Jet Substructure and Trimming in Boosted $t\bar{t}$ Decays in the ATLAS Detector at the LHC

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Motivation

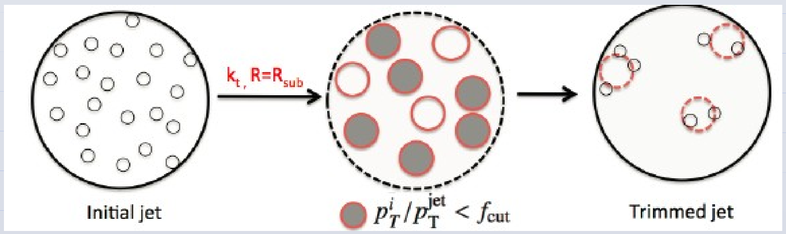
Boosted heavy particles may decay into multiple overlapping 'jets' which are not easily resolvable as separate objects. Such events are especially interesting in the context of the LHC, which is already produce such events in larger numbers.

Jet substructure variables, such as jet mass and k_t splitting scales, can be very powerful tool for studying these events. However, substructure observables are very sensitive to wide angle soft radiation, such as that produced by pileup. Thus, care must be taken when using these observables in an environment such as that produced by the LHC.

Jet Trimming

Jet Trimming is one of several tools for suppressing the diffuse low energy jet contamination which is produced by pileup and the underlying event. This technique is designed to leave heavy particle decay products, which may produce several high energy topo-clusters within a single jet, intact.

Jet Trimming Procedure

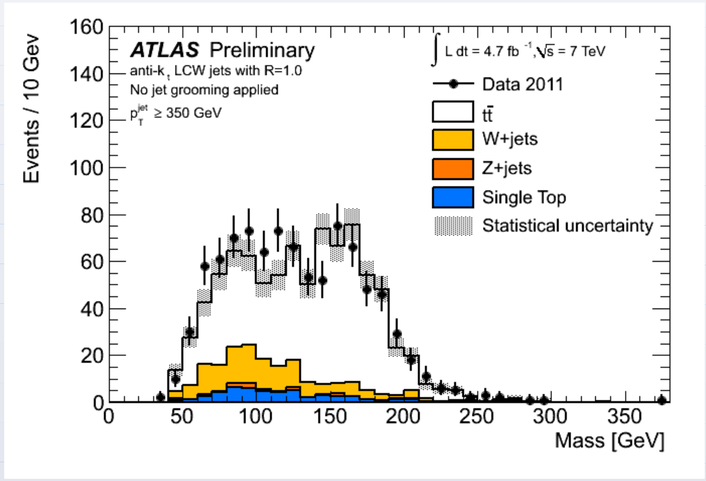


- Use a k_t algorithm with radius R_{sub} to re-cluster jet constituents
- Remove any subjets with p_T fraction $p_T^i / p_T^{jet} < f_{cut}$

Semi-Leptonic $t\bar{t}$ Event Selection

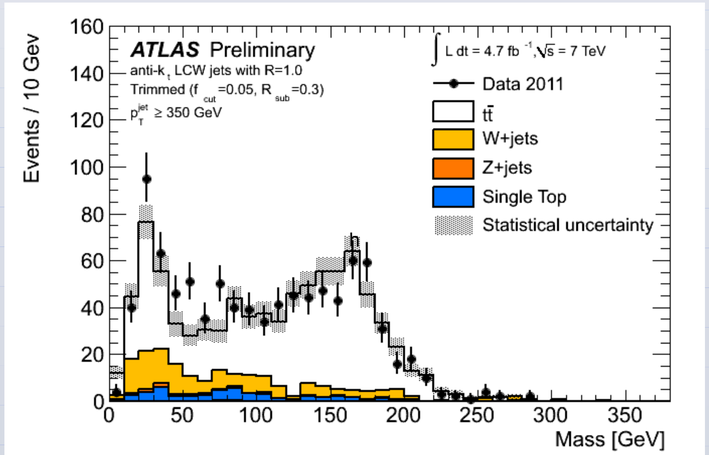
- Exactly one muon, no electrons
- MET>20 GeV
- MET+ mT of leptonic W > 60 GeV
- 4 or more Anti-k_t4 jets with pT >25 GeV and $|\eta|<2.5$
- B-tag requirement: at least 1 Anti-k_t4 jet is B-tagged (MV1>.607)
- Anti-k_t R=1.0 jet with p_T>350 GeV $|\eta|<2.0$

Jet Mass: Before and After Trimming



Ungroomed Anti-k_t R=1.0 Jets, f=0.05, R=0.3

Require 1 B-tagged Anti-k_t4 Jet



Trimmed Anti-k_t R=1.0 Jets, f=0.05, R=0.

Require 1 B-tagged Anti-k_t4 Jet

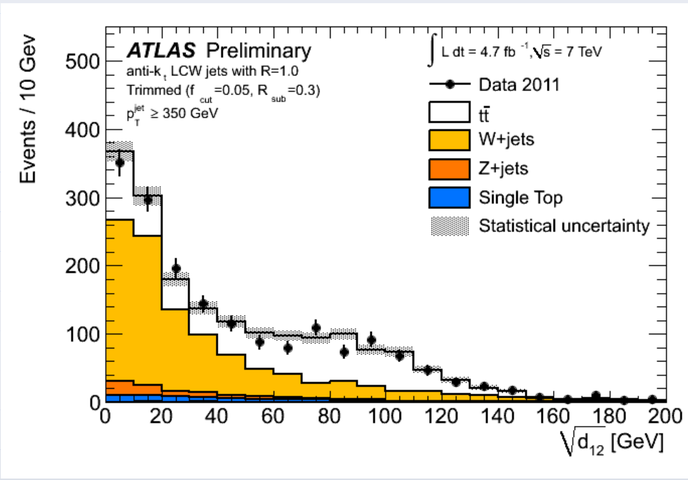
Jet Trimming improves jet mass resolution while substantially reducing the mass of 'QCD-like' background jets.

k_t Splitting Scale

- Recluster a jet using a k_t algorithm, and define the k_t splitting scale on the last step of reclustering:

$$\sqrt{d_{ij}} = \min(p_{Ti}, p_{Tj}) x \Delta R_{ij}$$

- Expect a steeply falling distribution for structureless QCD background
- Should peak around $M_{jet}/2$ for a jet with substructure



Trimmed Anti-k_t R=1.0 Jets, f=0.05, R=0.3

No B-tag requirement

Conclusions

Although a relatively new field, jet substructure is likely to play an increasingly important role in physics analysis at the LHC. By allowing us to discriminate between structureless QCD jets and jets resulting from the decays of heavy particles, jet substructure parameters open up new options for analyses involving the decays of boosted heavy objects.

Due to a high sensitivity to pileup, jet trimming is a powerful tool for improving the performance of substructure parameters.

Reference: ATLAS-CONF-2012-065