Overview of the Top FC Analysis

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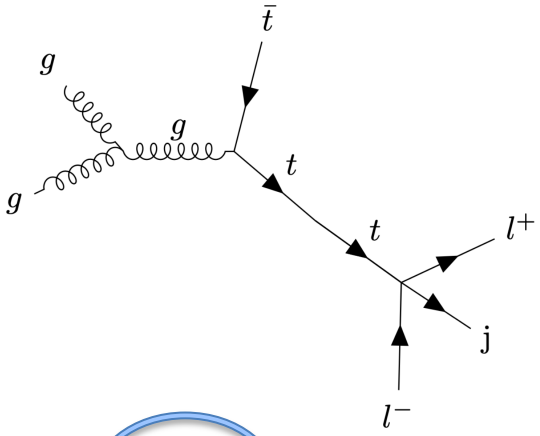
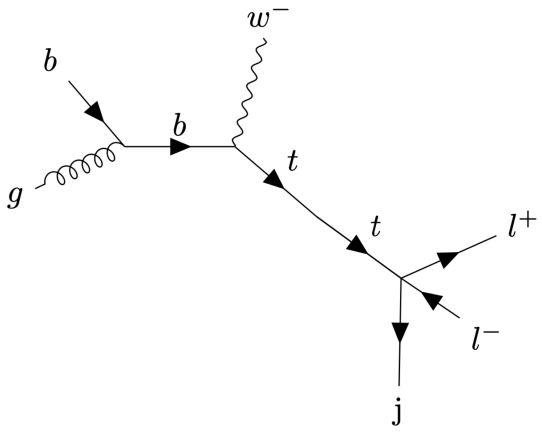
Weekly meting
2022-12-24

Flavor Changing in Top sector

In this analysis we looking for FC ($t \to u$ or $t \to c$) in top sector as the heaviest quark which may be an indicator of new flavor physics.



ttbar

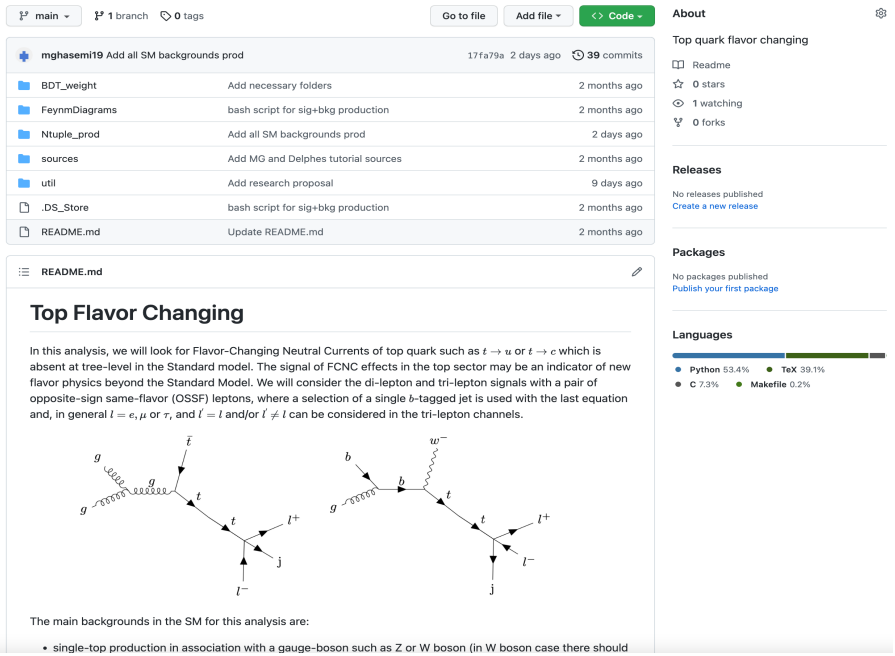


tW

- Starting with **ttbar**, targeting **final states** with three leptons (a pair of OP) and a b-tagged jet (one of the tops decays leptonically via w $\to l\ \nu_l$)
- There are **at least** two jets – other jets might come from showering
- Presence of several charged leptons allows an efficient lepton trigger
- The leading potential backgrounds are $tZ, t\bar{t}W, t\bar{t}Z, t\bar{t}t\bar{t}, WZ, ZZ$

