Event Shape Variables in Semileptonic Top Decays

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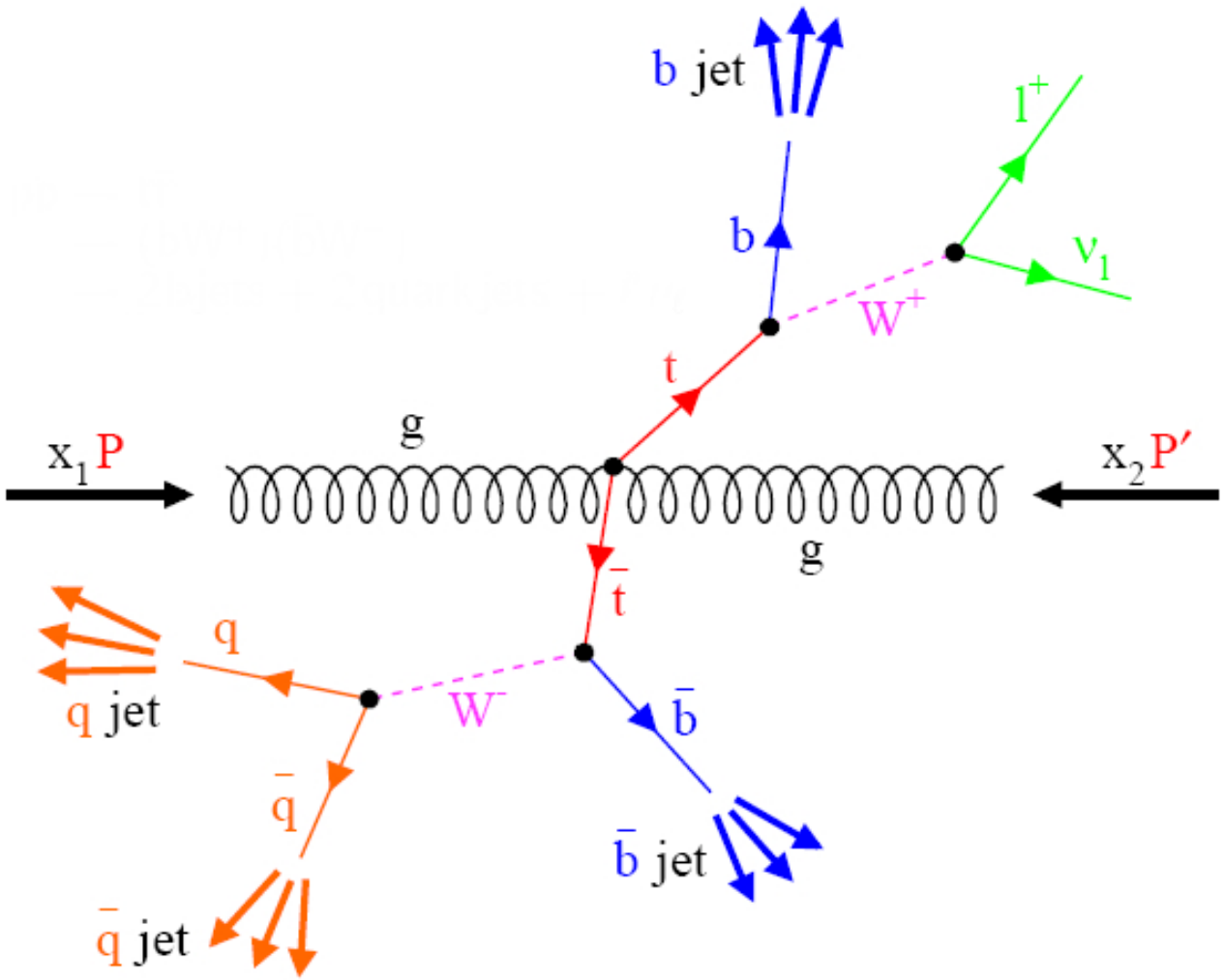
Overview

Object of this talk :

- Looking at the semileptonic $t\bar{t}$ decay channel
- Generator study in respect to event shapes in order to be able to distinguish between signal and background data
  - Signal data: Alpgen, Pythia, Herwig and Mc@nlo with Pt cut at 15GeV, as low energy jets are unlikely in a top event
  - Background data: Alpgen generator for W + Jets and QCD
  - Study of the following event shape variables: Fox Wolfram Moments, sphericity, circularity, aplanarity and centrality

Semileptonic $t\bar{t}$ Decay



Analysis of the Decay Mode

- Top events of such kind will be observed at the LHC
- Semileptonic top decay produces 4 characteristic jets therefore an investigation into 4 and 5 jet events was conducted
- The shape of the event can then help with the detection of a semileptonic top event.

