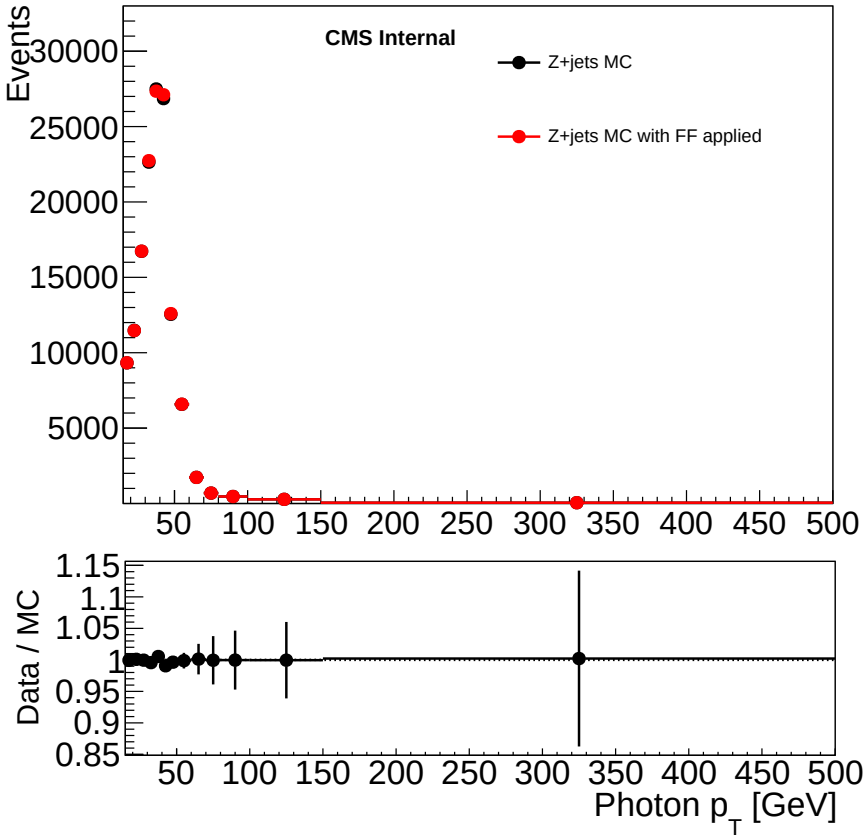


Fake factor vs η

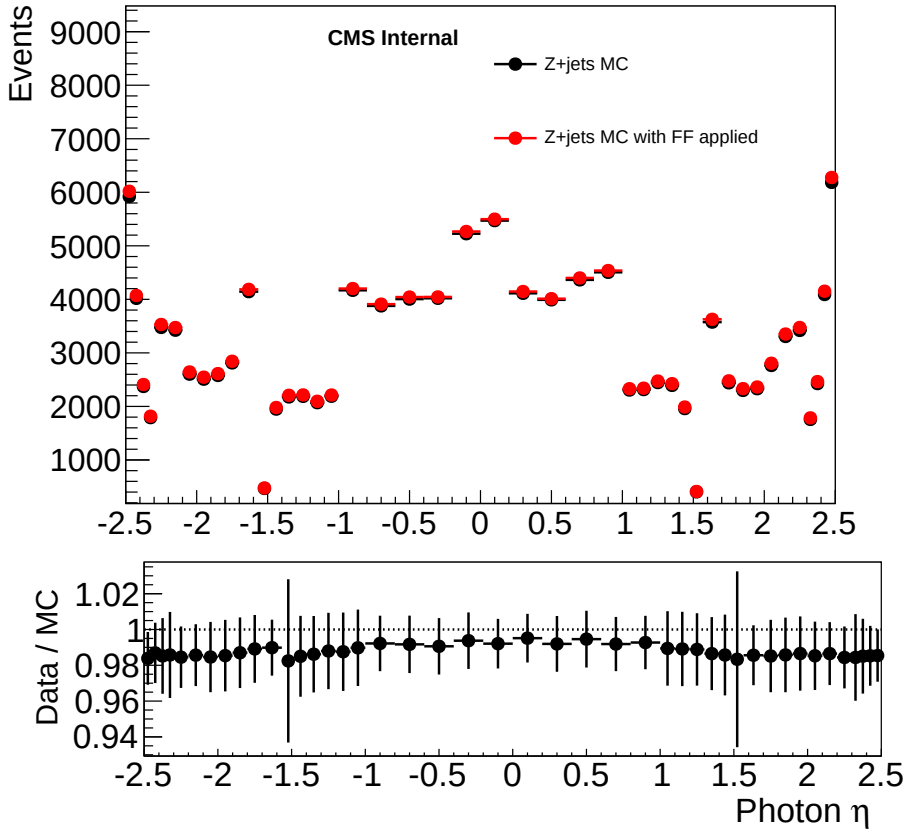


Sanity check

Comparison after applying p_T fake factor



