Search for Flavor Changing Neutral Currents in Top Quark Decays

B-Tagging Working Point and $e \rightarrow \gamma$ Fakes

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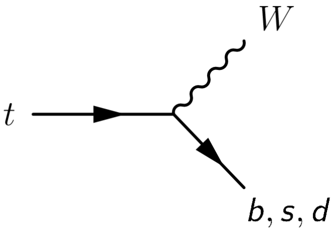
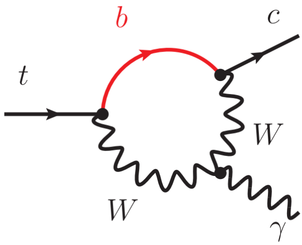
Overview

Top Quark Decays in the SM



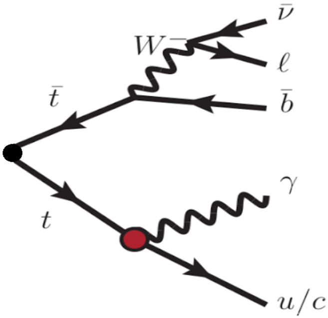


- $t \to bW \approx 99.83\%$
- $t \to sW \approx 0.16\%$
- $t \to dW \approx 0.01\%$

- $t \to q_{u,c}X \approx 10^{-17} - 10^{-12}$
- Limits on $t \to \gamma q$ processes: [JHEP 04 (2016) 035]
  - $t \to \gamma u < 1.3x10^{-4}$
  - $t \to \gamma c < 1.7x10^{-3}$

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

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

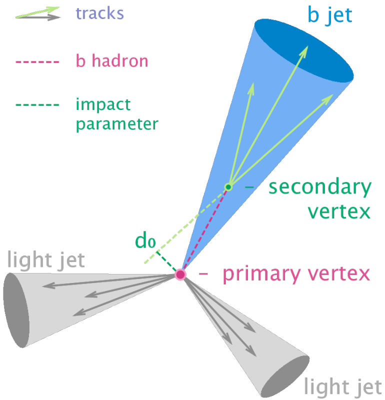


Object Preselection

- We preselect events with objects that look like similar to our expected topology
- Require:
  - Exactly one lepton (e or μ) $\geq$ 25 GeV
  - Exactly one good photon $\geq$ 15GeV
  - Missing Transverse Energy $\geq$ 30GeV
  - $\geq$ 1 Jets
- Further exploration of the BJets will be discussed

B-tagging

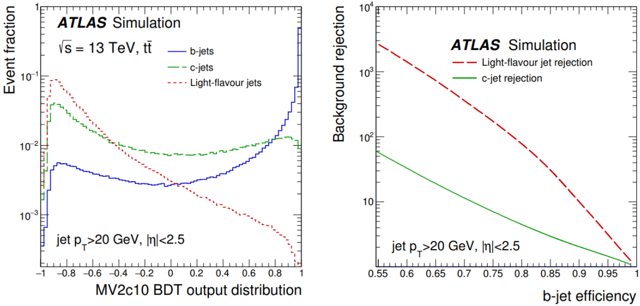
- B Hadrons travel a measureable distance before decay
- Tracks originate from outside of interaction point (Seconday Vertex)
- Backtracking tracks in displaced vertex gives an impact parameter
- Decay chain MVA attempts to reconstruct decay of the jet
- Outputs of these algorithms used in a BDT to determine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



(a) (b)

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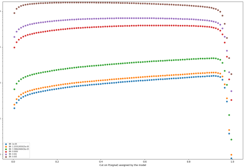
Neural Network Results

