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Calibration of the ATLAS b-tagging algorithm in $t\bar{t}$ events with high multiplicity of jets

Abstract

The calibration of the ATLAS b-tagging algorithm in environments characterised by high multiplicity of jets is presented. The calibration uses reconstructed $t\bar{t}$ candidate events collected by the ATLAS detector in proton-proton collisions at 13 TeV, with a final state containing one charged lepton, missing transverse momentum and at least four jets. The b-tagging efficiencies are measured not only as a function of the most relevant kinematic quantities, such as the transverse momentum or the pseudo-rapidity of the jets, but also as a function of quantities that are sensitive to close-by jet activity. The results extend the regions where data-to-simulation b-tagging scale factors are derived when using dilepton $t\bar{t}$ events.

Introduction

b-tagging

- b-tagging exploits the long lifetime of hadrons containing a b-quark and the presence of recostructed vertices inside a jet
- MV2c10 [1] is the ATLAS b-tagging algorithm for Run-II
- b-tagging is important for various final states, so analyses relying on flavour tagging benefit from a precise b-jet efficiency calibration

Motivation for $t\bar{t}$ ℓ+jets calibration

- $t\bar{t}$ dilepton based b-tagging calibrations [2] [3] are standard in ATLAS
- $t\bar{t}$ ℓ+jets based b-tagging calibration performed in Run-I [4] using tag-and-probe method on single lepton $t\bar{t}$ events ($t\bar{t}$ SL T&P)
- extract b-tagging scale factors for jets with higher p_T with respect to dilepton $t\bar{t}$ calibrations
- explore an environment with high multiplicity of jets and study the effect of close-by jet activity on the b-tagging performance

Selection and reconstruction

Selection requirements

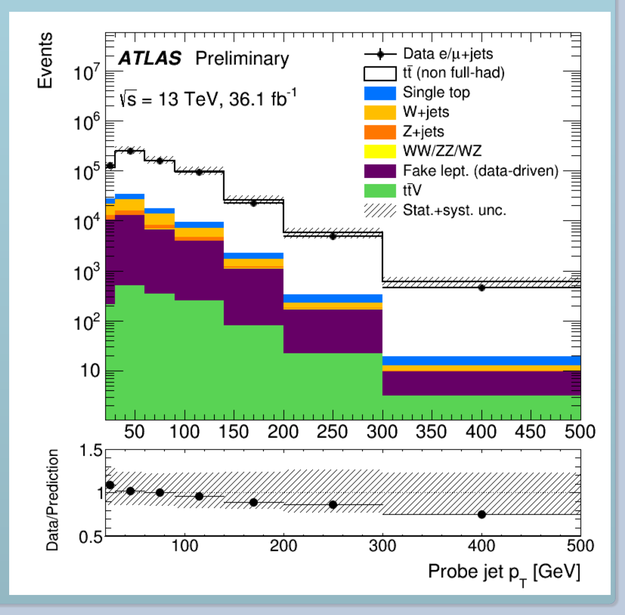
- one lepton (e,μ)
- at least 4 jets
- $E_T^{\text{miss}} > 20$ GeV
- $E_T^{\text{miss}} + M_T^W > 60$ GeV

- Improve the purity of the sample and reduce the background contamination

Reconstruction of $t\bar{t}$ decay

- a kinematic fitter is used to reconstruct the $t\bar{t}$ decay
- jets are assigned to the leptonic b-jet, W-hadronic jets and hadronic b-jet
- hadronic b-jet is the probe jet

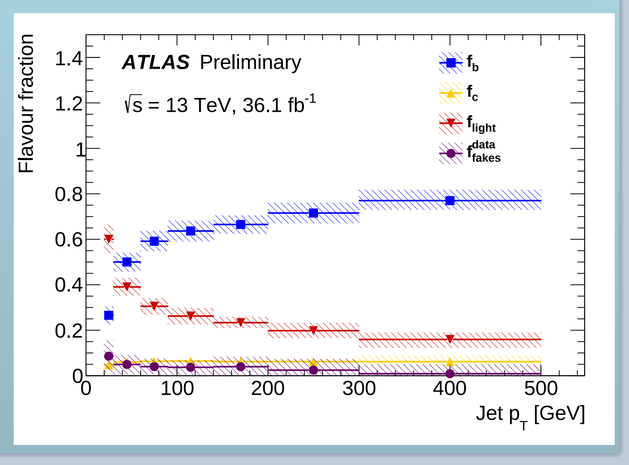
- The hadronic side of the $t\bar{t}$ decay is chosen since it provides higher jet multiplicity near the probe jet



