Identification of Highly-boosted h→bb Jets of $\sqrt{s}$ = 13 TeV at ATLAS

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Reference Document : ATL-PHYS-PUB-2017-010

Motivation

- Standard identification of h→bb decays performed via fixed radius track jets associated to large-R calorimeter jet with trimming (ATLAS-CONF-2016-039)
- For p_T(Higgs) > 1 TeV, ability to identify 2 distinct subjets for b-tagging degrades significantly → limits reach of searches at very high energy scales

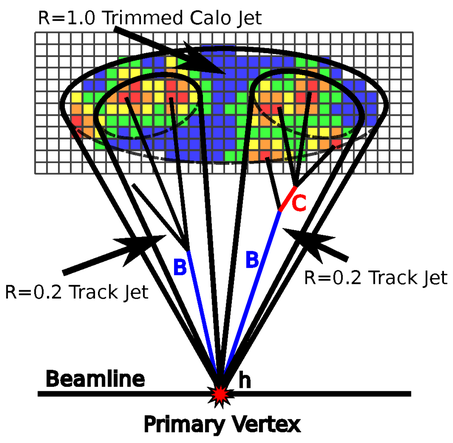

Figure 1 – Illustration of the reconstruction and identification of a true Higgs jet using a trimmed calorimeter jet and two associated fixed radius small-R track jets.

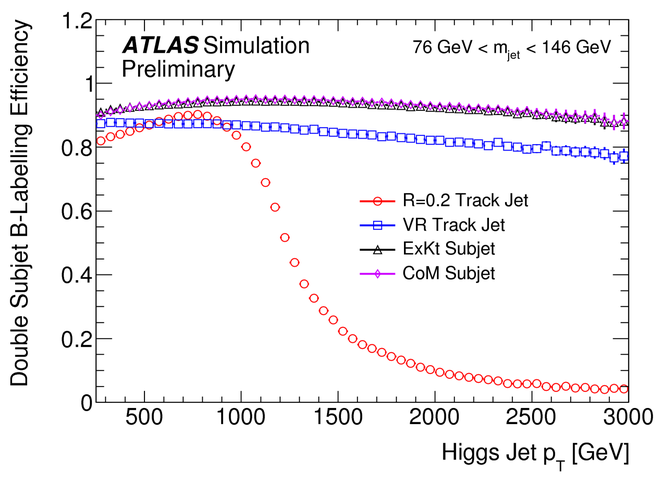

Figure 2 – The efficiency to label the two highest p_T subjets associated with a true Higgs jet and being associated to true b-hadrons. Note that no reconstruction-based b-tagging algorithm is implemented in this measure.

Alternative Techniques

- The use of fixed radius track jets to identify regions of interest with which to perform a double b-tag of the large-R jet can be modified in multiple ways
- Each alternative algorithm aims to more accurately divide the energy flow of the jet constituents to exclusively reconstruct the two b-hadron directions

Variable-Radius (VR) Track Jets
- Construct VR track jets for entire event (i.e. no large-R jet ROI)
- Associate to untrimmed large-R jet
- Evaluate MV2c10 b-tagging discriminant for two highest-p_T VR track jets

Exclusive-k_T (ExKt) Subjets
- Recluster trimmed large-R calorimeter jet with exclusive-k_T algorithm to form exactly 2 subjets
- Evaluate MV2c10 b-tagging discriminant for both subjets

Center of Mass (CoM) Subjets
- Boost topoclusters and tracks to trimmed large-R jet CoM
- Form two subjets of topoclusters and associate tracks to these subjets in the CoM
- Boost subjets and associated tracks to lab frame to evaluate MV2c10 b-tagging discriminant