Event Shape Variables

Event shape variables are used to characterise the final state of the event. Numerous ways of describing such a final state have been invented:

Fox Wolfram Moments:

- Fox Wolfram Moments are originally used in final states of electron positron anihilations.
- They provide a complete set of rotationally invariant observables HI.

Fox Wolfram Moments I

Event shape equation:

$$Hl = \sum_{i,j} \frac{\mid p_i \mid\mid p_j \mid}{E_{vis}^2} Pl(cos\theta_{ij}) \tag{1}$$

where E_{vis} represents the visible energy of the event.
Pl in the equation is given by the Legendre Polynomials. For P1 it is given by $P1 = cos(\theta_{ij})$, hence if the momentum is balanced within an event, the overall H1 of the Fox Wolfram Moment is zero.

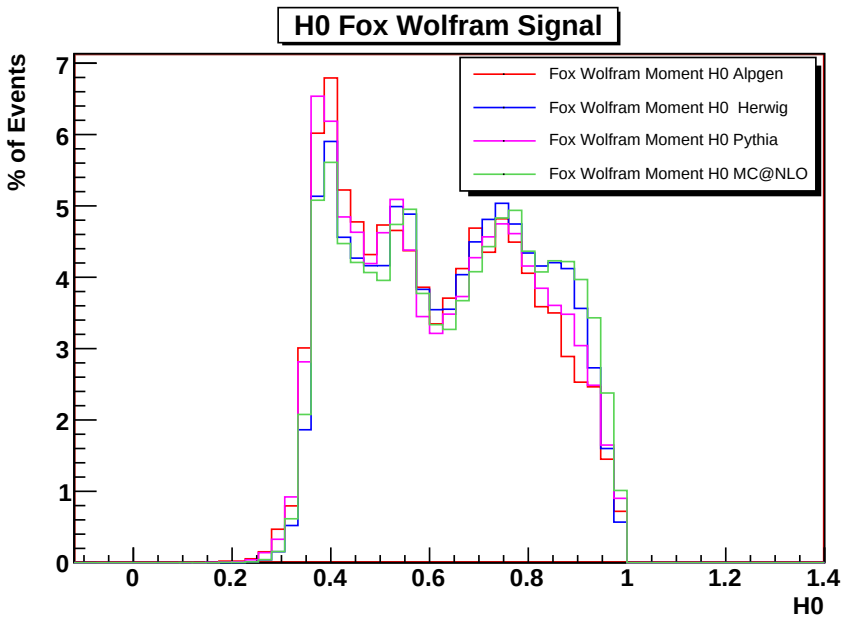
Fox Wolfram Moments II

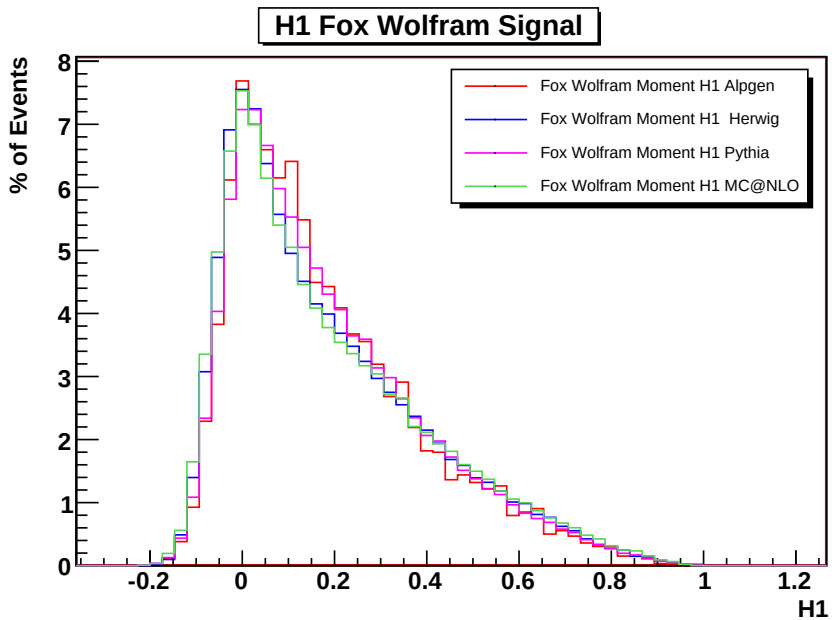
Adjustions made for generator studies

- Pt of 4 and 5 Jets observed using Jet type IC05 with 15GeV Pt cut.
- Signal studies for Alpgen, Herwig, Mc@nlo and Pythia generators
- QCD and W + Jets background with Alpgen

