Search for Flavor Changing Neutral Currents in Top Quark Decays

Fake Rates and Initial Asimov Fits

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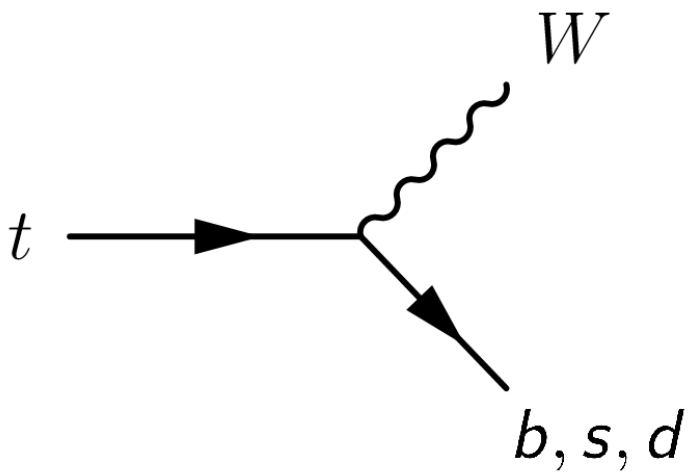
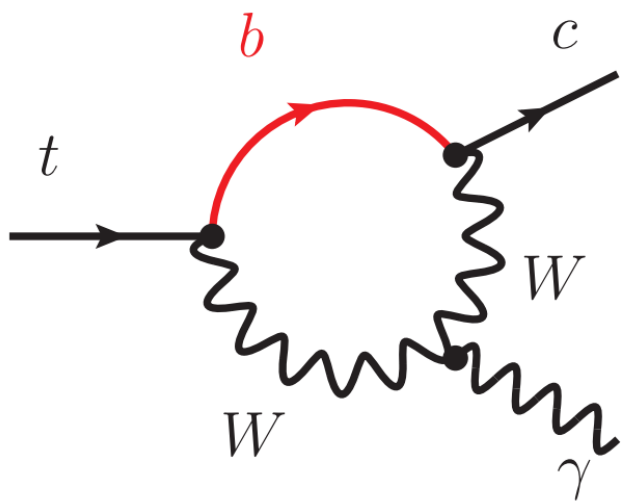
Overview

Top Quark Decays in the SM





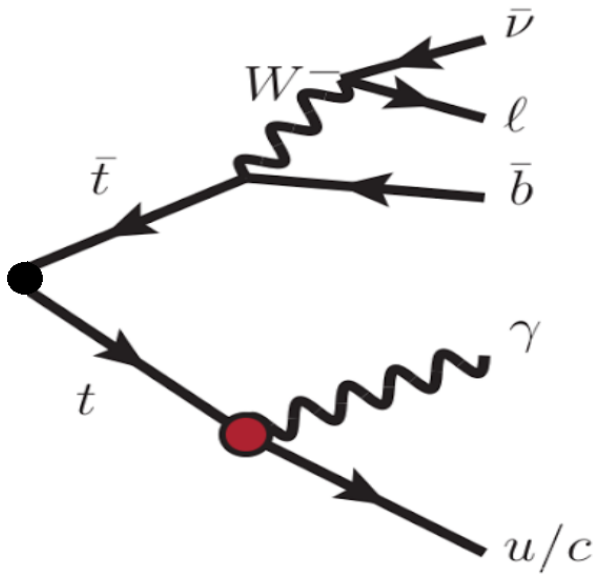
- $t \rightarrow bW \approx 99.83\%$
- $t \rightarrow sW \approx 0.16\%$
- $t \rightarrow dW \approx 0.01\%$

- $t \rightarrow q_{u,c}X \approx 10^{-17} - 10^{-12}$
- Limits on $t \rightarrow \gamma q$ processes: [Phys.Lett. B800 135082]
  - $t \rightarrow \gamma u < 2.8x10^{-5}$
  - $t \rightarrow \gamma c < 18x10^{-5}$

FCNC: What are we looking for? $t\bar{t} \rightarrow W(\rightarrow l\nu)b + q\gamma$