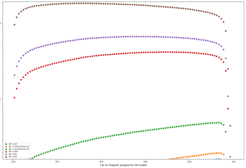
Electron Channel

- 70% Working Point



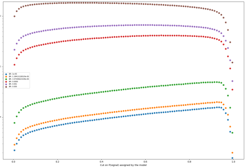
BR with Sig=2: 1.25×10^{-5}

- 77% Working Point



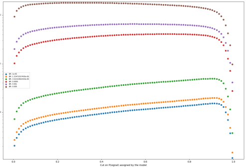
BR with Sig=2: 1.23×10^{-5}

- 85% Working Point

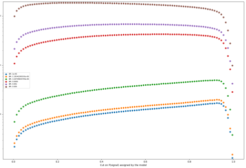


BR with Sig=2: 1.28×10^{-5}

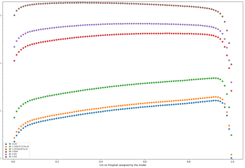
Muon Channel



BR with Sig=2: 1.31×10^{-5}



BR with Sig=2: 1.18×10^{-5}

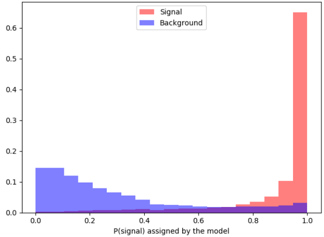


BR with Sig=2: 1.19×10^{-5}

Neural Network Separation

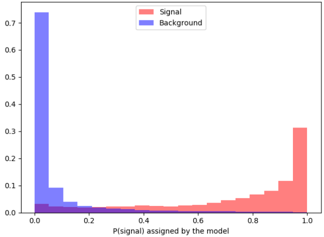
- MCee integral small range: 424,051.
- DATAee integral small range: 468,832
- MCeg integral small range: 110822
- DATAeg integral small range: 118198

Electron Channel

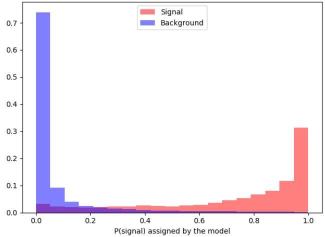


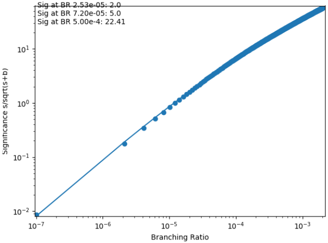
Channel

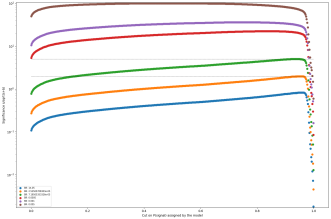
- Current

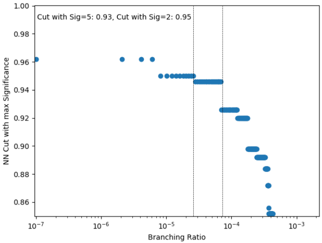


Significance Plots, Muon Channel









Branching ratio with Significance = 2: 2.5e-5

New Ntuple Production

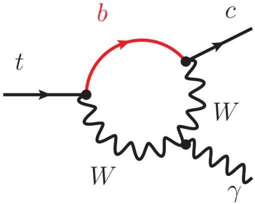
- New tools have been recently developed in the Top Group (Ref:VGammaORTool, Duplicate Event Removal,etc.)
- Replacing Custom Event Saver with that of tt+gamma group, more support and faster integration of new tools
- Custom post-grid local processing code developing
- Will transition with the currently running ntuples to local mini-ntuple creation
- Beginning to work with TRExFitter to push toward the statistical part of the analysis

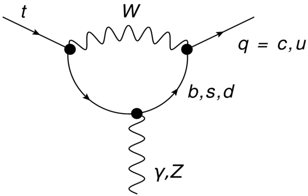
Outlook

- As always, still lots to be done
- Fake Rates $e \to \gamma$ and $j \to \gamma$ are being investigated, $e \to \gamma$ shown here, $j \to \gamma$ to be investigated soon.
- Happy with the state of the neural network studies, any further reduction would require significant time for insignificant gain, factor 2 improvement thanks to feedback I got during this meeting
- Questions?