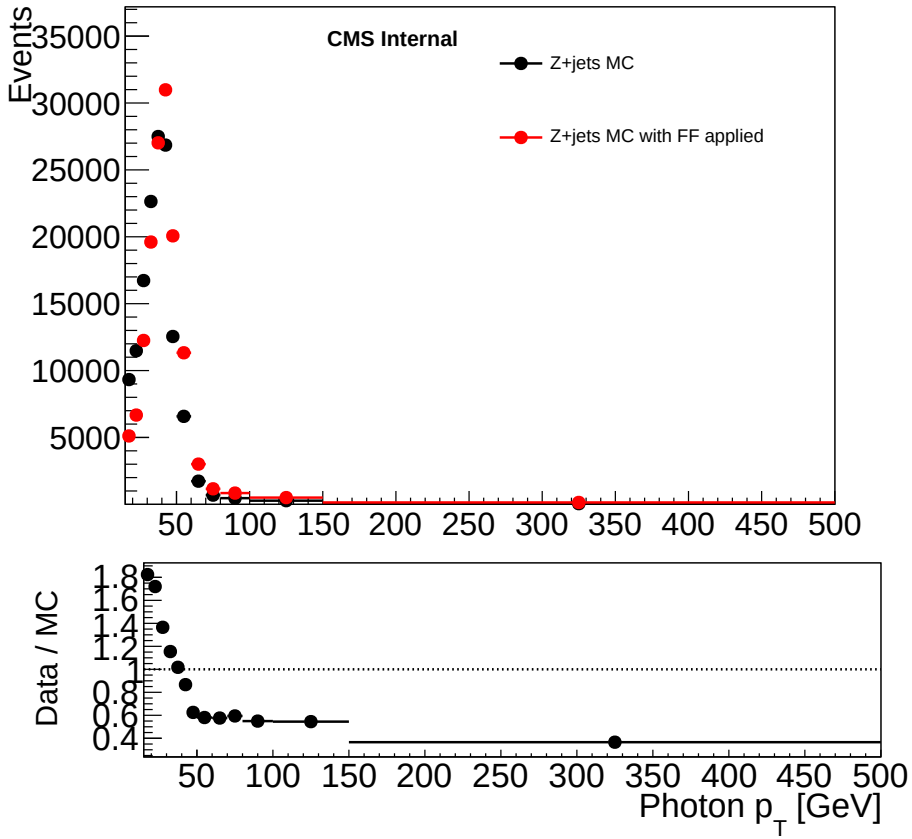
Comparison after applying η fake factor



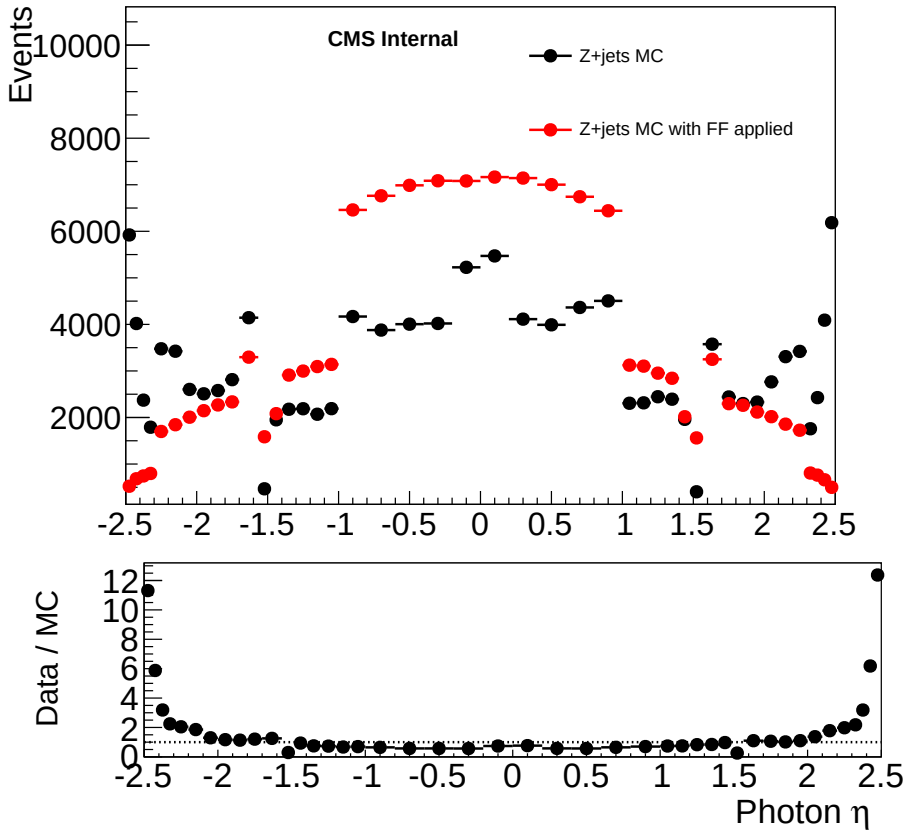
Is a 1D binning sufficient?