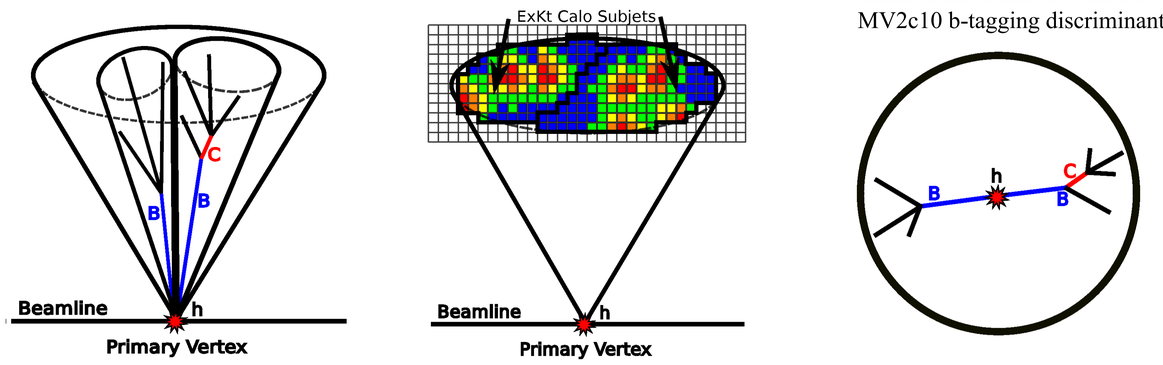

Figure 3 – Illustration and brief description of three alternative subjet reconstruction algorithms studied to improve the efficiency to exclusively reconstruct both b-hadrons contained within the Higgs jet.

Performance I (subjet reconstruction)

- Reconstruction of the h→bb topology evaluated by studying the accuracy of the reconstruction of each b-hadron separately (Figure 6) and the bb pair separation
  - VR track jet reconstruction scheme performs optimally
- Isolated improvements here translate into improvements in MV2c10 calculation (ATL-PHYS-PUB-2015-022)

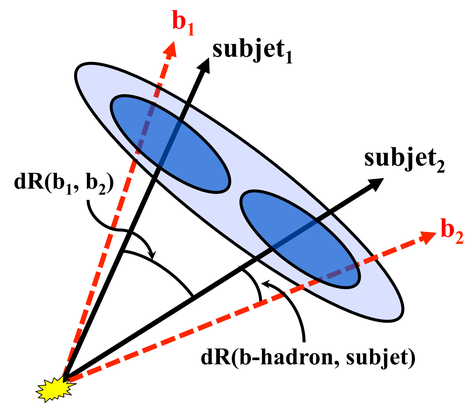

Figure 4 – Illustration of a representative h→bb decay. Indicated are the two measures, the separation between a b-hadron and the closest subjet dR(b-hadron, subjet) and the separation between the two b-hadrons or the two subjets dR(b_1,b_2), used to assess topology reconstruction accuracy.

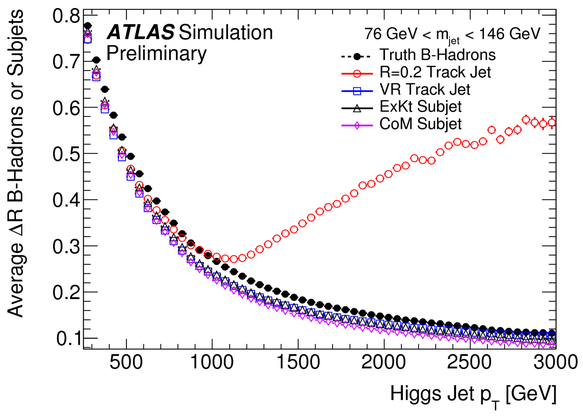

Figure 5 – Spectrum of the separation between either the two b-hadrons or the leading two subjets associated to a large-R Higgs jet.

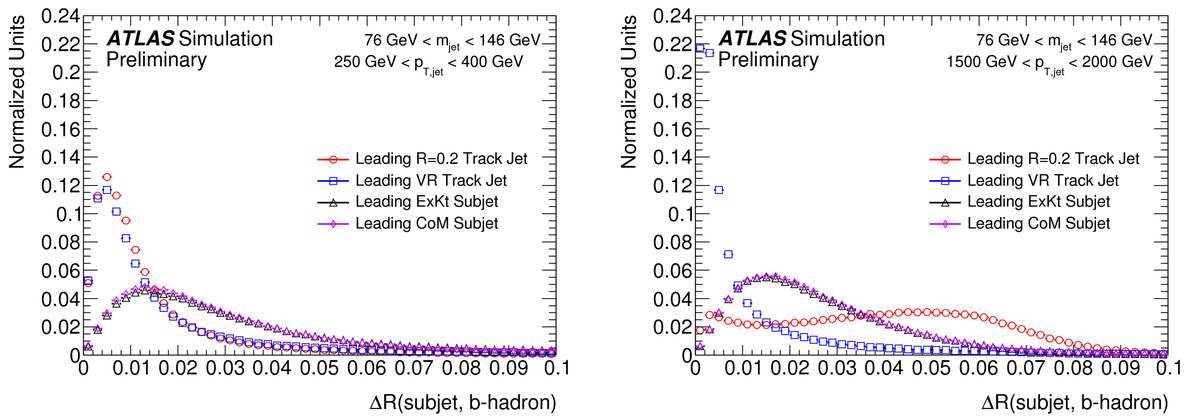

Figure 6 – For a selection of low-p_T (left) and high-p_T (right) Higgs jets, the separation (ΔR) between the leading subjet and the nearest b-hadron.