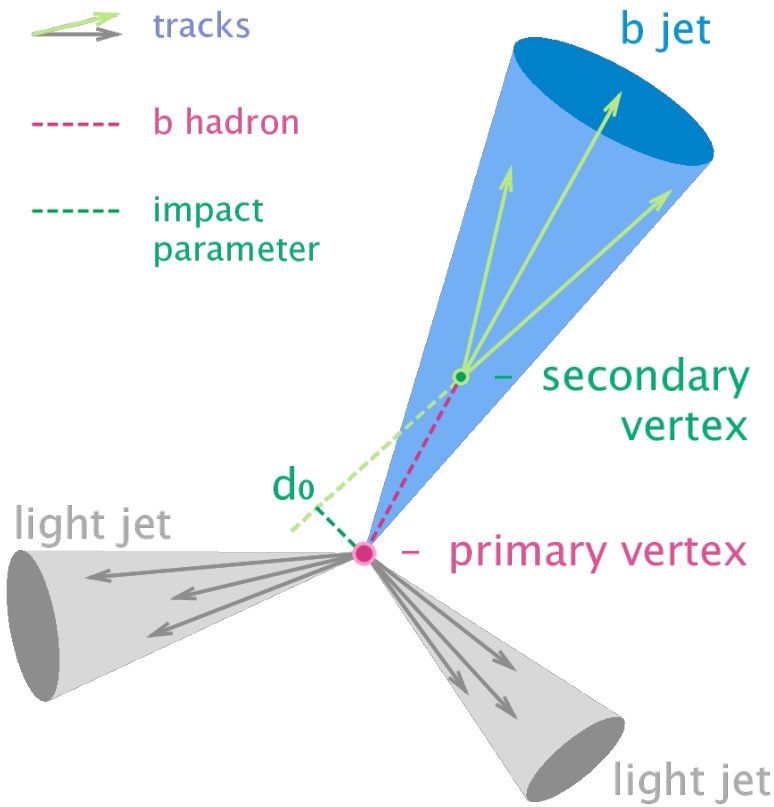
Will further investigate BJets here.

- Final state topology
  - One Neutrino, from W
  - One Lepton, from W
  - One B-jet, SM Top
  - One Photon, FCNC Top
  - One Jet, FCNC Top



B-tagging

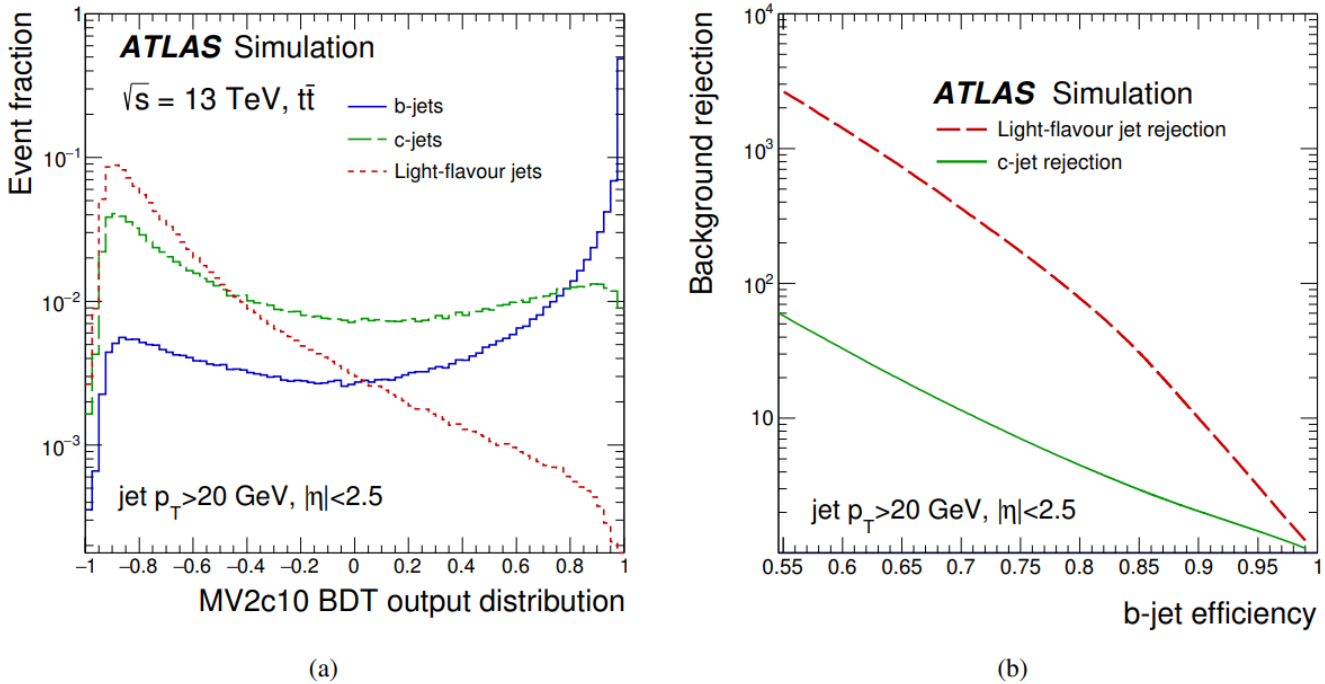
- B Hadrons travel a measureable distance before decay
- Tracks originate from outside of interaction point (Seconday Vertex)
- Backtracking tracks in displaced vertex gives an impact parameter
- Decay chain MVA attempts to reconstruct decay of the jet
- Outputs of these algorithms used in a BDT to determine if a Jet is from a b-quark