Fox Wolfram Moments III

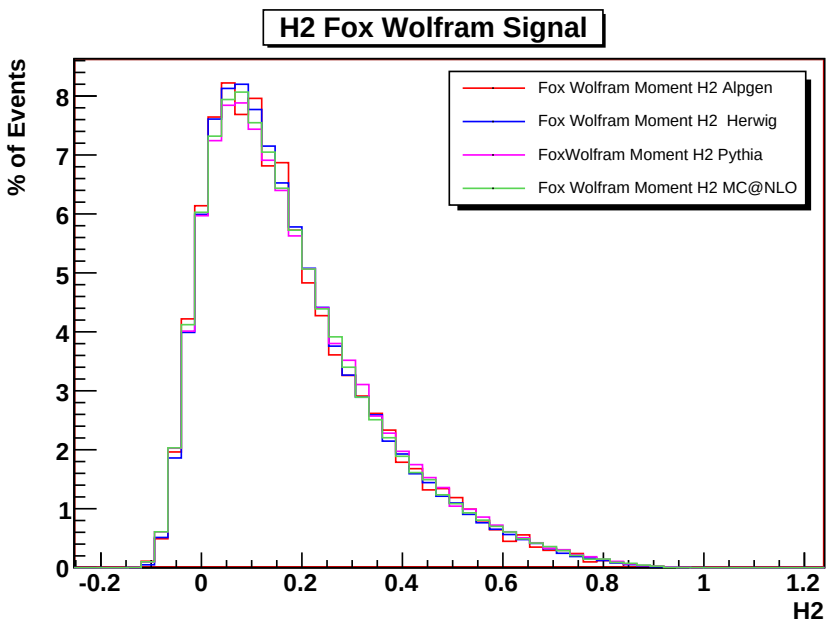
Signal for different Monte Carlo generator data: H0 and H1