Performance II (flavor tagging)

- All subjet reconstruction techniques use the same MV2c10 when evaluating the performance of the fully reconstructed Higgs tagger
  - No dedicated multivariate optimization performed
- Evaluation of possible working points in very high p_T (>1500 GeV) region extended to higher signal efficiencies
- Background rejection for a fixed Higgs tagging efficiency of 50% evaluated for comparison between reconstruction techniques

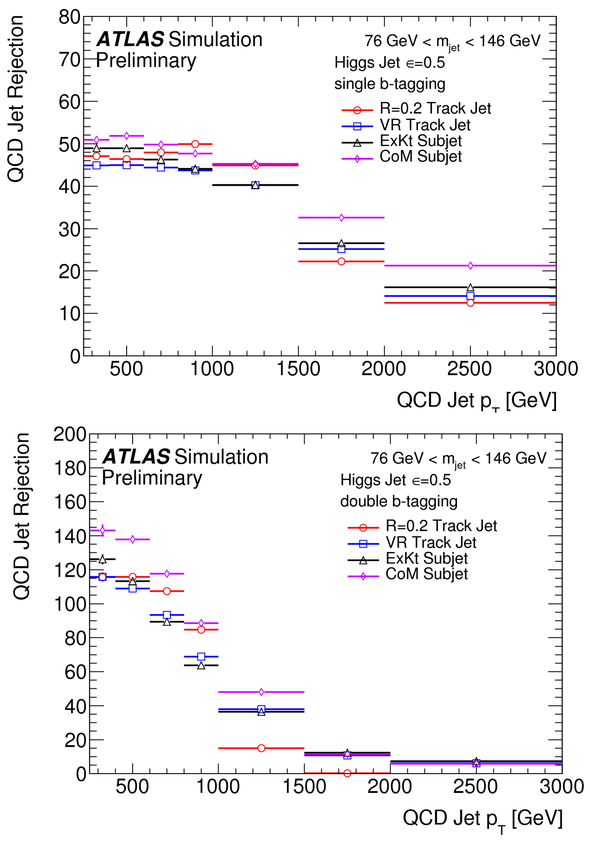

Figure 7 – The QCD jet rejection as a function of jet p_T for the various subjet reconstruction h→bb tagging algorithm achieved for single (top) and double (bottom) b-tagging for a fixed Higgs jet efficiency of 50%.

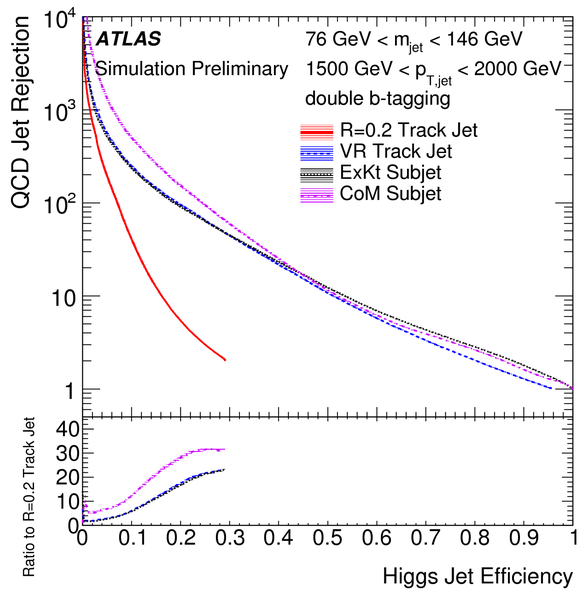

Figure 8 – The receiver-operator curve showing the Higgs jet efficiency versus QCD jet rejection for a double b-tag based on the two leading p_T subjets associated to a large-R jet for a selection of very high p_T jets.

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