Mv2c10

MV2c10 is used to tag b-jets. The c10 implies a 10% c-jet fraction in the background training sample. Can use various fixed-cut working points for b-jet identification.

Using a different working point can change which jets are identified as originating from b-quarks in the analysis.



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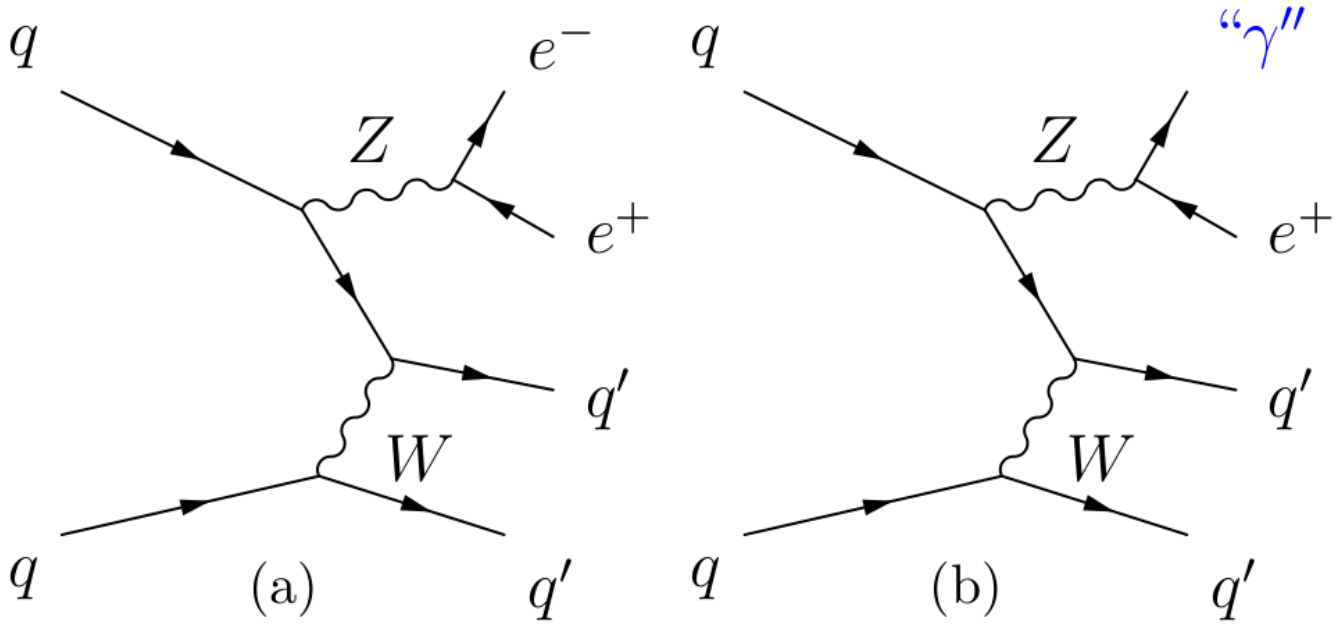
Neural Network Reminder