Analysis links

- Useful analysis links:
  - Paper
  - Feynrules models: includes all the model parameters and interactions
  - Github repo: includes all the analysis code from production to statistical fits



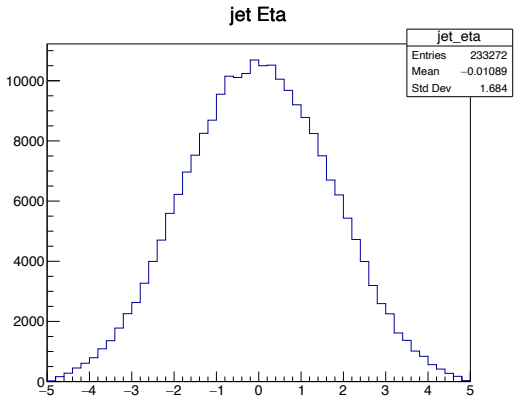
Signal generation and preselection

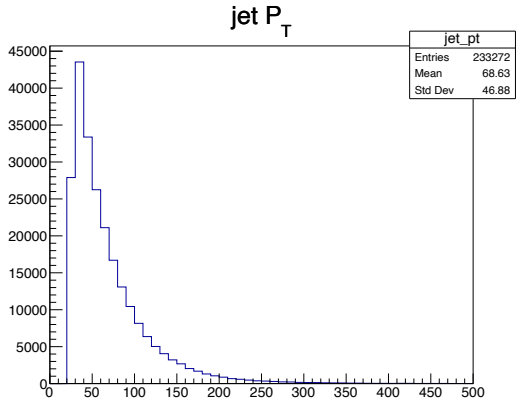
- Signal events are generated with MG5 (for ME) + PYTHIA (for PS and HAD) + Delphes (for HLLHC card detection). almost 3M events for both charm and up signals.

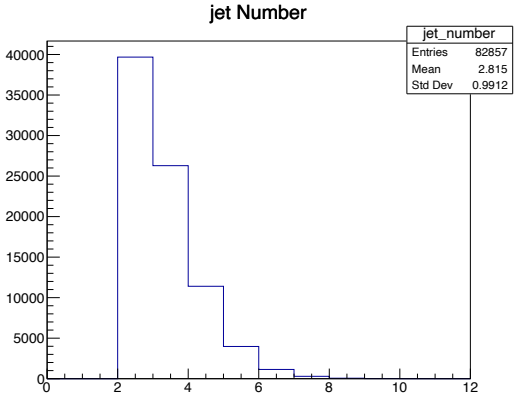
- To generate signal events, set 5 flavor scheme, all coupling to 1 (scalar-, vector-, and tensor-like), and NP scale to 1 TeV.

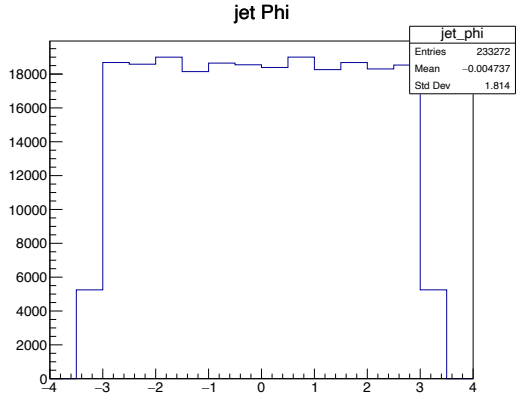
- The preselections applied:
  1. exactly 3 leptons (for now just electrons) with one pair of OS
  2. At least 2-jets with one b-tagged jet
  3. no minimum cuts on jet's P_T or lepton's P_T. Might be useful to have it!
  4. no lepton trigger at this level

