Measuring the b-jet tagging efficiency using samples of jets containing muons with ATLAS data

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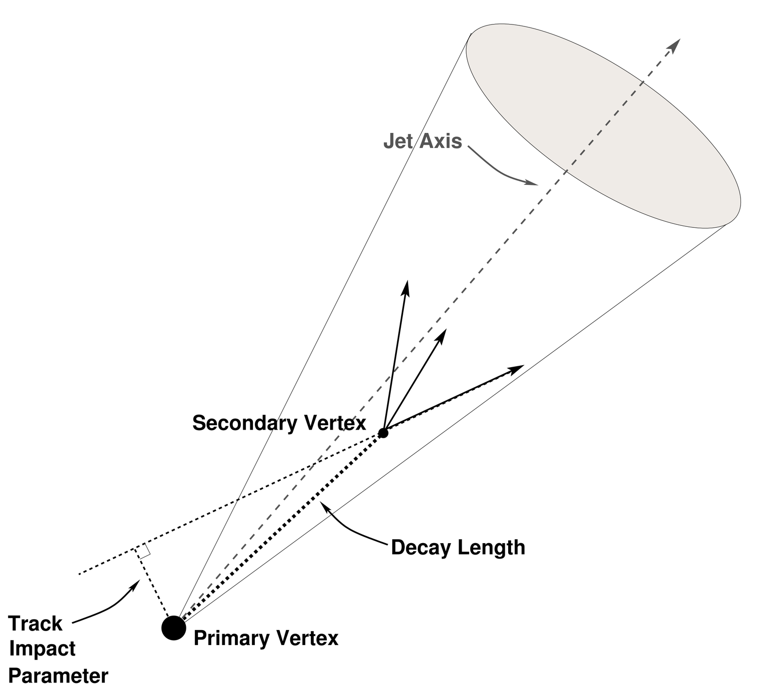
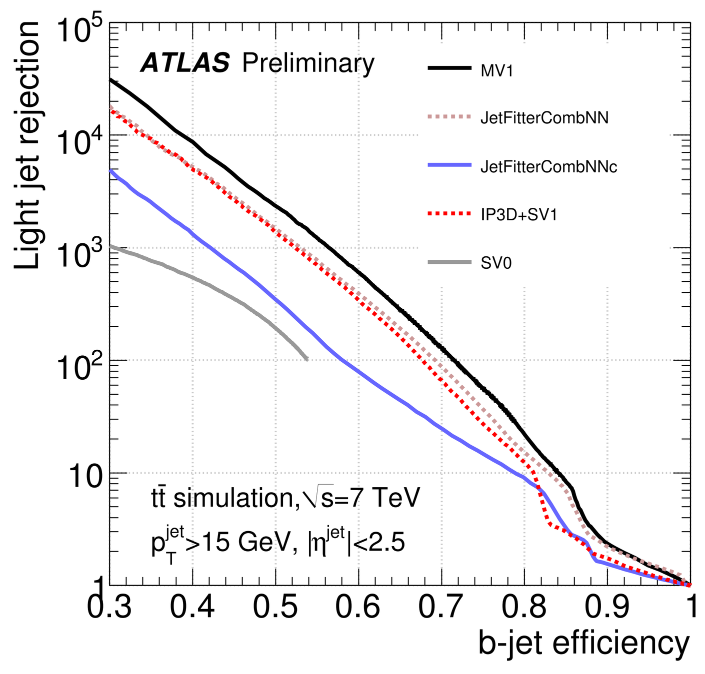
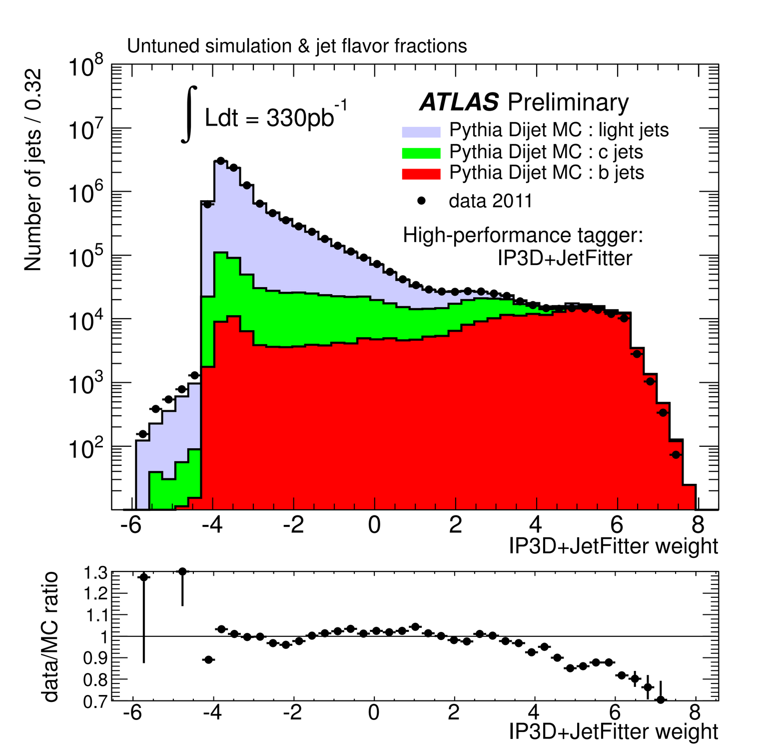
B-Tagging