Branching ratio with Significance = 2: 1.18e-5

Fake Rate Studies



Want to be able to correct the number of fake photons predicted in MC to those present in Data

Fake Rate Object Selection

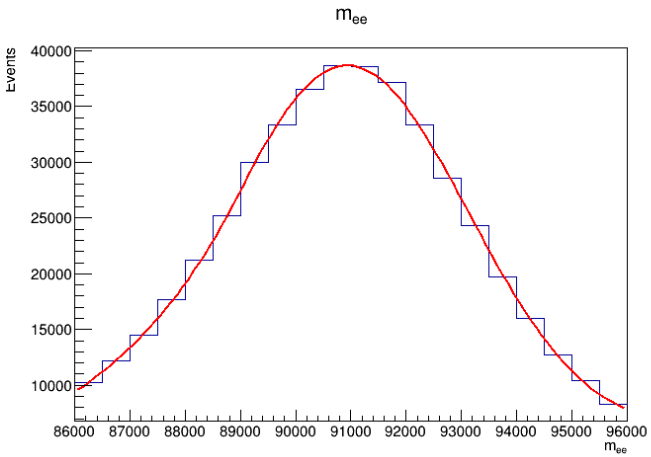
- Want to calculate fake rate in events which could enter the signal region.
- Create 2 control regions: $Z \rightarrow ee$ and $Z \rightarrow e\gamma$
- Require:
  - Common Object Selection (MET,Jets,Triggers, etc.)
  - Exactly 1Bjet
  - $Z \rightarrow ee$: 2 Opposite Sign Electrons, 86.1 GeV $< m_{e^+e^-} <$96.1 GeV
  - $Z \rightarrow e\gamma$:1 Electron, $\geq$1 Photon, 86.1 GeV $< m_{e\gamma} <$96.1 GeV
- Tag and Probe Method used
- Systematic determined by varying tail size and other parameters