Signal jet distributions

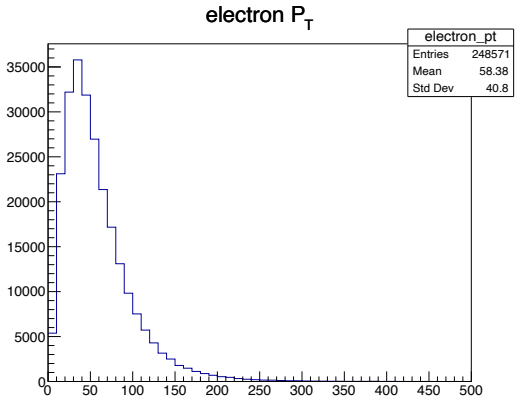


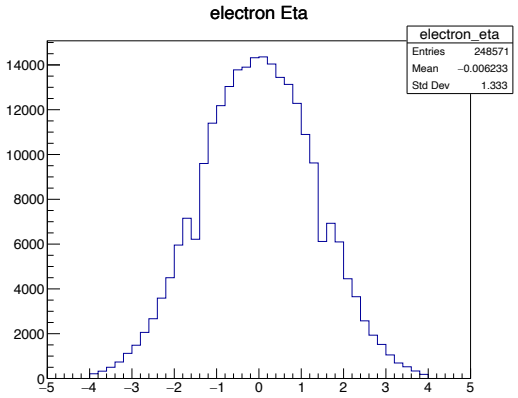


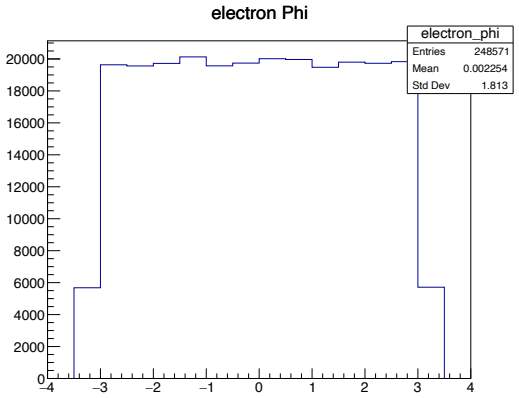




Signal lepton distributions



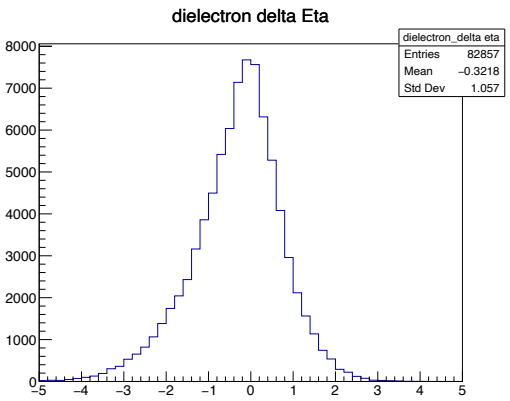


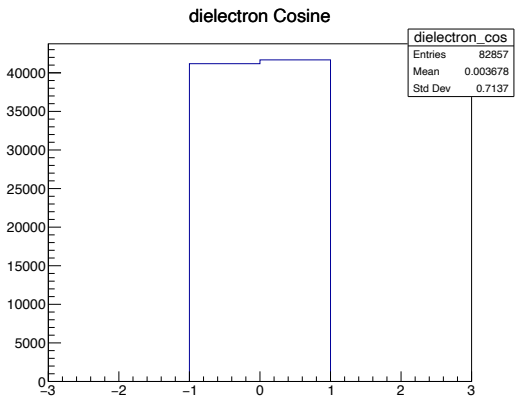


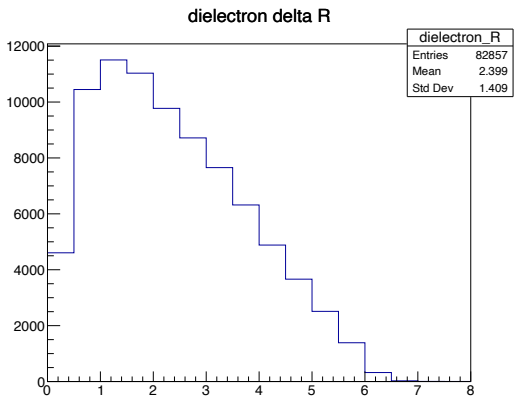
Signal Di-lepton distributions

- Two electrons with opposite sign and minimum $\Delta\eta$ are selected to reconstruct the FC top. The other electron and MET branch are used to reconstruct the W-boson and top mass.

- Can we change the electron selection by looking at $\Delta(M_{llq} - m_{top})$. I will consider this as an alternative.