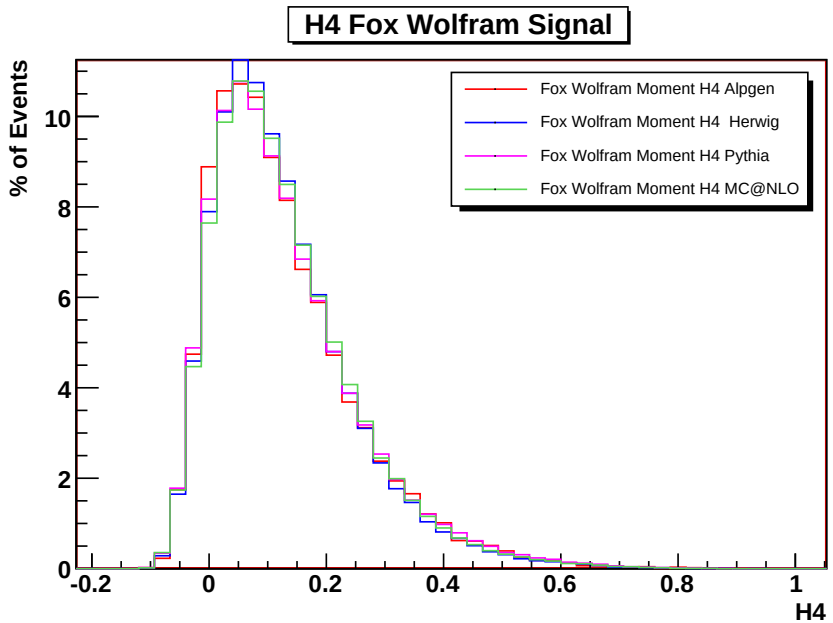




Fox Wolfram Moments IV

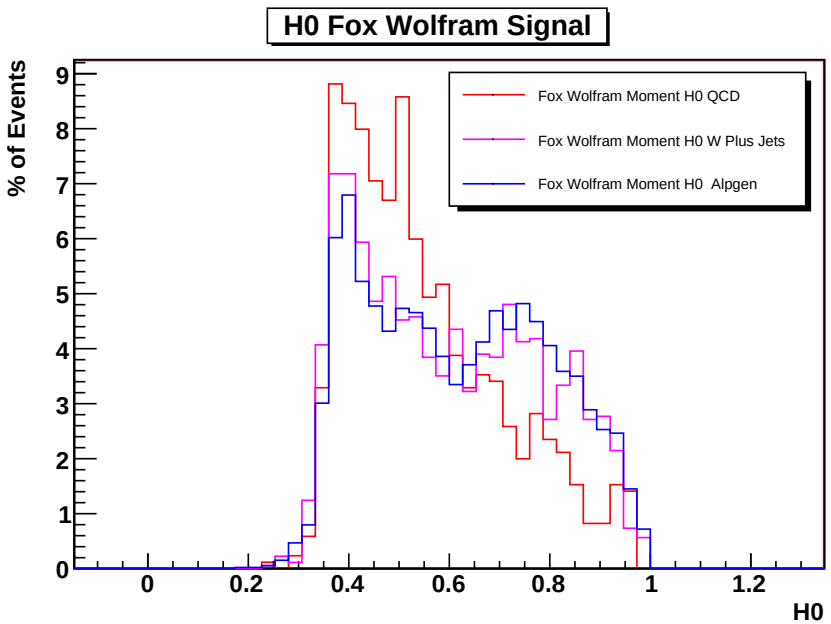
Signal for different Monte Carlo generator data: H2 and H4

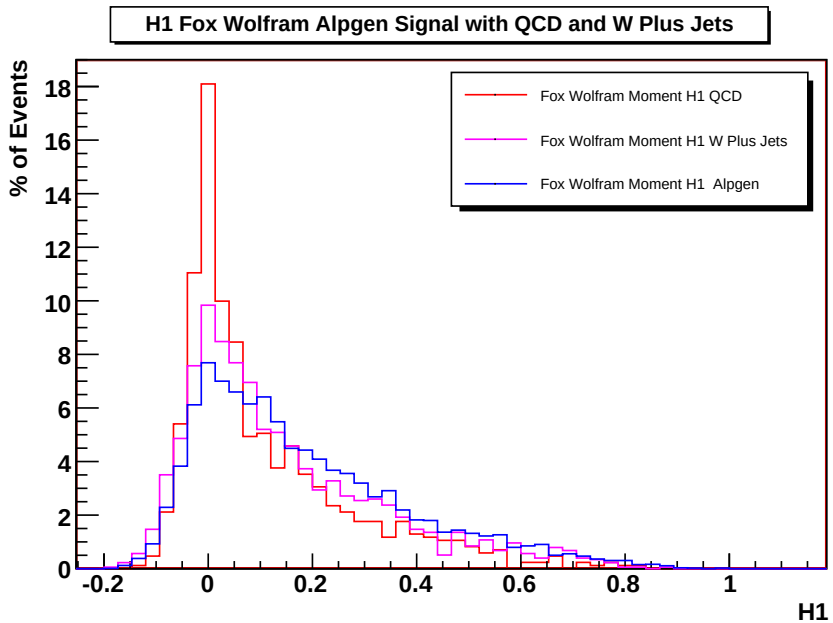




Fox Wolfram Moments V

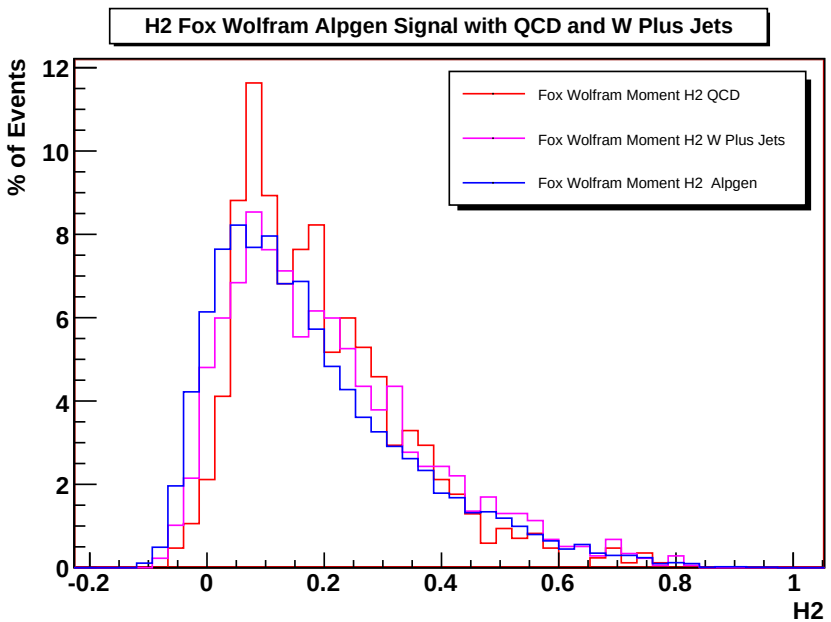
QCD and W+Jets Background with Alpgen signal: H0 and H1