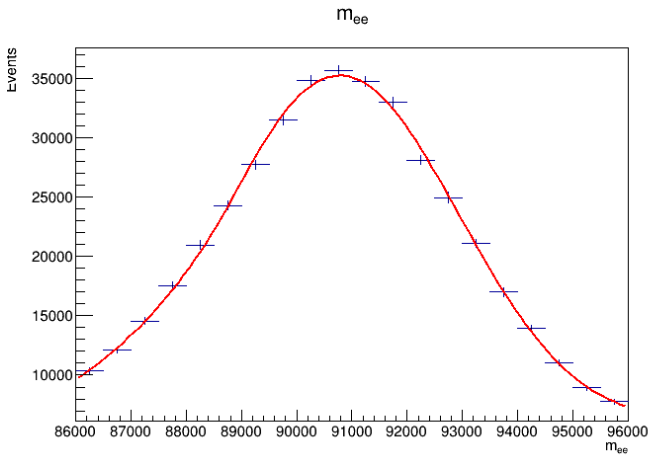
m_{ee}, $m_{e\gamma}$

Data and MC

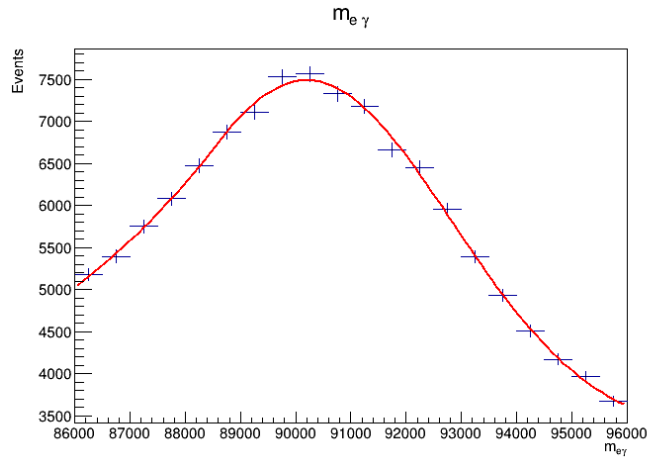
- Data
- Monte Carlo

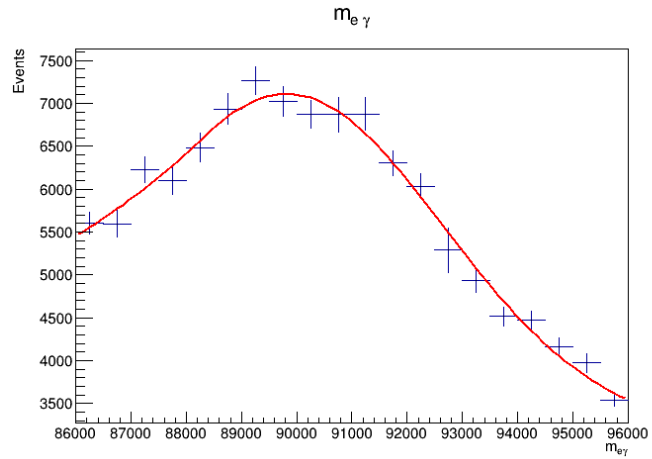
m_{ee}





$m_{e\gamma}$





Scale Factor

$$\mathrm{FR}^{\text{e-fake}} = \frac{N_{e,\gamma}}{N_{e,e}}$$

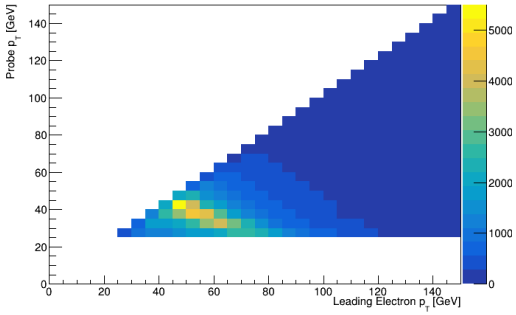
$$\mathrm{SF}_{\mathrm{FR}}^{\text{e-fake}} = \frac{\mathrm{FR}_{\mathrm{data}}^{\text{e-fake}}}{\mathrm{FR}_{\mathrm{MC}}^{\text{e-fake}}}$$

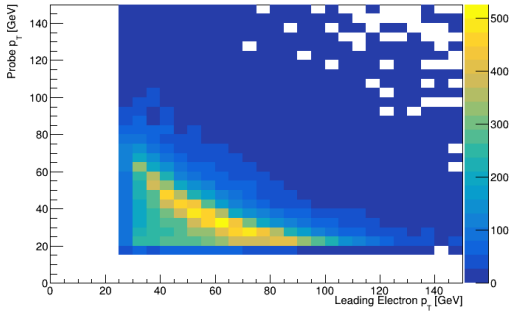
Basic Scale Factor can be calculated for the entire spectrum:
$\mathrm{SF}_{\mathrm{FR}}^{\text{e-fake}} = 0.97 \pm 0.01$
In practice this scale factor is calculated for converted and unconverted photons as well as in bins of η and ϕ

