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Measurement of $D^{*\pm}$, $D^{\pm}$ and $D_s^{\pm}$ meson production cross sections in pp collisions at $\sqrt{s} = 7$ TeV with the ATLAS detector

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Abstract

The production of $D^{*\pm}$, $D^{\pm}$ and $D_s^{\pm}$ charmed mesons has been measured with the ATLAS detector in pp collisions at $\sqrt{s} = 7$ TeV at the LHC, using data corresponding to an integrated luminosity of 280 nb^{-1}. The charmed mesons have been reconstructed in the range of transverse momentum $3.5 < p_{\mathrm{T}}(D) < 100$ GeV and pseudorapidity $|\eta(D)| < 2.1$. The differential cross sections as a function of transverse momentum and pseudorapidity were measured for $D^{*\pm}$ and $D^{\pm}$ production. The next-to-leading-order QCD predictions are consistent with the data in the visible kinematic region within the large theoretical uncertainties. Using the visible D cross sections and an extrapolation to the full kinematic phase space, the strangeness-suppression factor in charm fragmentation, the fraction of charged non-strange D mesons produced in a vector state, and the total cross section of charm production at $\sqrt{s} = 7$ TeV were derived.

1. Introduction

Measurements of heavy-quark production at the Large Hadron Collider (LHC) provide a means to test perturbative quantum chromodynamics (QCD) calculations at the highest available collision energies. Since the current calculations suffer from large theoretical uncertainties, the experimental constraints on heavy-quark production cross sections are important for mea-

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surements in the electroweak and Higgs sectors, and in searches for new physics phenomena, for which heavy-quark production is often an important background process.

Charmed mesons are produced in the hadronisation of charm and bottom quarks, which are copiously produced in pp collisions at $\sqrt{s} = 7$ TeV. The ATLAS detector[1] [1] at the LHC has been used previously to measure D^{*+} mesons[2] produced in jets [2] and in bottom hadron decays in association with muons [3]. Associated production of D mesons and W bosons has been also studied by the ATLAS Collaboration [4]. Production of D mesons in the hadronisation of charm quarks has been studied by the ALICE Collaboration in the central rapidity range ($|y| < 0.5$) [5,6] and by the LHCb Collaboration at forward rapidities ($2.0 < y < 4.5$) [7]. Open-charm production was also measured by the CDF Collaboration [8] at the Tevatron collider in $p\bar{p}$ collisions at $\sqrt{s} = 1.96$ TeV.

In this paper, measurements of the inclusive D^{*+}, D^+ and D_s^+ production cross sections and their comparison with next-to-leading-order (NLO) QCD calculations are presented. Contributions from both charm hadronisation and bottom hadron decays have been included in the measured visible D production cross sections and in the NLO QCD predictions. The measured visible cross sections have been extrapolated to the cross sections for D meson production in charm hadronisation in the full kinematic phase space, after subtraction of the cross-section fractions originating from bottom production. The extrapolated cross sections have been used to calculate the total cross section of charm production in pp collisions at $\sqrt{s} = 7$ TeV and two fragmentation ratios for charged charmed mesons: the strangeness-suppression factor and the fraction of charged non-strange D mesons produced in a vector state.

2. The ATLAS detector

A detailed description of the ATLAS detector can be found elsewhere [1]. A brief outline of the components most relevant to this analysis is given below.

The ATLAS inner detector has full coverage in ϕ, covers the pseudorapidity range $|\eta| < 2.5$ and operates inside an axial magnetic field of 2 T of a superconducting solenoid. It consists of a silicon pixel detector (Pixel), a silicon microstrip detector (semiconductor tracker, SCT) and a transition radiation tracker (TRT). The inner-detector barrel (end-cap) parts consist of 3 (2×3) Pixel layers, 4 (2×9) double-layers of single-sided SCT strips and 73 (2×160) layers of TRT straws. The TRT straws enable track-following up to $|\eta| = 2.0$.

The calorimeter system is placed outside the solenoid. A high-resolution liquid-argon electromagnetic sampling calorimeter covers the pseudorapidity range $|\eta| < 3.2$. This calorimeter is complemented by hadronic calorimeters, built using scintillating tiles in the range $|\eta| < 1.7$ and liquid-argon technology in the end-cap ($1.5 < |\eta| < 3.2$). Forward calorimeters extend the coverage to $|\eta| < 4.9$.

The ATLAS detector has a three-level trigger system [9]. For the measurement of D mesons with $3.5 < p_T < 20$ GeV (low-p_T range), two complementary minimum-bias triggers are used.

[1] The ATLAS coordinate system is a Cartesian right-handed system, with the coordinate origin at the nominal interaction point. The anti-clockwise beam direction defines the positive z-axis, with the x-axis pointing to the centre of the LHC ring. Polar (θ) and azimuthal (ϕ) angles are measured with respect to this reference system, which corresponds to the centre-of-mass frame of the colliding protons. The pseudorapidity is defined as $\eta = -\ln\tan(\theta/2)$ and the transverse momentum is defined as $p_T = p\sin\theta$. The rapidity is defined as $y = 0.5\ln((E + p_z)/(E - p_z))$, where E and p_z refer to energy and longitudinal momentum, respectively.

[2] Hereafter, charge conjugation is implied.