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

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1 Introduction

The identification of jets originating from the decay of b-hadrons is used in many physics channels like top quark and Higgs boson physics.

We describe several algorithms used in the ATLAS experiment [1] to identify b-jets produced in pp collisions at 7 TeV center of mass energy. These algorithms exploit the properties of tracks from b-hadron decays and the existence of secondary vertices in jets to identify them. An example for such an algorithm is the MV1 algorithm, a neural-net-based combination of three SV1, IP3D and JetFitter algorithms [2].

In order for these algorithms to be used in the simulation they must be calibrated by measuring their efficiency in data. One calibration approach is to exploit the fact that muons emerging from b-hadrons carry a relatively high transverse momentum with respect to the axis of the b-jet. That variable $p_{\mathrm{T}}^{\mathrm{rel}}$ is sensitive to the flavour of the original quark and works independently of a specific b-tagging algorithm. Such calibrations are carried out in the so called $p_{\mathrm{T}}^{\mathrm{rel}}$ and system8 methods.

2 Calibration Methods and Results

In the $p_{\mathrm{T}}^{\mathrm{rel}}$ method template fits to the distribution of the muon $p_{\mathrm{T}}^{\mathrm{rel}}$ are performed before and after the tagging criterion to obtain the number of b-jets before and after the decision. The efficiency is then the number of b-jets after the tagging requirement divided by the original number of b-jets. The templates for b- and c-jets are taken from simulation while the template for light-quark jets is taken from data with the additional requirement that no jet in the event is tagged by a very efficient b-tagging algorithm. The resulting light-quark jet sample has a about $(2-6)\%$ contamination of b-jets which needs to be corrected for.

The system8 method uses three criteria to split the jet sample into 8 different sub-samples to build a system of eight equations. One of the three criteria is the b-tagging algorithm which is to be calibrated. Another one is a cut on the $p_{\mathrm{T}}^{\mathrm{rel}}$ of the muon inside the jet. The third criterion is the presence of an opposite side b-tagged jet. In this method the b-tagging efficiency is one of the parameters in the set of equations. A key feature of the method is that the only reliance on simulation it has comes from the correlation between the different criteria.

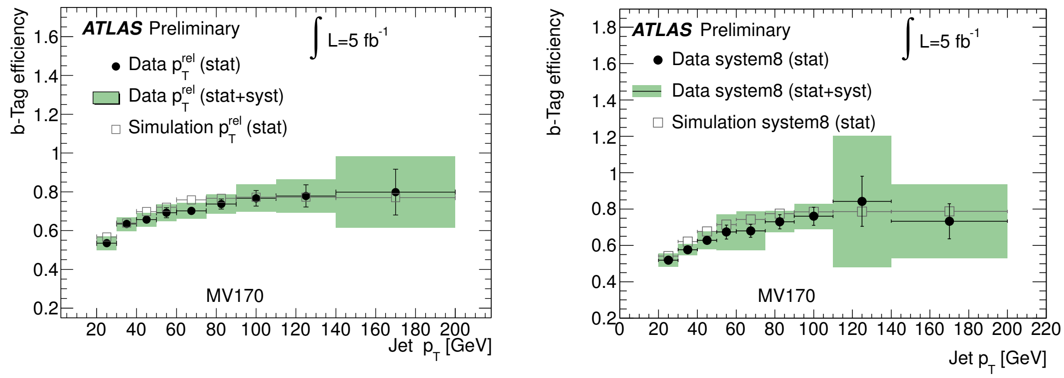

Figure 1: The b-tagging efficiency for the MV1 algorithm at a efficiency of 70% in simulation and measured by the $p_{\mathrm{T}}^{\mathrm{rel}}$ (left) and the system8 (right) methods [3].

Both methods calibrate jets which are based on an anti-k_T algorithm with a cone size of 0.4 using topological clusters in the ATLAS calorimeters. Muons are reconstructed by a statistical combination of the tracks from the muon spectrometer and the inner detector. Additionally the muon is required to have a transverse momentum of at least $p_T > 4\,\mathrm{GeV}$ and to be within the cone of a jet.

As the b-tagging efficiency depends on the transverse momentum of the jet, the measurement is carried out in several bins of p_T, varying from 20 GeV to 200 GeV. Figure 1 shows the efficiency for the MV1 b-tagging algorithm in simulation and the measurement with both methods. The parameters of the algorithm were chosen such that it has 70% b-tagging efficiency in a sample of $t\bar{t}$ simulated events. Both methods show good agreement between data and simulation with a slightly lower efficiency in data then in simulation. The ratio of the efficiency in data and simulation is used as a scale factor to correct the simulation performance.

References

[1] ATLAS Collaboration, JINST **3**, S08003 (2008).

[2] ATLAS Collaboration, ATLAS-CONF-2011-102, `http://cdsweb.cern.ch/record/1369219`

[3] ATLAS Collaboration, ATLAS-CONF-2012-043, `http://cdsweb.cern.ch/record/1435197`