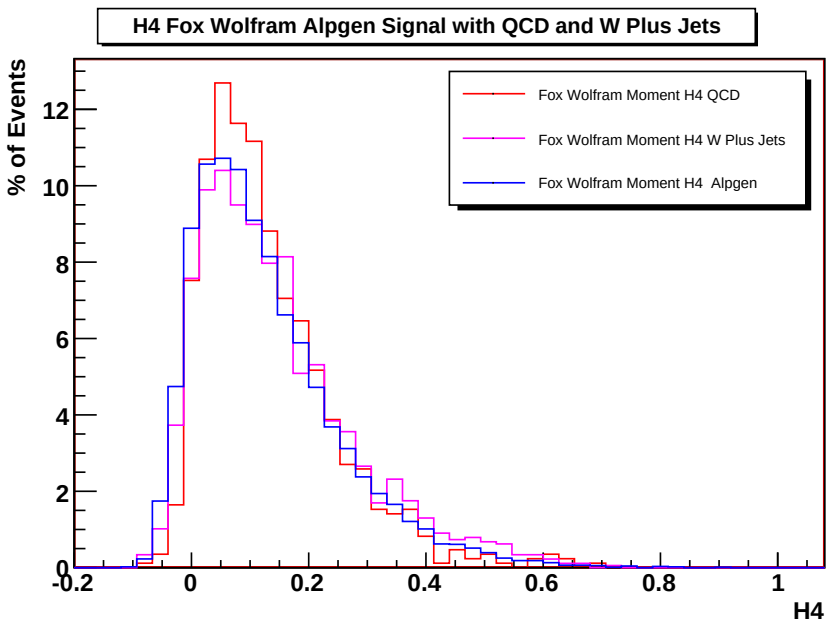




Fox Wolfram Moments VI

QCD and W+Jets Background with Alpgen signal: H2 and H4





Sphericity I

Sphericity can be seen as a measure of the summed transverse momentum with respect to the event axis. The Sphericity tensor is defined as:

Sphericity tensor

$$S^{\alpha\beta} = \frac{\sum_i p_i^\alpha p_i^\beta}{\sum_i \mid p_i \mid^2} \tag{2}$$

where, $\alpha, \beta = 1, 2, 3$ representing the x,y and z components of the vectors.

Sphericity II

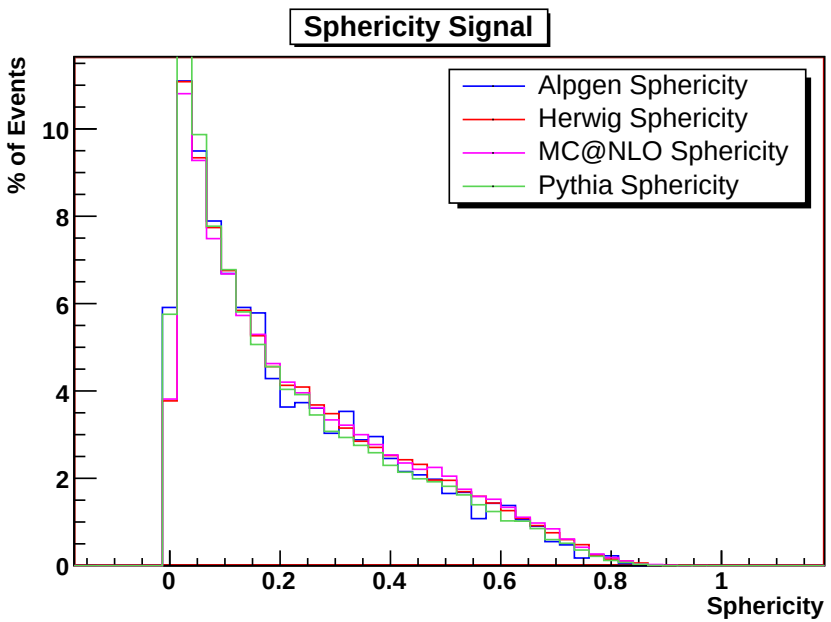
Through the standard diagonalisation of the matrix, 3 eigenvalues can be found: $\lambda_1 \geq \lambda_2 \geq \lambda_3$
The eigenvalues are normalised and sphericity can be defined:

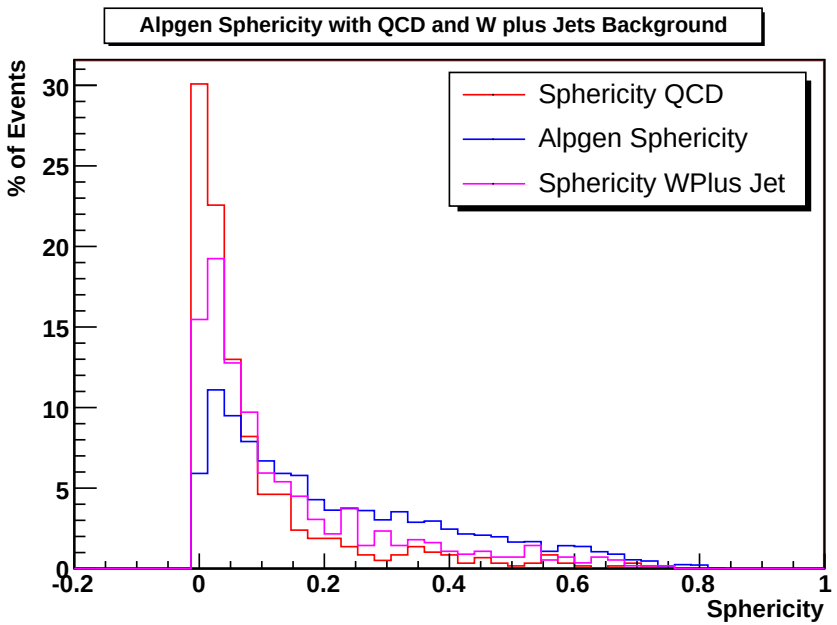
Sphericity

$$S = 3/2(\lambda_2 + \lambda_3) \tag{3}$$

Sphericity III

Signal and background plots for Sphericity





Aplanarity

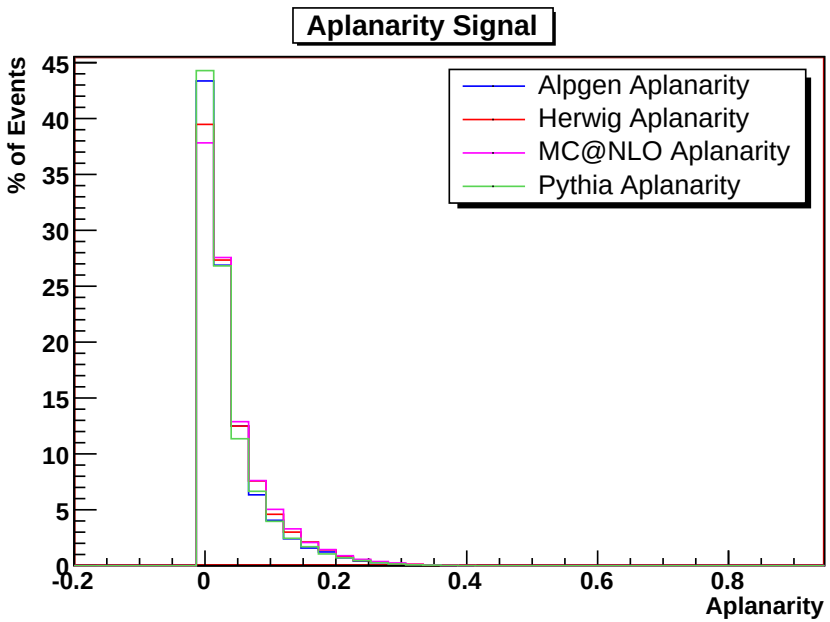
Aplanarity can be obtained through an eigenvalue of the tensor:

