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Electron efficiency measurement at low energies with J/ψ in ATLAS

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The J/ψ meson is one of the few "standard candles" that are used to calibrate the ATLAS detector and measure its performance. The $J/\psi \to e^+e^-$ channel is the most abundant source of low transverse momentum isolated electrons in ATLAS. We present a measurement of the electron identification efficiencies with 2010 proton-proton collision data at $\sqrt{s} = 7$ TeV corresponding to an integrated luminosity of about 40 pb^{-1}, for electrons with a transverse energy between 4 GeV and 20 GeV, in the pseudorapidity range $|\eta| < 2.5$. This measurement was made with a tag-and-probe method applied to $J/\psi \to e^+e^-$ events.

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1. Electron trigger, reconstruction and identification

A full description of the ATLAS detector can be found in Ref. [1]. The two main sub-systems used in the reconstruction and identification of electrons are the inner tracker - made of a pixel silicon detector, a silicon micro-strips detector and of a Transition Radiation Tracker (TRT) - and the lead/liquid-argon sampling electromagnetic calorimeter.

To keep the data recording rate within the processing capabilities ($\sim$ 200Hz), only a fraction of the data selected by higher rate triggers is recorded, and the rejection rate (prescale) of each trigger increases with instantaneous luminosity. $J/\psi \to e^+e^-$ events were selected using a set of low transverse energy (E_T) single electron triggers with E_T-thresholds between 5 and 10 GeV. Towards the end of 2010 another trigger was also implemented, requiring a second electromagnetic cluster with $E_T > 4$ GeV.

The electron reconstruction begins with the creation of seed energy clusters in the electromagnetic calorimeter with significant energy. In the standard "sliding window" algorithm, seed clusters are a fixed-size rectangular window with $E_T > 2.5$ GeV. Electrons are reconstructed from these clusters if there is a suitable match with a track of $p_T > 0.5$ GeV.

The electron identification relies on reference sets of rectangular cuts which have progressively stronger jet rejection factor and decreasing efficiency. "Medium" electrons pass cuts on hadronic leakage, lateral shower shapes, track quality and track matching. In addition, "tight" electrons also pass cuts on TRT variables and tighter cuts on track quality and track matching [2].

2. The tag-and-probe method applied to $J/\psi \to e^+e^-$ events

A set of $J/\psi \to e^+e^-$ event candidates was selected, by applying stringent identification cuts (typically tight requirements) on one electron - the tag - but not on the other one - the probe - of each event. The selected probes - about 6000 in 2010 collision data - provide a sample of unbiased electrons, on which any selection cut can then be applied to measure its efficiency. The

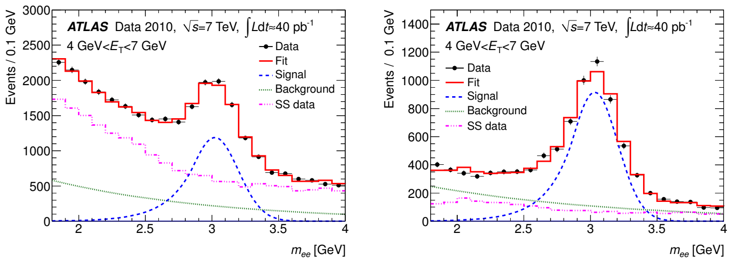

Figure 1: Distributions of the dielectron invariant mass of $J/\psi \to e^+e^-$ candidate events before applying identification cuts (left) and after medium cuts (right) on the probes, for probes with 4 GeV $< E_T <$ 7 GeV.

invariant mass of the opposite-charge electron pair is used as a discriminating variable to subtract the background contamination. For each bin of probe E_T, a fit of the invariant mass is performed, as shown in Figure 1. The signal contribution is modelled by a Crystal-Ball function. The background contribution is modelled by a data-driven component based on the spectrum of same-sign electron pairs - describing the shape of random combinations of fake or real electrons - in addition to a decreasing exponential component. This method allowed to extract the efficiencies in 4 E_T bins, given the available statistics in 2010, as shown in Figure 2 (top).

