



# THE IMPORTANCE OF JET SHAPES FOR TAGGING PURPOSES

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## DEFINITIONS OF OBSERVABLES.

The integrated jet shape in a cone of radius  $r \leq R = 0.4$  is defined as, see [1]:

$$\Psi(r) = \frac{p_T(0, r)}{p_T(0, R)} \quad (1)$$

The differential jet shape in a cone of radius  $r \leq R = 0.4$  is defined as, see [1]:

$$\rho(r) = \frac{1}{\Delta r} \frac{p_T(r - \Delta r, r)}{p_T(0, R)} \quad (2)$$

The pull is defined as, see [2]:

$$\vec{t} = \sum_{i \in \text{Jet}} \frac{p_T^i |r_i|}{p_T^{\text{jet}}} \vec{r}_i \quad (3)$$

$$\vec{t} = |\vec{t}| (\cos\theta_t, \sin\theta_t) \quad (4)$$

## AIMS.

The purpose of this analysis is to investigate possible applications of jet shape measurements in two study cases:

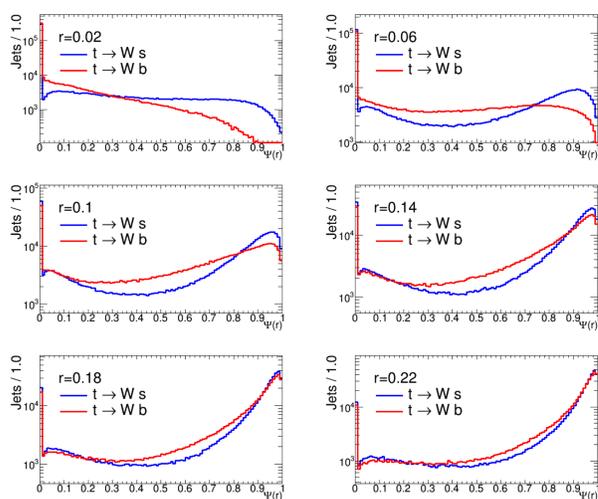
- the feasibility to measure  $|V_{ts}|$  in  $t\bar{t}$  final states when one  $t \rightarrow Wb$  and the second one goes to  $t \rightarrow Ws$
- the possibility to discriminate  $pp \rightarrow ZH$ , with the Z boson decaying to electron or muon pairs and the  $H \rightarrow b\bar{b}$ , from the main background  $pp \rightarrow Z + b\bar{b}$ .

## MEASURING $|V_{ts}|$ .

Following the analysis in [3], multivariate techniques were used to separate the signal  $t \rightarrow Ws$  from dominant background  $t \rightarrow Wb$ . By studying the b- and s-jets profiles:

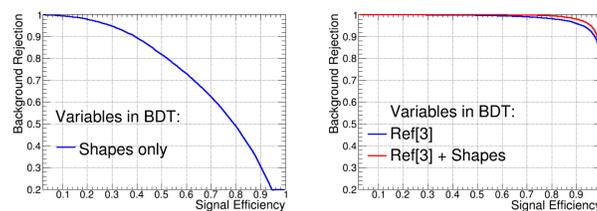
- the E and  $p_T$  of  $K_S^0$  and  $\Lambda^0$ 's
- the presence (absence) of secondary vertices
- the spectrum of soft leptons
- the integrated jet shapes.

## JET SHAPES FOR $t\bar{t}$ EVENTS.



The expected integrated jet shapes (1) for b- and s-jets in the process  $pp \rightarrow t\bar{t} \rightarrow WbWs$ . There is a clear difference between these two shapes as due to the b-quark being heavier than the light quarks. These results were proved with data in [1].

## TMVA RESULTS FOR $t\bar{t}$ .



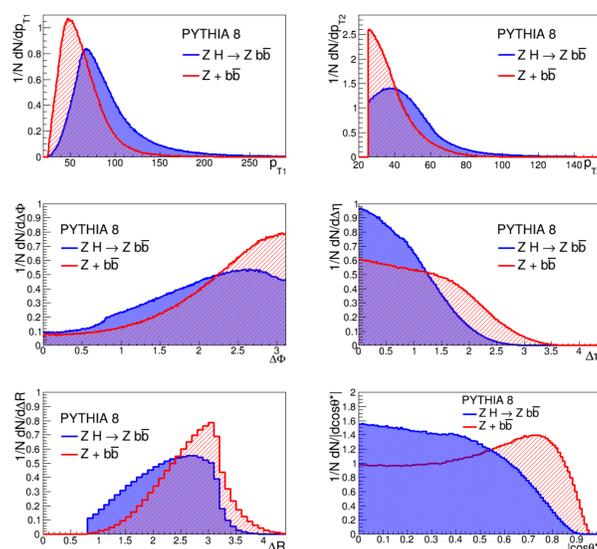
The ROC curve from only using jet shapes (left) shows a non-negligible discrimination power. The ROC curve (right) shows the improvement of adding the jet shapes to the other variables in the analysis.