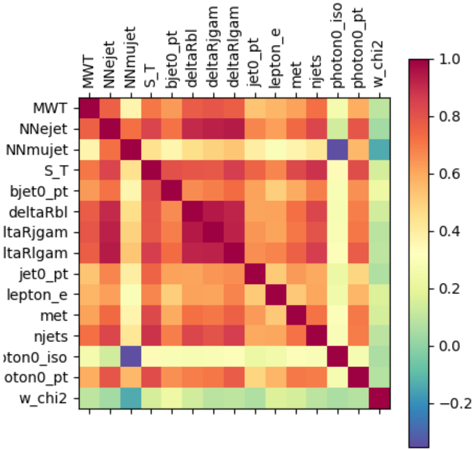
Backup

FCNC Diagrams





NN Input Variable Correlations



Neural Network Model Inputs

$$\text{Separation} = \sum_i^{bins} \frac{n_{si} - n_{bi}}{n_{si} + n_{bi}}$$

mu+jets channel

Variable	Separation
photon0iso	41.18
mqgam	28.27
photon0pt	24.07
mtSM	11.60
mlgam	7.56
deltaRjgam	5.64
deltaRbl	4.42
MWT	3.34
ST	3.30
nuchi2	3.12
jet0pt	2.81
njets	2.07
smchi2	1.89
wchi2	1.87
jet0e	1.52
deltaRlgam	1.17
leptone	0.87
deltaRjb	0.86
met	0.68
bjet0pt	0.52
leptoniso	0.27

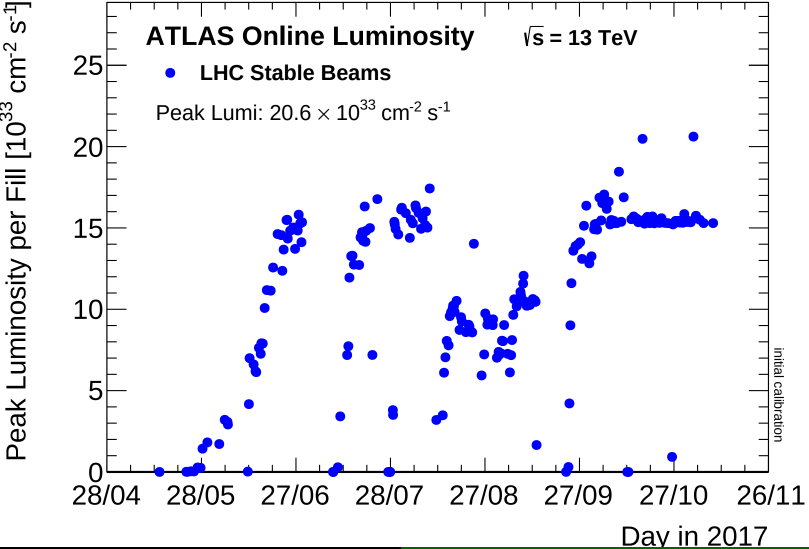
e+jets channel

Variable	Separation
photon0pt	23.14
mqgam	22.73
photon0iso	18.70
mtSM	11.02
mlgam	9.53
deltaRbl	5.00
deltaRjgam	4.60
ST	3.83
MWT	3.16
jet0pt	2.47
njets	1.70
nuchi2	1.59
deltaRlgam	1.40
wchi2	1.33
smchi2	1.09
deltaRjb	0.88
leptone	0.85
leptoniso	0.56
bjet0pt	0.50
met	0.47

Input Variables

['photon0iso','photon0pt','mqgam','mlgam','mtSM','deltaRjgam','deltaRbl', 'MWT','ST','njets','wchi2','jet0pt','deltaRlgam','leptone','met','bjet0pt']

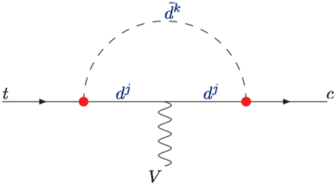
Integrated Luminosity



A Couple BSM Diagrams

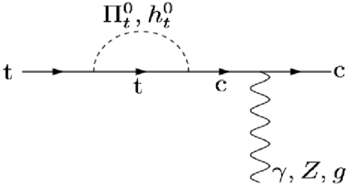
- R-parity-violating supersymmetric models

  [arXiv:hep-ph/9705341]



- Top-color-assisted technicolor models

  [arXiv:hep-ph/0303122]



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

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