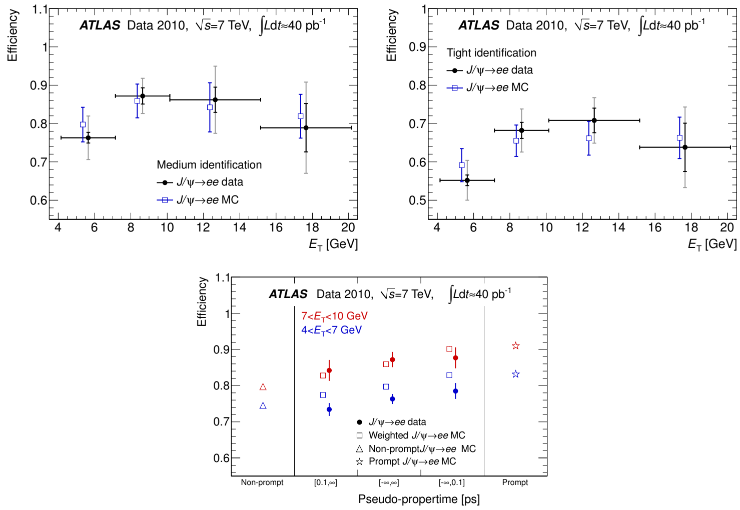

Figure 2: Top: electron identification efficiencies measured from $J/\psi \rightarrow e^+e^-$ events and predicted by Monte-Carlo (MC) for medium (left) and tight (right) selection cuts as a function of E_T. For data, the total (outer bars) and the statistical (inner bars) uncertainties are shown. For MC, only the total uncertainties are shown. Bottom: electron identification efficiency for medium selection cuts for $4 < E_T < 7$ GeV (blue) and $7 < E_T < 10$ GeV (red) measured from data and predicted by MC for different ranges of pseudo-propertime, and predicted by pure prompt and non-prompt J/ψ MC.

The sample of selected electron probes is a mix of isolated electrons from prompt J/ψ mesons and of non-isolated electrons from non-prompt J/ψ mesons produced via B-hadron decays. Their fraction depends on the electron E_T. These samples can be discriminated by using the pseudo-propertime of the J/ψ candidate[1]. Figure 2 (bottom) shows the increase of the efficiencies measured from MC as the fraction of non-prompt decays decreases. The data show the same trend but more statistics will be needed to measure precisely the variation of the efficiency with the fraction of decays from prompt J/ψ production in the data, and to separate the two samples.

Several sources of systematic uncertainties were studied such as the fitting range, the integration range and the background and signal models for the fitting of the invariant mass. For the predictions from MC, the uncertainties linked to the non-prompt J/ψ fraction were studied, as well as the effect of the modelling of the mixture of triggers used. Figure 2 shows a good agreement between data and MC for the E_T dependence of the efficiencies. The shape can be attributed to the increasing contribution with E_T of non-isolated electrons from non-prompt J/ψ, for which the efficiency is significantly lower at all E_T than for electrons from prompt J/ψ.

References

[1] G. Aad *et al.* [ATLAS Collaboration] "The ATLAS Experiment at the CERN Large Hadron Collider" JINST **3** (2008) S08003.

[2] G. Aad *et al.* [ATLAS Collaboration] "Electron performance measurements with the ATLAS detector using the 2010 LHC proton-proton collision data" *submitted to Eur. Phys. J. C* arXiv:1110.3174v1 [hep-ex]

[1] The pseudo-propertime is defined as: $\tau_0 = \frac{L_{xy}.M}{p_T.c}$ where L_{xy} is the distance between the primary vertex and the extrapolated common vertex of the two electrons in the transverse plane, M (p_T) is the reconstructed mass (transverse momentum) of the J/ψ candidate, and c the speed of light.