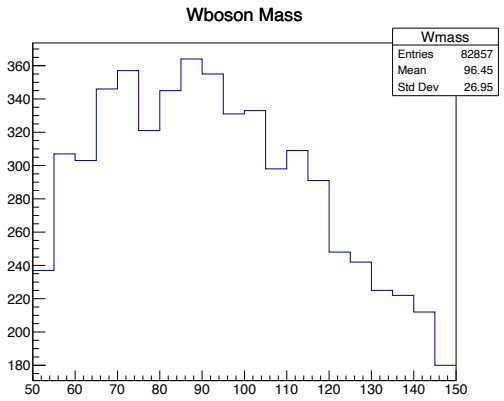


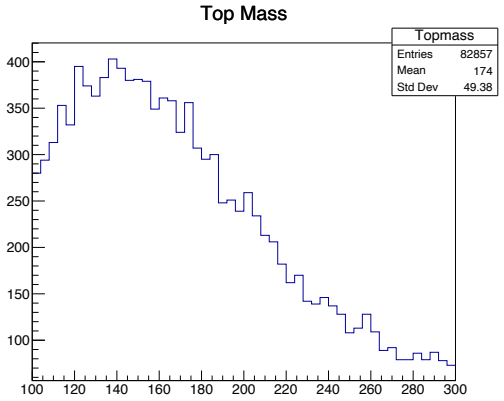
Top and W boson mass distributions

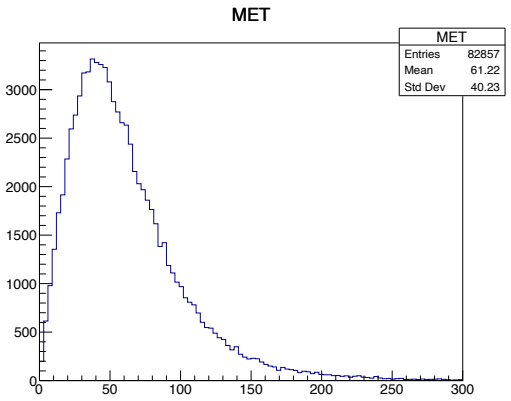
The isolated electron and MET branch are used to reconstruct the W boson. (code below)

```
      met = branchMET.At(0)
      histMET.Fill(met.MET)
      met_vec = ROOT.TLorentzVector()
      elec_vec = ROOT.TLorentzVector()
      bjet_vec = ROOT.TLorentzVector()
      met_vec.SetPtEtaPhiE(met.MET, met.Eta, met.Phi, met.MET)
      elec_ET = ROOT.TMath.Sqrt(branchElectron.At(index[0]).PT**2 + 0.005**2)
      #elec_vec.SetPtEtaPhiE(branchElectron.At(index[0]).PT, branchElectron.At(index[0]).Eta, branchElectron.At(index[0]).Phi, bra
nchElectron.At(index[0]).PT)
      elec_vec.SetPtEtaPhiE(branchElectron.At(index[0]).PT, branchElectron.At(index[0]).Eta,
branchElectron.At(index[0]).Phi, elec_ET)
      bjet_ET = ROOT.TMath.Sqrt(branchJet.At(bjet_index).PT**2 + 4.67**2)
      bjet_vec.SetPtEtaPhiE(branchJet.At(bjet_index).PT, branchJet.At(bjet_index).Eta, branchJet.At(bjet_index).Phi, bjet_ET)
      W_vec = met_vec + elec_vec
      top_vec = met_vec + elec_vec + bjet_vec

      mW = W_vec.Mt()
      mTop = top_vec.Mt()
```





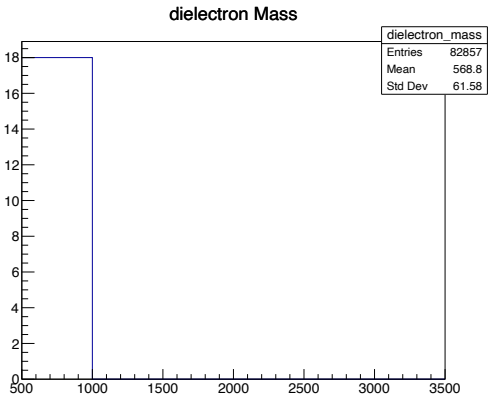


Di-lepton mass distributions

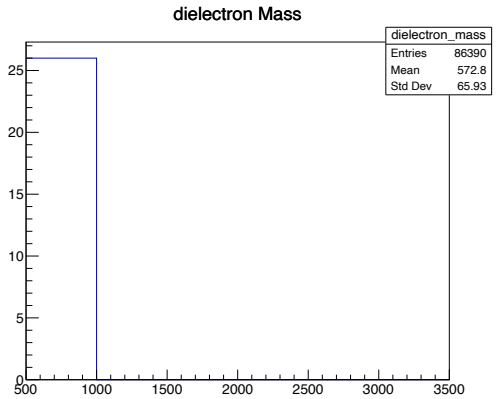
m_{ll} distribution coming from OS leptons with minimum $\Delta\eta$

