Measurement of inclusive lepton cross-sections with the ATLAS detector

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An understanding of electron and muon production in proton-proton (pp) collisions is a prerequisite for measurements and searches including these particles in the final state. Moreover, the inclusive production of these particles can be used to constrain theoretical predictions for heavy-flavour production, for which large uncertainties exist.

The p_T spectra of inclusive electrons and muons were measured; comparisons to theoretical predictions are also reported. In particular, theoretical predictions for heavy-flavour production obtained from fixed order next-to-leading order calculations with next-to-leading log high-p_T resummation (from the FONLL program [2]) can be probed directly for the first time at the LHC. A detailed description of the analysis can be found in [1] and additional information is in the references therein.

The data sample was collected at $\sqrt{s}$=7 TeV during April-August 2010. Requirements were made on the detector conditions and data quality, yielding total integrated luminosities of 1.28±0.04 pb^{-1} and 1.42±0.05 pb^{-1} for the electron and muon analyses, respectively. Events were selected using the hardware-based first-level calorimeter or muon triggers; a collision vertex with more than two associated tracks was also required. Electron and muon candidates were required to pass several identification criteria based on track matching and quality. In addition to prompt signal leptons from heavy-flavour and W/Z/γ^* decays, candidate leptons comprise a significant background component: conversion electrons, jets faking electrons, muons from π decays in flight, misidentified muons and muons from hadronic showers in the calorimeters. The signal fraction is extracted from a fit using the distributions of few discriminating variables. The analysis is performed in the acceptance region $7 < p_T < 26$ GeV and within $|\eta| < 2.0$, excluding $1.37 < |\eta| < 1.52$, for electrons and in the extended p_T range $4 < p_T < 100$ GeV within $|\eta| < 2.5$ for the muons. In the electron analysis, the accepted cross-section of W/Z/γ^* decays (based on the PYTHIA expectation) is subtracted before applying the correction factors, applicable to heavy-flavour electrons. The measured heavy-flavour electron cross-section as measured in the p_T and η regions of our selection is σ^e_{HF}=0.946±0.020(stat.)±0.146(syst.)±0.032(lumi.)μb. The cross-section for inclusive muons as measured in the extended p_T and η region results to be $\sigma^{\mu}_{Inc.}$=6.55±0.01(stat.)±0.37(syst.)±0.22(lumi.)μb. In order to compare to the results of the electron analysis, the muon cross-section has been studied in

the same acceptance region as for electrons and with the subtraction of the W/Z/γ^* contribution, giving a heavy-flavour muon cross-section of σ^{μ}_{HF}=0.818±0.003(stat.) ±0.036(syst.)±0.028(lumi.)μb.

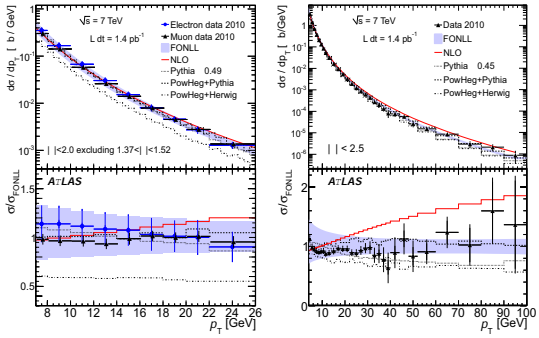

Figure 1: (Left) Electron and muon differential cross-sections as a function of the charged lepton transverse momentum in the electron acceptance region. (Right) Muon differential cross-section as a function of the muon transverse momentum for $|\eta| < 2.5$. The ratio of the measured cross-section and the other predicted cross-sections to the FONLL calculation is given in the bottom of each plot. The PYTHIA (L0) cross-sections are normalized to the data in order to compare the shape of the spectra.

The measured differential cross-sections of electrons and muons arising from heavy-flavour production (shown in Fig.1) are found to be in good agreement in the acceptance of the electron selection (left). In the figure, the prediction from FONLL and other Monte Carlo programs are also shown. The theoretical uncertainties in FONLL (shown as a band in the figure) are in the approximate range 20-40%, decreasing with p_T. The dominant contribution comes from the renormalisation and factorization scales (up to 35% at low p_T). The uncertainty on the heavy quark masses contributes up to 9% at low p_T, and the PDF related uncertainty is below 8%. The theoretical predictions for heavy-flavour production from the FONLL computation are in good agreement with the electron and muon measurements. Comparisons are also made to the NLO central value expectation obtained from the FONLL program by excluding the NLL resummation part of the perturbative QCD calculation. As shown in Fig.1 (right), the data deviate from the NLO prediction. Good agreement is also seen with the predictions of POWHEG+PYTHIA, although POWHEG+HERWIG predicts a lower total cross-section.

References

[1] Measurements of the electron and muon inclusive cross-sections in proton-proton collisions at sqrt(s) = 7 TeV with the ATLAS detector, ATLAS Collaboration, arXiv:1109.0525 [hep-ex] (2011) - Submitted to Phys. Lett. B.

[2] M. Cacciari, S. Frixione, M. L. Mangano, P. Nason and G. Ridolfi, JHEP 0407 (2004) 033.