## ASSOCIATED HIGGS SEARCH.

Multivariate techniques to separate the signal  $ZH \rightarrow Zb\bar{b}$  from dominant background  $Z + b\bar{b}$ . By studying the two b-jets:

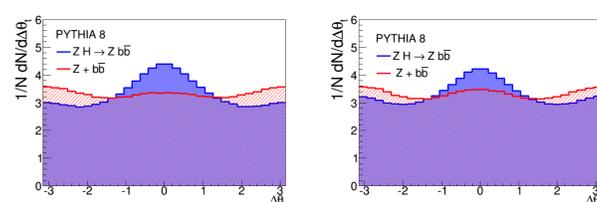
- Kinematics:  $p_T, \eta, \Phi, \Delta\eta_{b\bar{b}}, \Delta\Phi_{b\bar{b}}, \Delta R_{b\bar{b}}, \theta_{Hb}^*$
- the pull angles  $\theta_t$
- the differential jet shapes.

## KINEMATICS VARIABLES.



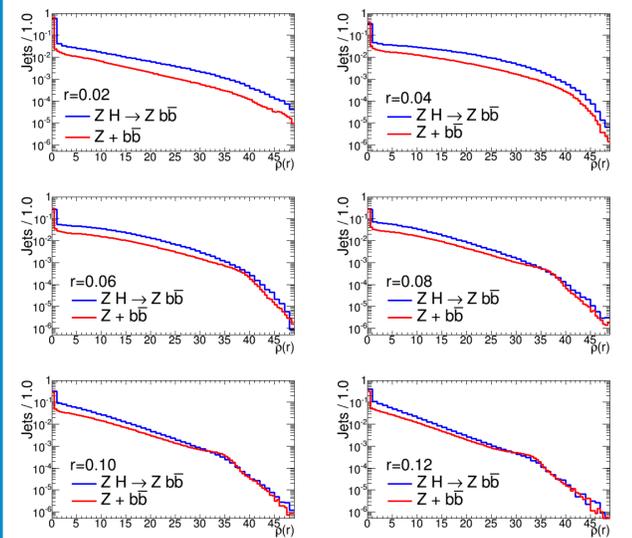
The most powerful expected kinematics discriminators are shown in the figures above.

## PULL ANGLES.



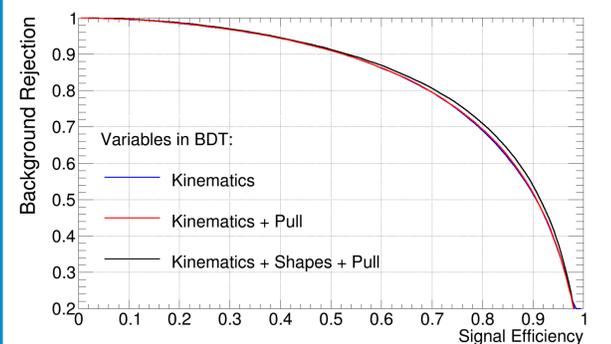
The pull angle (4)  $\theta_t$  has the zero defined as pointed towards the other b-jet. The signal and background have different angular distributions due to their color structures.

## JET SHAPES FOR ZH EVENTS.



The expected differential jet shapes (2) for b-jets from the Higgs and the QCD background. There is a difference between these two shapes as due to the color structures.

## TMVA RESULTS FOR ZH.



The ROC curves show a slight improvement by adding the jet shapes to the kinematics and pull angle analysis.

## CONCLUSION.

The jet shapes have potential to discriminate b- from light jets and improve:

- b-tagging algorithms
- measurement of  $|V_{ts}|$

## REFERENCES.

- [1] ATLAS Coll., EPJ C73 (2013) 2676
- [2] J. Gallicchio and M.D. Schwartz, Phys. Rev. Lett. 105 (2010) 022001
- [3] A. Ali, F. Barreiro and Th. Lagouri, Phys. Lett. B693 (2010) 44-51