The tagging of jets originating from b-quarks is used in a large variety of physics analyses for example in the identification of top quarks or in some decay modes of the standard model Higgs boson. B-Tagging uses the properties of the tracks associated to jets to distinguish those originating from heavy-flavour quarks from those originating from light-flavour partons. Due to the long lifetime of b-hadrons the tracks from b-decays tend to have a significant displacement from the primary vertex. If at least two of these tracks are present it may be also possible to reconstruct the decay vertex of the b-hadron.



Each of this algorithms has an output weight which is discriminating between b-jets and light-flavoured jets. All jets which have a higher value in this output distribution than a chosen cut value are considered "b-tagged". "Each cut value, referred to as an operating point, corresponds to a specific b-tagging efficiency and light-flavoured jet rejection.





Calibration of B-Tagging Algorithms

The performance of the b-tagging algorithms needs to be measured in data to enable them to be used in physics analyses. There are several quantities which need to be measured, the efficiency of identifying a b-jet as well as the probabilities of mistakenly tagging a c-jet or a light-flavoured jet as a b-jet.

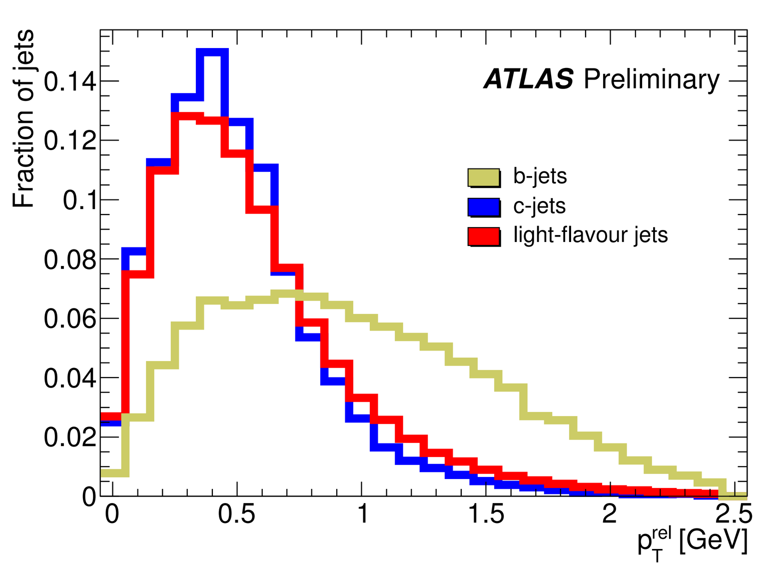
⟹A. Ferretto

This poster focuses on the efficiency of the b-tagging algorithms. Both methods presented use a specific decay mode of the b-quark, the one where it decays into a muon. Other possible techniques would be exploiting the known flavour composition of specific processes, e.g. top-antitop-production.