A 2D binning is prefered

Comparison after applying η fake factor

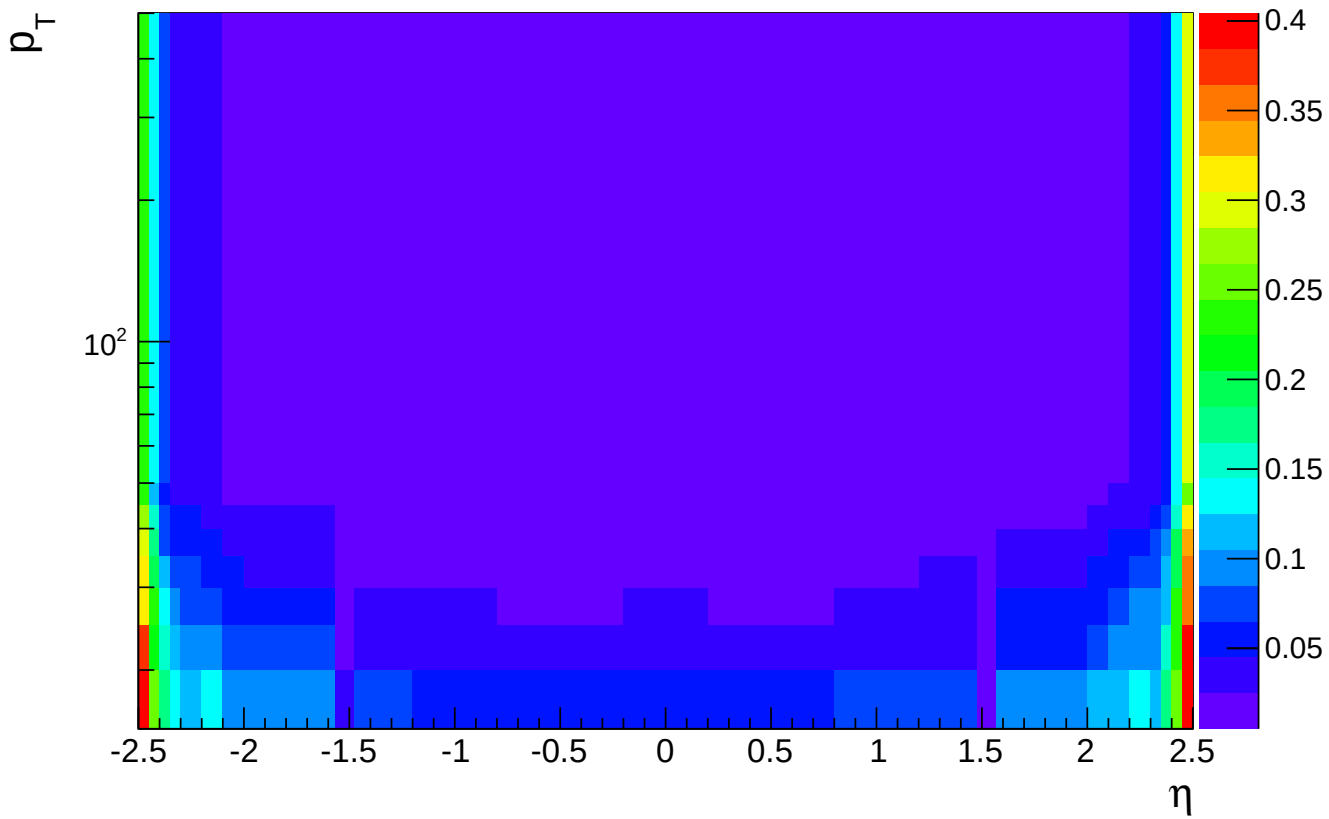


Comparison after applying p_T fake factor



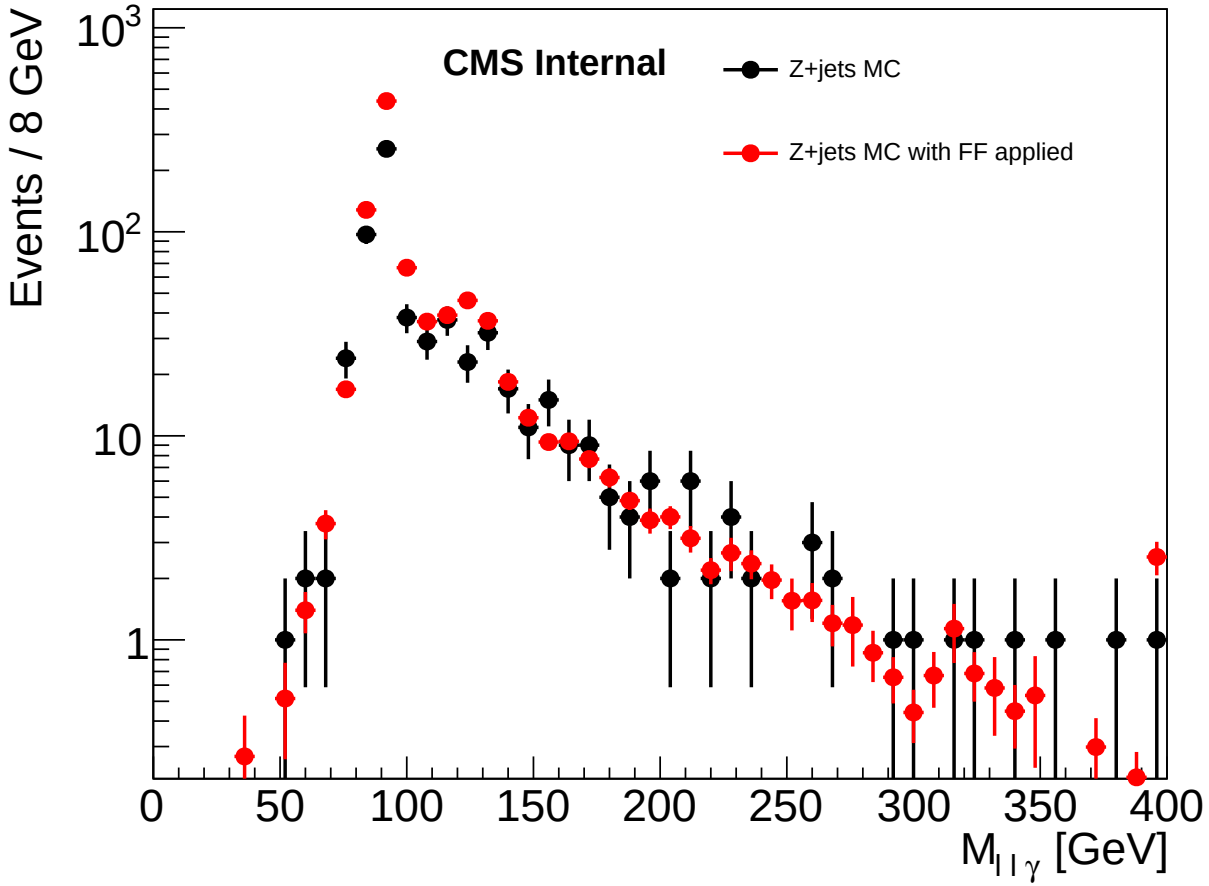
2D fake factor

Must widen the bins to have sufficient statistics



Test in 2 photon selection

- Compare $M_{l\gamma\gamma}$ between nominal MC and MC with FF applied
- Fairly good agreement is observed



Summary, To do

- Developed a basic method for determining the background from fake electrons
- Similar to other methods used, but does not rely on a looser photon denominator
- Next steps :
  - Apply method to data
  - A concern is the level of background in the electron+photon selection at low p_T
  - Plan to present at photon fakes working meeting

$$A_{W\gamma\gamma} = \frac{N_{MC}^{gen,fiducial}}{N_{MC}^{gen,total}}$$

$$C_{W\gamma\gamma} = \frac{N_{MC}^{reco}}{N_{MC}^{gen,fiducial}} \frac{\epsilon^{data}}{\epsilon^{MC}}$$