Why B-tagging?

Identification of jets formed from b-quark fragmentation is important for many physics analyses.
- Higgs ($H\rightarrow bb$)
- Top ($t\rightarrow Wb$)
- SUSY/Exotics ($X_i\rightarrow X_j b$)
- Standard Model

B-tagging Algorithms in ATLAS

B-jets have a number of unique characteristics which b-tagging algorithms can exploit to identify them.
- The long lifetime of a b-quark allows for the identification of a secondary vertex, located close to the primary vertex.
- The large mass of the b-quark enables discrimination based on the invariant mass of the secondary vertex.

In order to benefit from the b-tagging algorithms available, the tag weight distributions need to be calibrated taking into account the effect of systematic uncertainties. These calibrations are released as scale factors to correct the efficiencies in simulation to those measured in data.

Measuring B-tagging Efficiencies

The top quark to b-quark branching ratio is approximately unity, a single lepton and di-lepton top-pair selection can provide a sample of pure b-jets with kinematics relevant to physics analyses. These methods can calibrate higher transverse momenta jets than dijet methods. The large luminosity delivered at 7 TeV has allowed this method to produce competitive results.

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Top-Pair Methods

The kinematic fit method uses the single lepton top-pair topology to identify a purified sample of b-jets using kinematic constraints. A $X^2$ fit is performed to find the permutation of jets which best satisfies the event hypothesis.

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1. The $p_{rel}$ method uses semi-leptonic muon decays of b-hadrons. Measuring the relative transverse muon momenta creates a variable $p_{rel}$, which has a flavour dependent spectrum. Template fits estimate the flavour fraction of jets in a data sample before and after b-tagging.

2. The systemmL method uses three uncorrelated event selections, one of which uses $p_{rel}$, to solve a set of eight constrained equations to extract b-tag efficiencies.

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Final 2011 B-Tagging Efficiency Scale Factor Combination

Measuring Mistag Rates

Whilst important to know the b-tagging efficiency, it is important to calibrate the contamination in the various taggers coming from the mistagging of jets which come from charm and light decays.

Measuring Charm Jet Efficiency

It is possible to measure the tagging efficiency of a c-jet with b-tagging algorithms, using a $D^*$ analysis. This analysis uses b- and c-jet templates in order to extract the c-jet efficiency using a sample pre- and post-tag. The efficiency is then solved from $c_{\tau} = \frac{f_{c\tau}}{f_{c\tau} + f_{b\tau}}$.

Measuring Light Jet Efficiency

Displaced vertices can be misidentified resulting in the mistagging of light jets. The appearance of these vertices is expected to be symmetric about the primary vertex, whereas true secondary vertices have an asymmetry. Reversing the signed decay length and impact parameters provides negatively tagged events which can be used to estimate the negative tag rate on a sample mainly made of light jets which can be extrapolated to get the mistag rate.

Combination Procedure

- A maximum likelihood fit on the product of constrained Gaussian probability density functions is performed in all transverse momenta and pseudo-rapidity bins to identify the scale factor which gives the best simulation to data correction.
- The combination correlates relevant systematic uncertainties between the different calibration methods. The final b-tag scale factors can then have these components of systematic uncertainties varied individually at the physics analysis level to fully propagate uncertainties.

Future Results and Taggers

For 8 TeV, calibration procedures are being carried out which have produced preliminary results compatible with the corresponding 7 TeV results.

Improvements to b-tagging algorithms have also been taking place, with improvements to MV1 and commissioning of new taggers aimed at improving c-jet rejection, as well as light jet rejection.