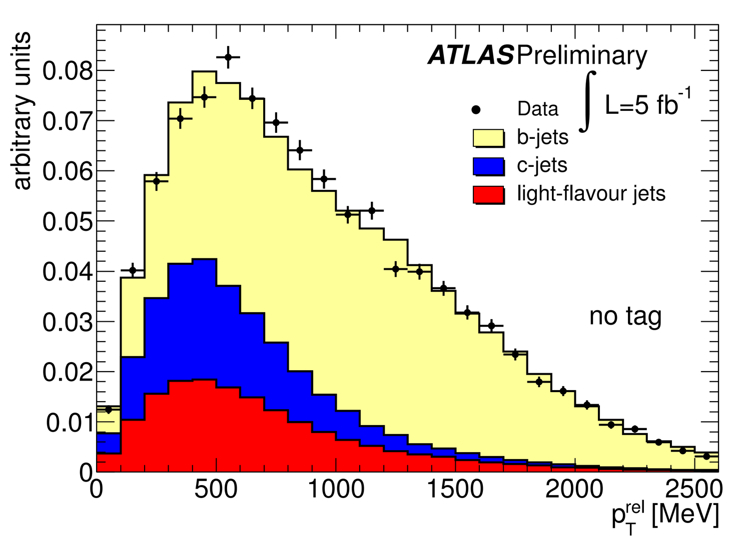
⟹D. Duda

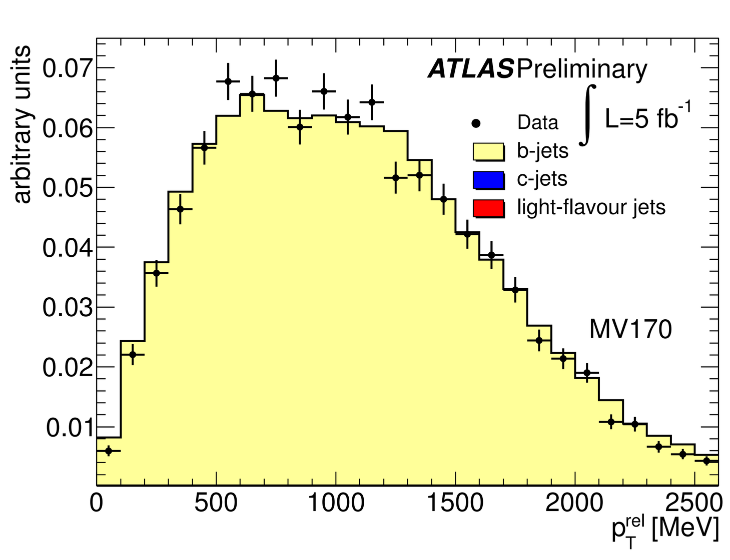
Both muon-based techniques exploit that the properties of the muon from the b-decay can be used to estimate the flavour content of the selected dijet sample in an uncorrelated way to the actual algorithms. In order to improve the b-purity in the sample one jet in the event is required to be tagged by the SV0 b-tagging algorithm. In the p_T^{rel} analysis this sample is used for the complete analysis, in the system8 analysis this is referred to as the "p-sample".

The pTrel Method



The p_T^{rel} method makes use of the p_T of the muon with respect to the muon-jet axis, the so called p_T^{rel}. Since the p_T^{rel} for muons from b-decays is larger than for muons in c- and light-flavoured jets, fitting the p_T^{rel} distribution to templates derived separately for b-, c- and light-flavoured jets can provide a measurement of the flavour composition of the sample. The p_T^{rel} fits are performed both on the b-tagged and non b-tagged samples in order to extract the number of b-jets before and after applying the b-tagging requirement. The ratio of these two numbers is an estimate of the b-tagging efficiency for semileptonic jets.