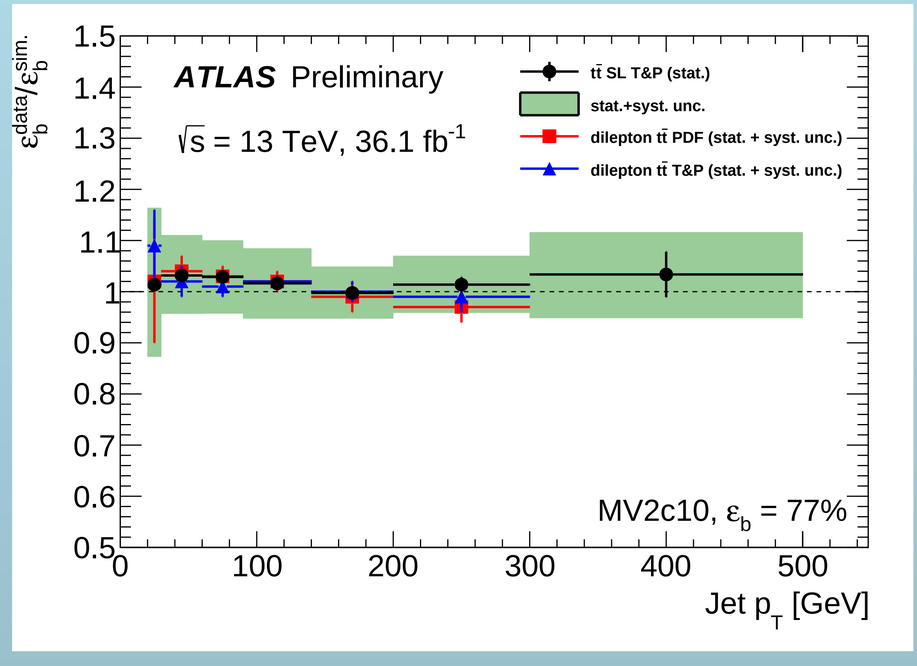
Measurement of the b-tagging efficiency in data

$$\varepsilon_b = \frac{1}{f_b} \cdot \left(f_{\text{tag}} - \varepsilon_c f_c - \varepsilon_{\text{light}} f_{\text{light}} - \varepsilon_{\text{fake}} f_{\text{fake}}\right)$$

- f_b,f_c and f_{light} denote the fractions of $b-$, $c-$ and light-flavour jets within the sample of probe jets and they are estimated by the Monte Carlo simulations
- f_{fake} is the fraction of jets coming from the multijet background estimated from data
- f_{tag} is the fraction of jets tagged by MV2c10
- the mistag efficiencies ε_c and $\varepsilon_{\text{light}}$ for $c-$ and light-flavour jets respectively, are taken from the simulation
- the tagging efficiency of the jets coming from QCD multijet events $\varepsilon_{\text{fake}}$ is extracted from a control region in data
- the scale factor is defined as the ratio between the b-tagging efficiency measured in data $\varepsilon_b^{\text{data}}$ and the b-tagging efficiency obtained from the simulation $\varepsilon_b^{\text{sim.}}$.



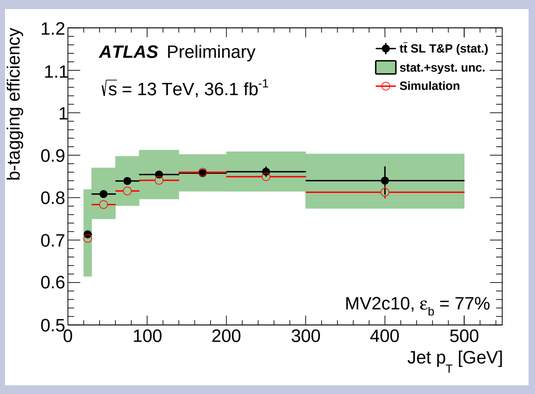
Comparison with dilepton $t\bar{t}$ calibrations

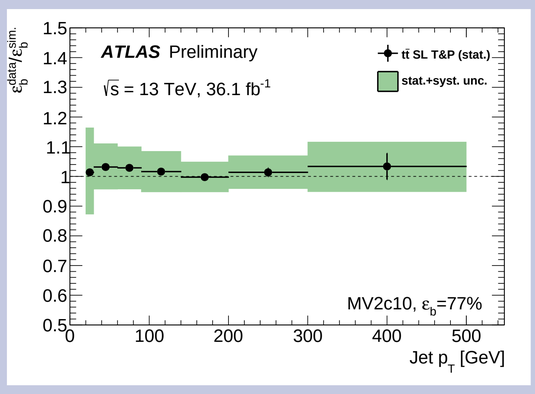


- the results obtained with the tag-and-probe method on $t\bar{t}$ SL events ($t\bar{t}$ SL T&P) are shown as black dots
- the results by using the combinatorial likelihood (PDF) method on $t\bar{t}$ dilepton events (dilepton $t\bar{t}$ PDF) [5] are shown as red squares
- the results obtained with the tag-and-probe method on $t\bar{t}$ dilepton events (dilepton $t\bar{t}$ T&P) [6] are shown as blue triangles