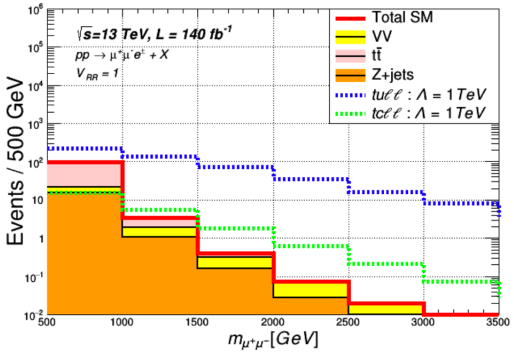
```
  elec_first_vec = ROOT.TLorentzVector()
  elec_first_ET = ROOT.TMath.Sqrt(branchElectron.At(index[1]).PT**2 + 0.005**2)
  elec_second_vec = ROOT.TLorentzVector()
  elec_second_ET = ROOT.TMath.Sqrt(branchElectron.At(index[-1]).PT**2 + 0.005**2)
  elec_first_vec.SetPtEtaPhiE(branchElectron.At(index[1]).PT, branchElectron.At(index[1]).Eta,
branchElectron.At(index[1]).Phi, elec_first_ET)
  elec_second_vec.SetPtEtaPhiE(branchElectron.At(index[-1]).PT, branchElectron.At(index[-1]).Eta,
branchElectron.At(index[-1]).Phi, elec_second_ET)
  mLL = (elec_first_vec + elec_second_vec).Mt()
  histdiElectronMass.Fill(mLL)
```

Signal charm



Signal up





Few points to double check

- Are we happy with

1. preselections
   - is it ok to start with just electrons and add muons later?
   - need to apply minimum P_T cut on final objects?
   - what kind of trigger need to be passed?

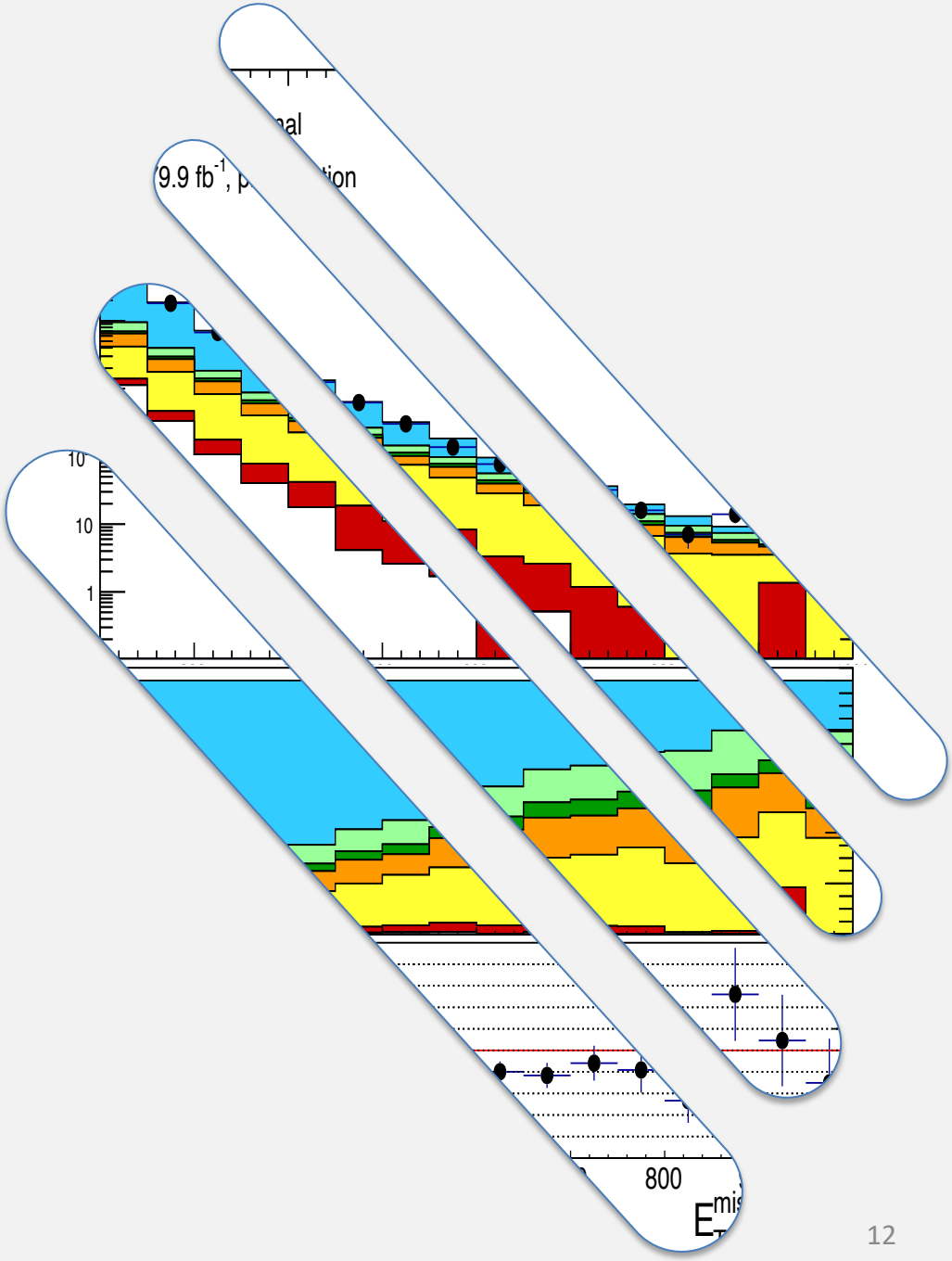
2. analysis Hist production code
   - now it includes event-loop and bunch of Hist filling. At the end might be better to have final trees with object variables as branches (nearly done code).