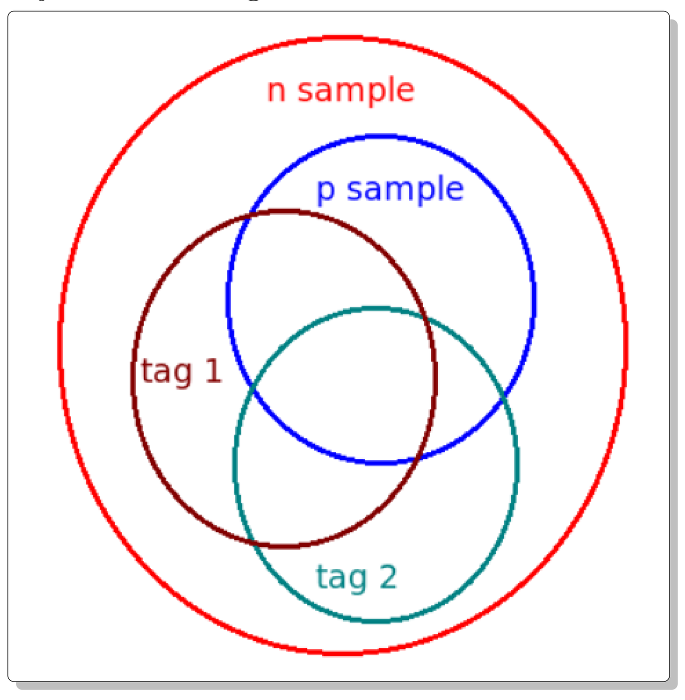


The templates for b- and c-jets are taken from PYTHIA dijet simulation with a specific filter to enhance the fractions of muons in the events. This simulation is not expected to describe the behaviour of light-flavoured jets very well. The template for light-flavoured jets is therefore taken from data where an additional requirement has been made that no jet has been tagged by a very efficient tagging algorithm. Since the p_T^{rel} variable does not separate very well between c- and light-flavoured jets only the amount of b- and non-b-jets has been fitted. To obtain a proper shape for the non-b-template the ratio of c- to light-flavoured jets has been fixed to the prediction of the simulation.

The System8 Method

Similarly to the p_T^{rel} method the system8 method uses jets containing muons. All selected events form the "n"-sample. This sample is further reduced using three independent criteria to build a system of 8 subsets:

- The b-tagging criterion under study ("tag 1")
- A cut on the p_T^{rel} of the muon ("tag 2")
- The presence of a second jet in the event which is tagged by the SV0 tagger ("p sample")

