Research Semester at CERN
Progress Report 1

Alex Emerman
Local Mentor: Lynn Marx
3 October 2013

Current Project

- Finishing
  - 14 TeV KK W sensitivity studies
    - Effect of pile-up
      - https://indico.cern.ch/getFile.py/access?contribId=4&resId=0&materialId=slides&confId=275341
- Starting
  - Apply Q-jets algorithm to ZZ->llqq search at 8 TeV
    - ZZ->llqq is a completed search at ATLAS using 7.2 fb^{-1} at 8 TeV
      - https://cds.cern.ch/record/1559274?ln=en
    - Check significance with/without Q-Jets
      - Is the improvement worth spending more time on?
  - How does telescoping jet compare to Q-jet?
    - Run *kt* algorithm with multiple R values

kt jet clustering algorithm

- *kt* jet clustering algorithms try to reverse parton shower
  - β determines the p_T dependence, varies between algorithms
  - Calculate distance parameter between particles
  - Find minimum of the set of d_{ij} and d_{iB}
  - If d_{ij} is min then combine particles and repeat
  - If d_{iB} is min then it is a final jet, remove from list
    - Continue until no particles remain
- Jet pruning checks each recombination
  - If both conditions are met the softer particle is discarded

- Input: R, z_{cut}, d_{cut}

$$d_{ij} = \min(p_{Ti}^{\beta}, p_{Tj}^{\beta}) \frac{\Delta R_{ij}^2}{R^2}$$

$$d_{iB} = p_{Ti}^{\beta}$$

$$\Delta R_{ij}^2 = (y_i - y_j)^2 + (\phi_i - \phi_j)^2$$

$$y = \frac{1}{2} \ln\left(\frac{E + p_z c}{E - p_z c}\right)$$

- Pruning cuts

$$z_{ij} = \frac{\min(p_{Ti}, p_{Tj})}{|\vec{p_{Ti}} + \vec{p_{Tj}}|} < z_{cut}$$

$$\Delta R_{ij} > d_{cut}$$

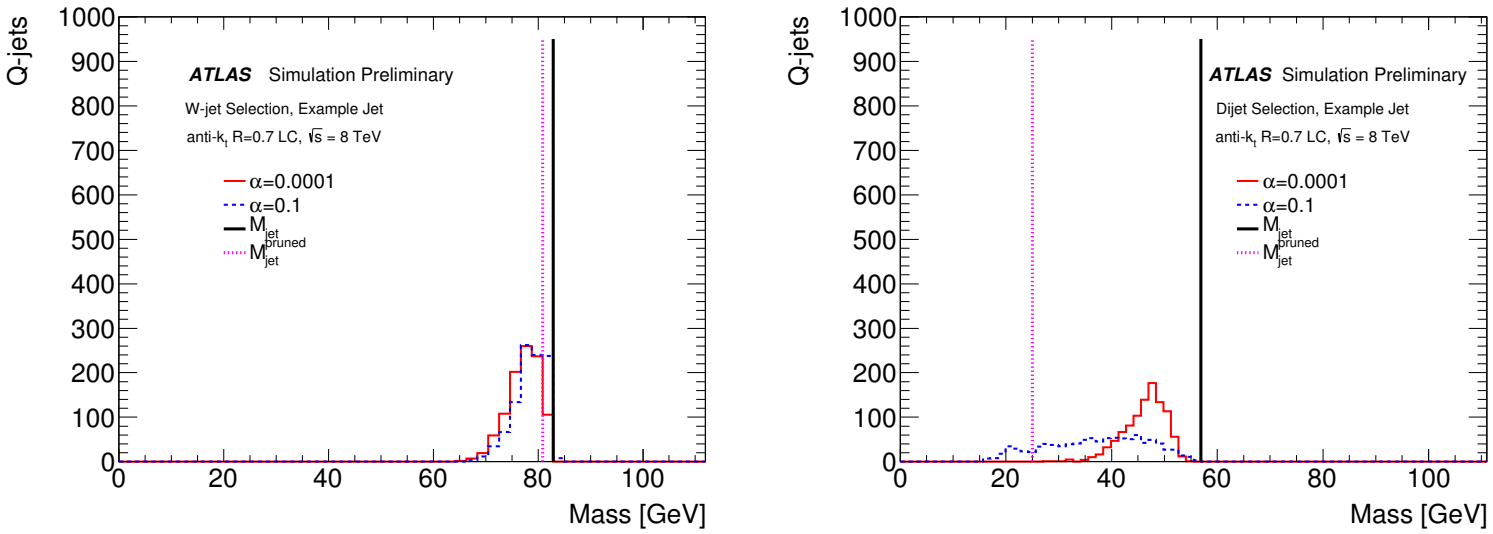
Q-jet algorithm (1)

- Q-jets algorithm reconstructs multiple possible event histories
- Merges constituents randomly with a weighting factor that reflects the likelihood that they would be paired
  - Weights are: $\omega_{ij}^{(\alpha)} = \exp\left\{-\alpha \frac{\Delta R_{ij} - d_{\min}}{d_{\min}}\right\}$
  - α is the rigidity, controls sensitivity to RNG

$$\Omega_{ij} = \frac{\omega_{ij}}{\Sigma \omega_{ij}}$$

  - Merge pairs according to probability density function
    - Veto if the pair meets the jet pruning conditions on slide 3
  - Continue until all pairs are merged, this is a Q-jet
  - Repeat the algorithm to get a distribution of Q-jets

Q-jet algorithm (2)



(a) (b)

Figure 2: Q-jet mass distribution when generating 1000 Q-jets per jet for (a) a jet from a W boson decay in a $t\bar{t}$ event and for (b) a jet from a dijet event, reconstructed from topological clusters. The distribution for $\alpha = 100$ is not shown as it coincides with the pruned jet mass, as expected.

Taken from https://cds.cern.ch/record/1572981/files/ATLAS-CONF-2013-087.pdf

Future Projects

- Study b-tag efficiency for high p_T jets containing multiple b quarks
  - Work on specific case of boosted Higgs/Z decay to bb~
    - Study jet substructure for boosted jets
    - Go to weekly jet substructure and b-tagging meetings