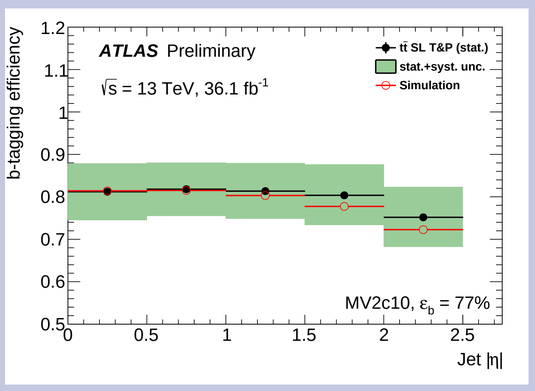
Results

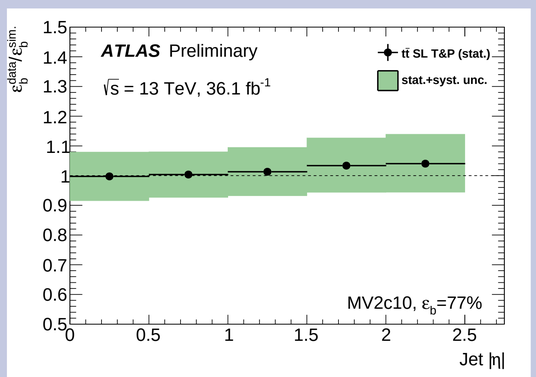
b-tagging efficiencies and scale factors as a function of jet p_T



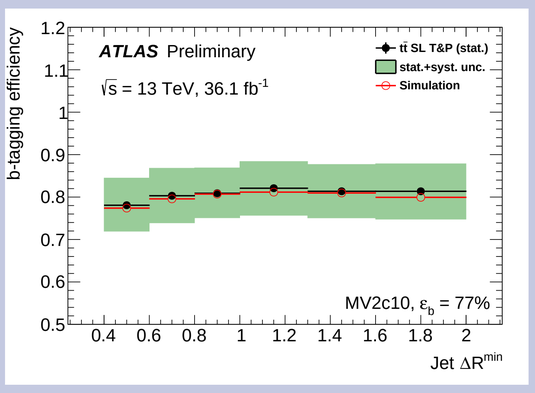


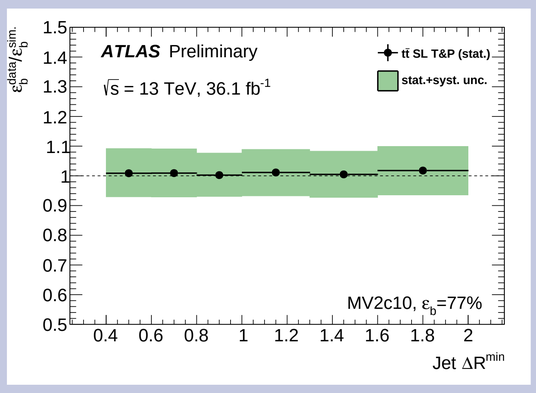
b-tagging efficiencies and scale factors as a function of jet $|\eta|$





b-tagging efficiencies and scale factors as a function of the angular separation between the probe jet and its nearest neighbouring jet ΔR^{min}





Conclusion and outlook

- The results of the $t\bar{t}$ calibration using ℓ+jets events are compatible with the results obtained by using dilepton $t\bar{t}$ events with PDF and T&P methods. This technique allows the calibration to be extracted for jets of up to 500 GeV, beyond the reach of the dilepton $t\bar{t}$ method.
- The method can explore the b-tagging efficiency in an environment with high multiplicity of jets. The small degradation in b-tagging efficiency in the presence of nearby jet activity is well-described by the simulation.

Bibliography

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[5] The ATLAS Collaboration, *b-tagging calibration plots using dileptonic $t\bar{t}$ events produced in pp collisions at $\sqrt{s} = 13$ TeV and a combinatorial likelihood approach*, FTAG-2016-003.

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