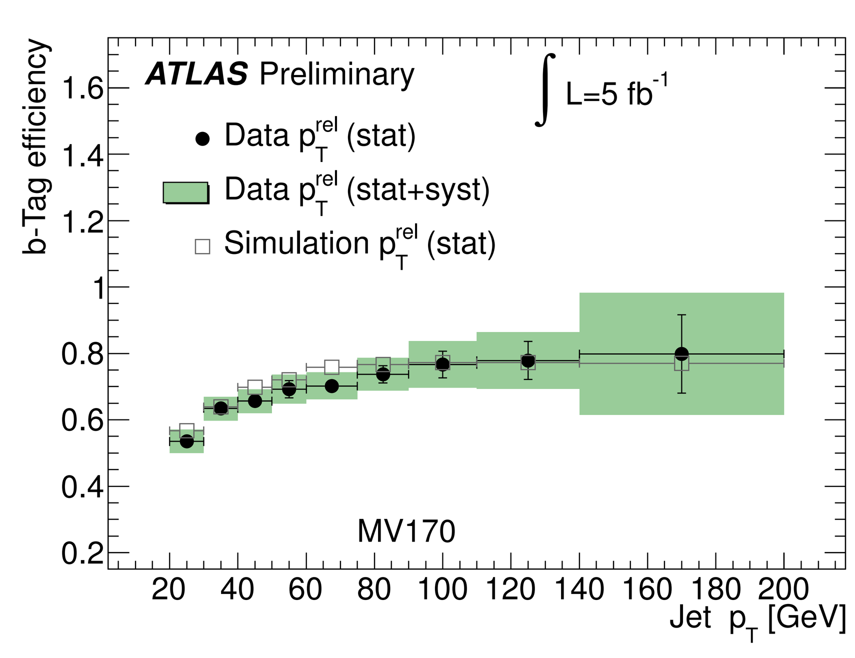


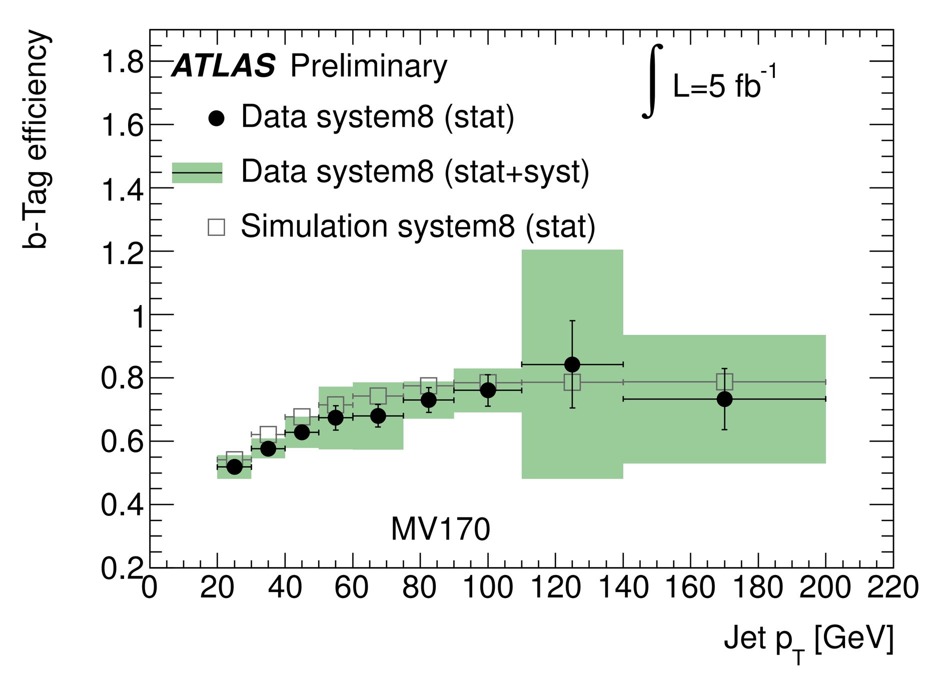
The only input needed from simulation is the level of correlation between the selection criteria defining the 8 disjoint sets and the universality of the tagging efficiencies in the various samples.

The simulation samples used are the same as in the p_T^{rel} analysis.
The modeling of light jets is done by letting a randomly chosen charged particle track model a muon.