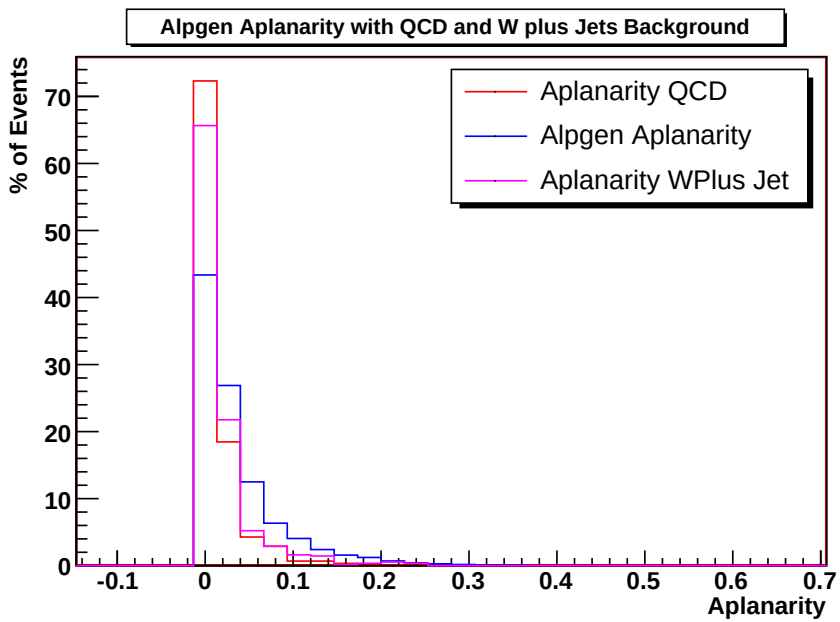
Aplanarity

$$A = \frac{3}{2}\lambda_3 \tag{4}$$

Aplanarity II

Signal and background for aplanarity





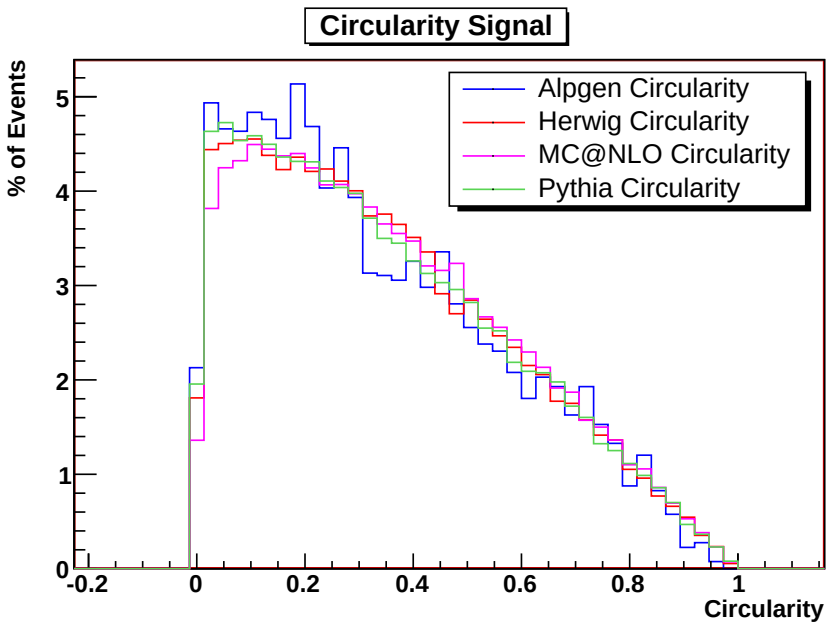
Circularity I

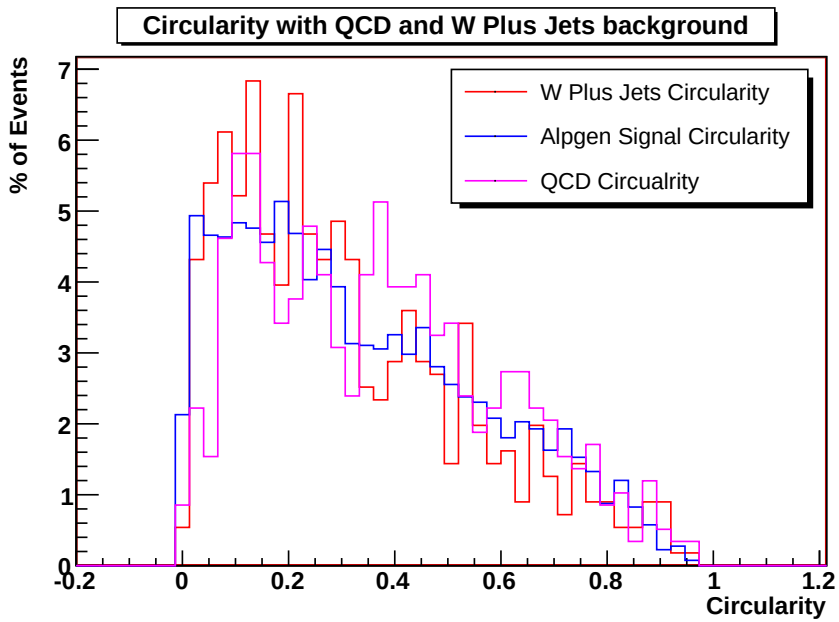
As well as before circularity is given by a combination of eigenvalues

$$C = \frac{2min(\lambda_1; \lambda_2)}{\lambda_1 + \lambda_2} \tag{5}$$

Circularity II

Signal and background circularity





The last event shape variable investigated was centrality. Centrality can be defined in the following way:

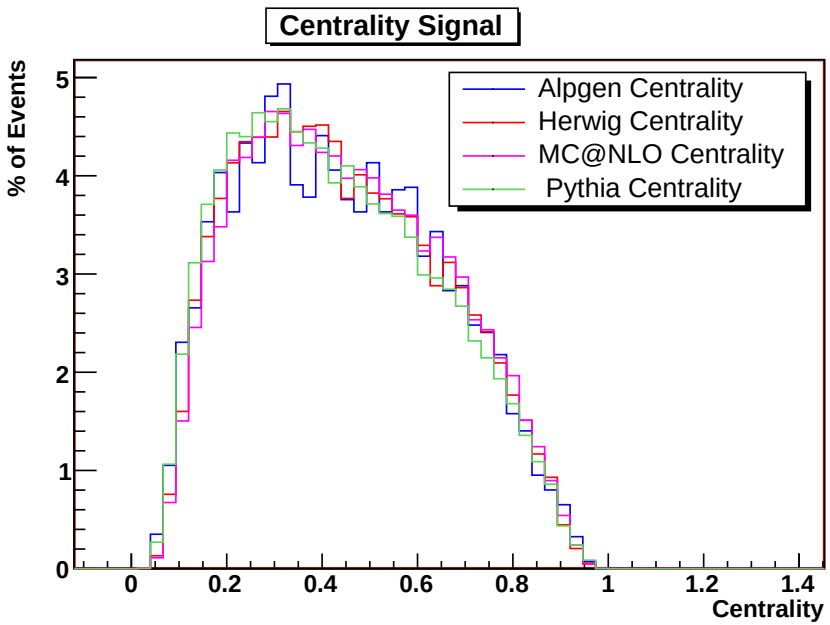
Centrality

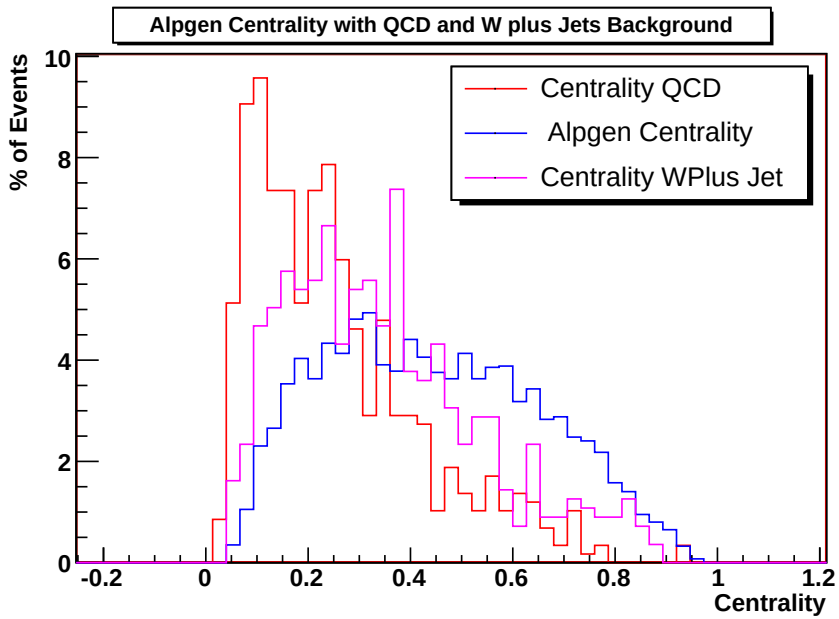
$$Cent = \frac{\sum Pt}{\sum E_{vis}} \tag{6}$$

Again only the Pt of the events with 4 and 5 jets have been looked at.

Centrality II

Signal and background centrality





Results and Summary

Observations

- The shape of an event is generator independent
- For the semileptonic decay channel only centrality appears to be a valuable event shape variable to distinguish between signal and background