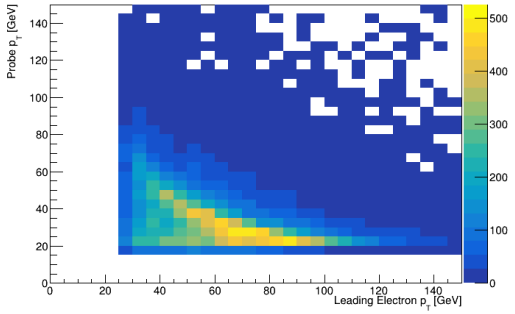
Data and MC Distributions

- Probe e
- Converted γ
- Unconverted γ

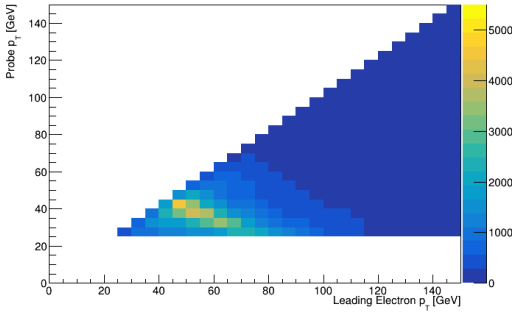
Data

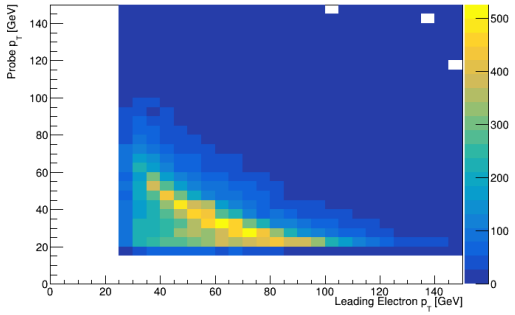


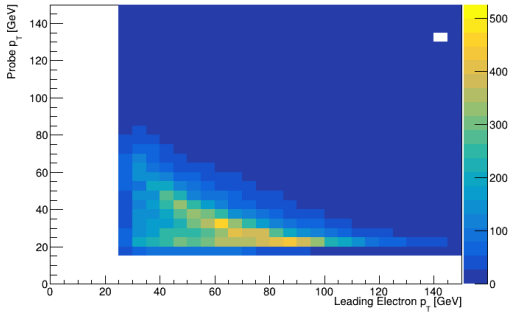




MC

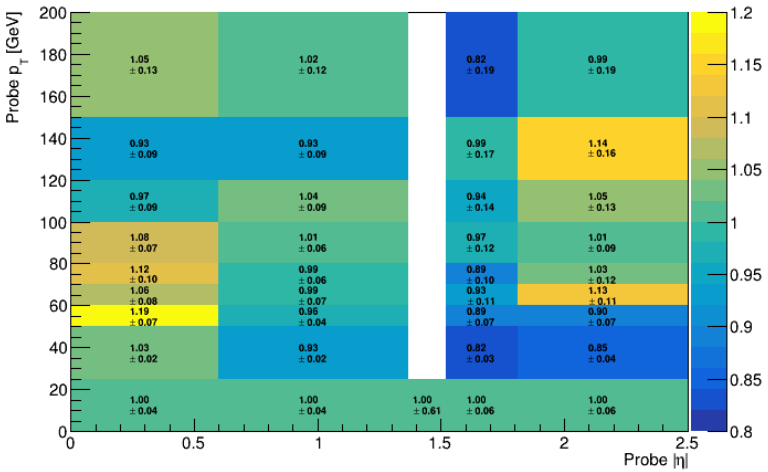




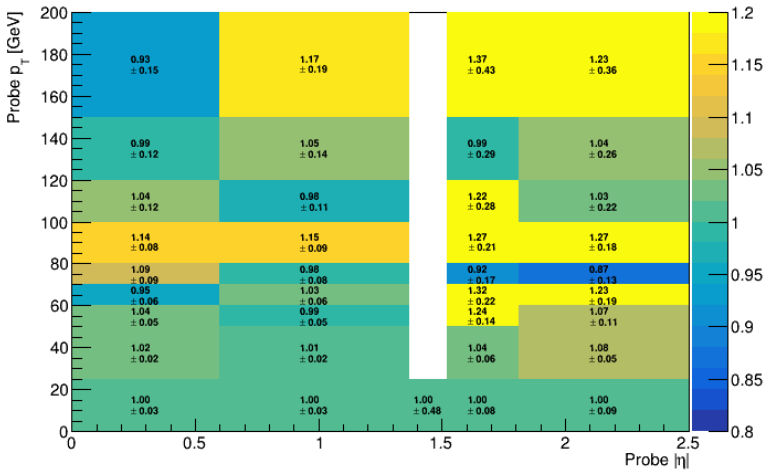


2D Fake Rates

- Converted γ

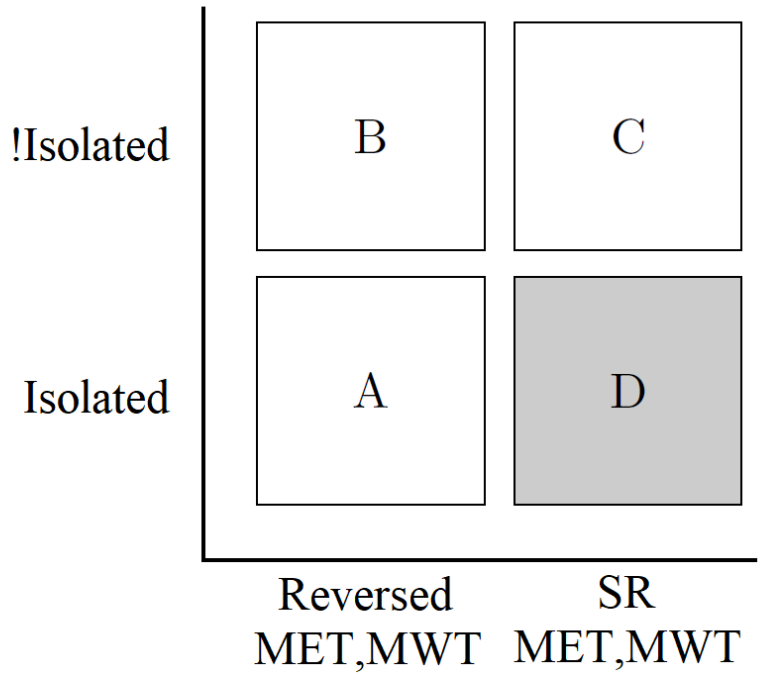


- Unconverted γ



Fake Rate Studies

Majority of hadronic fake photons from from $t\bar{t}$ events where a final state jet radiates a non-prompt photon. Similarly radiated photons for W+jets and single top processes can enter the signal region through the radiation of a non-prompt photon.

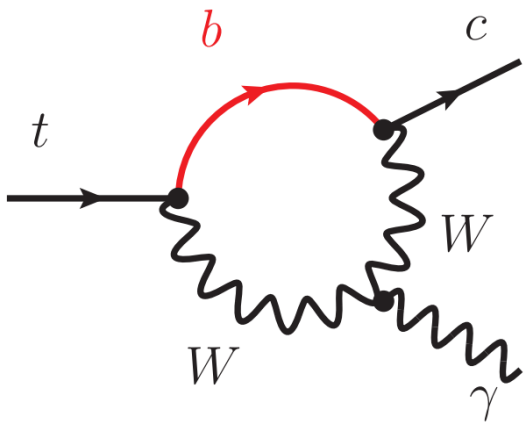


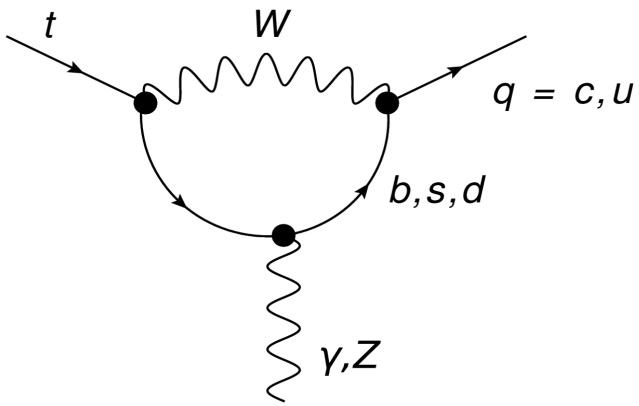
Outlook

- As always, still lots to be done
- Fake Rate: $e \rightarrow \gamma$ has been investigated, further systematic investigations will continue
- Fake Rate: $j \rightarrow \gamma$ to be investigated soon
- Was able to squeak an extra factor of 2 out of Neural Network since I had to redo it for working points anyway
- Questions?

Backup

FCNC Diagrams





Jets/AntiKT

$$d_{ij} = min(\frac{1}{p_{ti}^2}, \frac{1}{p_{tj}^2})\frac{\Delta_{ij}^2}{R^2}$$

$$d_{iB} = \frac{1}{p_{ti}^2}$$

$$\Delta_{ij}^2 = (\eta_i - \eta_j)^2 + (\phi_i - \phi_j)^2$$

- Find minimum of entire set of $\{d_{ij}, d_{iB}\}$
- If d_{ij} is the minimum particles i,j are combined into one particle and removed from the list of particles
- If d_{iB} is the minimum i is labelled as a final jet and removed from the list of particles
- Repeat until all particles are part of a jet with distance between jet axes Δ_{ij} is greater than R

$$\mathcal{L}^{eff}_{tq\gamma} = -e\bar{c}\frac{i\sigma^{\mu\nu}q_\nu}{m_t}(\lambda^L_{ct}P_L + \lambda^R_{ct}P_R)tA_\mu + H.c.$$