Results

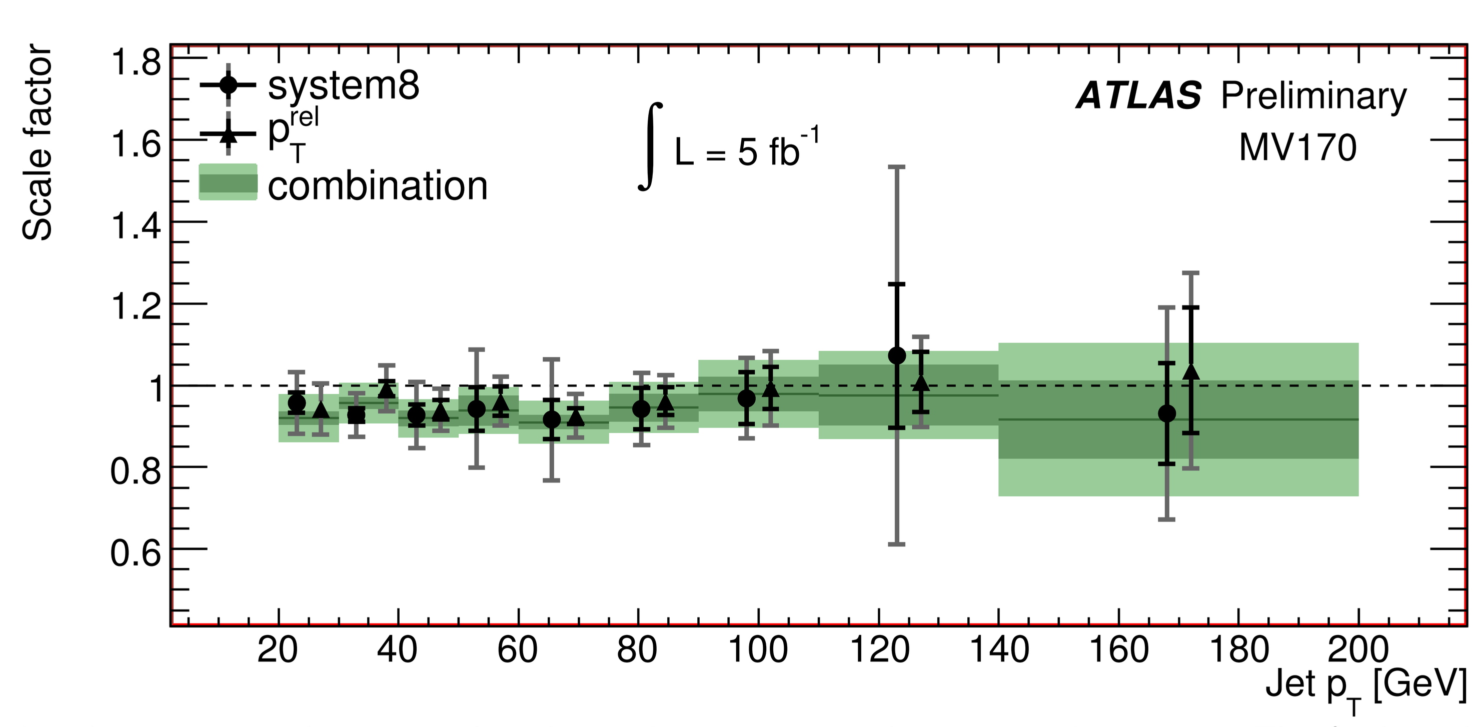
A neural-network-based combination of three complementary input tagging algorithm called MV1 is the best performing ATLAS b-tagging algorithm. Results are shown for an operating point corresponding to a 70% b-tag efficiency. The p_T^{rel} and system8 methods show excellent agreement with each other and show a b-tagging efficiency in data which is compatible with the one of simulated events.
Since both methods rely on similar quantities they share most of the systematic uncertainties. Dominating uncertainties are (depending on the p_T of the jet) simulation statistics, the assumption on the amount of charm- and light-flavoured jets in the non-b-sample and the assumption that any data-to-simulation differences observed in the semileptonic b-jet sample are present also in an inclusive b-jet sample.





⟹G. Watts

Combination



The pTrel and system8 results are combined in order to increase the statistical precision. The final results are presented as data-to-simulation scale factor: $\kappa_b = \frac{\epsilon_b^{data}}{\epsilon_b^{sim}}$. Pseudo-experiments have been performed to estimate the statistical correlation between the p_T^{rel} and the system8 methods. The correlation coefficient was found to be less than 0.66 for all p_T bins.

References

[1] ATLAS-CONF-2012-043 : Measurement of the b-tag Efficiency in a Sample of Jets Containing Muons with $5 fb^{-1}$ of Data from the ATLAS Detector

[2] ATLAS-CONF-2011-102 : Commissioning of the ATLAS high-performance b-tagging algorithms in the 7 TeV collision data