3. variable distributions
   - m_{top} looks fine but m_W needs more optimization. Any brilliant ideas on this ☺?
   - m_{ll} looks terrible!

Summary & ongoing

- Signal events generation is almost done. First round of analysis variables are added to the Git repo but some more optimizations are needed to get better distributions.
- Last week, starts background generation while it goes so slow cause of CPU limitation.
- Analysis tree production with important variables are nearly done code. Got some issues with dynamic size array which is solved by the help from Root forum guys.
- At some point, need to discuss about the trigger to be passed on.
- Made a presentation with IPM affiliation on NLP usage in HEP (poster and slides). With NLP we can train ATLAS and CMS papers to get useful predictions on DM.
- Finished postdoc application – Just Albert, Michel Lefebvre (from UVic), and Max Swiatlowski from (CERN-triumf) sent recommendation letters.
- Your feedback is welcome and appreciated.

Backup



Definition of Key Variables

$\Delta\phi_{\min}^{4j}$ to suppress multijets in which E_T^{miss} is aligned with one jet:

$$\Delta\phi_{\min}^{4j} = \min(|\phi_1 - \phi_{E_T^{miss}}|, \ldots, |\phi_4 - \phi_{E_T^{miss}}|)$$

Inclusive effective mass, to select highly energetic events:

$$m_{eff}^{incl} = \Sigma_{i \le n}\, p_T^{j_i} + \Sigma_{j \le m}\, p_T^{lep_j} + E_T^{miss}$$

m_T to remove semileptonic $t\bar{t}$ and W+jets events (region ≥ 1 lepton) :

$$m_T = \sqrt{2 p_T^l E_T^{miss} (1 - \cos\Delta\phi(\vec{p}_T^{miss}, \vec{p}_T^{\,l}))}$$

$m_{T,min}^{b-jets}$ min transverse mass between E_T^{miss} and three leading b-jets:

$$m_{T,min}^{b-jets} = \min_{i \le 3}\left(\sqrt{2 p_T^{b-jet_i} E_T^{miss} \left(1 - \cos\Delta\phi\left(\vec{p}_T^{miss}, \vec{p}_T^{\,b-jet_i}\right)\right)}\right)$$

$M_J^{\Sigma,4}$ sum of the mass of re-clustered jets (higher for Gtt signal):

$$M_J^{\Sigma,4} = \Sigma_{i \le 4} m_{J,i}$$

Poster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توسط: دکتر عبدالصمد کرامت‌فر و دکتر میثم قاسمی
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Signal-up distributions