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Tau reconstruction, energy calibration and identification at ATLAS

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Abstract. Tau leptons play a central role in the LHC physics programme, in particular as an important signature in many Higgs boson and supersymmetry searches. They are further used in Standard Model electroweak measurements, as well as detector-related studies like the determination of the missing transverse energy scale. Copious backgrounds from QCD processes call for both efficient identification of hadronically decaying tau leptons, as well as large suppression of fake candidates. A solid understanding of the combined performance of the calorimeter and tracking detectors is also required. We present the current status of the tau reconstruction, energy calibration and identification with the ATLAS detector at the LHC. Identification efficiencies are measured in $W \to \tau\nu$ events in data and compared with predictions from Monte Carlo simulations, whereas the misidentification probabilities of QCD jets and electrons are determined from various jet-enriched data samples and from $Z \to ee$ events, respectively. The tau energy scale calibration is described and systematic uncertainties on both energy scale and identification efficiencies discussed.

Keywords. ATLAS; Large Hadron Collider; tau physics; performance.

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1. Introduction

Tau leptons are massive (1.777 GeV/c) short-lived (2.9×10^{-13}s) particles playing a significant role in the search for the Standard Model Higgs boson and supersymmetry. They are recognized in the ATLAS detector via their hadronic decays [1]. The main challenge in recognizing these decays lie in differentiating them from QCD jets. Distinguishing features such as the number of final-state particles, the width of the energy depositions in the calorimeter, the displacement of the secondary vertex and the small invariant mass are used to overcome this challenge.

2. Reconstruction

Tau candidates are found by scanning the ATLAS calorimeter for jets with a transverse momentum (p_{T}) higher than 10 GeV. Tracks in the angular vicinity of the jet barycentre

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($\Delta R = 0.2$) are associated with the tau candidate. The associated tracks and calorimeter information from the jet are then used to calculate a number of identification variables. Tau candidates are treated differently whether they have one or multiple tracks.

3. Energy calibration

For each tau candidate, an energy scale correction is applied to the sum of the calibrated energy clusters with noise suppression found within $\Delta R = 0.2$ of the candidate's barycentre. The tau energy scale is obtained from the measured transverse momentum by scaling it to its expected value from Monte Carlo simulation of tau decays in the detector. Different response functions as a function of p_{T} are derived depending on the track multiplicity and the pseudorapidity of the tau candidate.

4. Identification

Three separate identification methods are maintained. Each of them is based on the identification variables calculated during reconstruction. The simplest method is a cut-based approach for which the cuts have been parametrized by the transverse momentum of tau candidates. The second method (likelihood) consists of taking the logarithm of the ratio of the joint probability of the identification variables for signal over the joint probability for background. The third method consists of boosted decision trees which define regions in the multidimensional space defined by the identification variables. These regions are each assigned a score which tells how likely it is that they contain a signal. Figure 1 shows the mass spectrum after $Z \to \tau\tau$ event selection in ATLAS data [2]. Figure 2 shows the track spectrum for tau candidates in the same events.

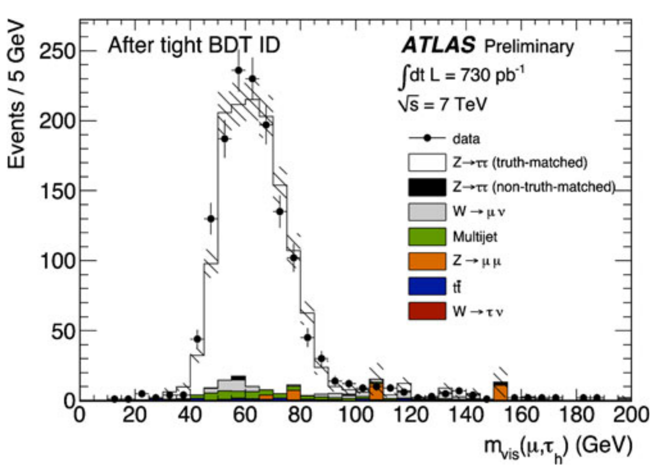

Figure 1. Ditau invariant mass spectrum after $Z \to \tau\tau$ event selection in ATLAS data, where one tau decays hadronically and the other one decays to a muon and a neutrino [2].

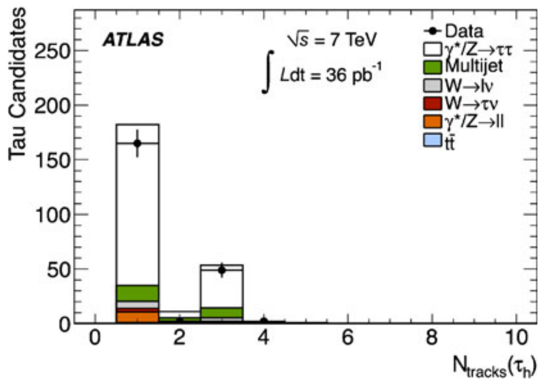

Figure 2. Track spectrum for tau candidates after $Z \to \tau\tau$ event selection in ATLAS data, where one tau decays hadronically and the other one decays to a muon and a neutrino [2].

5. Identification efficiency in data

Tau identification efficiency has been measured in data using $W \to \tau\nu$ events [3]. A first method was used, selecting events with large missing E_{T}, and measuring the efficiency

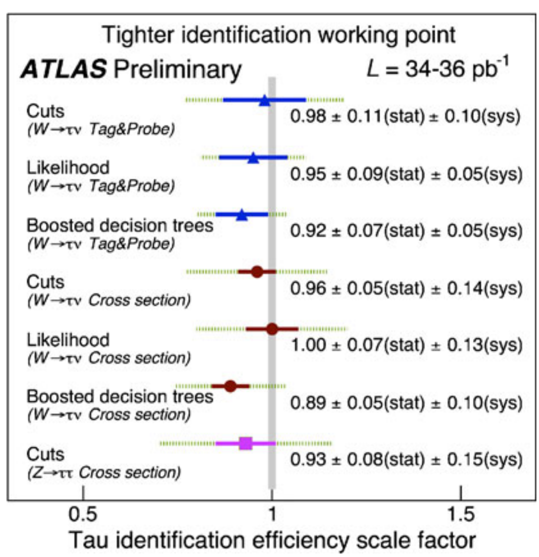

Figure 3. Tau identification efficiency scale factors to the efficiency predicted in Monte Carlo simulation for different tau identification methods, measured via both the $W \to \tau\nu$ tag and probe and cross-section methods [3].

of the tau candidate, by fitting the track multiplicity spectrum to determine the signal purity. A second method compared the expected signal yield of $W \to \tau\nu$ events with the observed number of events in data. Both methods are consistent with Monte Carlo prediction within 7–15% uncertainty. Figure 3 shows the tau identification efficiency scale factors to the efficiency predicted in Monte Carlo simulation for different tau identification methods.

References

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