Open heavy flavour production in pp collisions at $\sqrt{s} = 7$ TeV with ALICE at the LHC

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ALICE (A Large Ion Collider Experiment) is the LHC experiment dedicated to the study of the Quark Gluon Plasma (QGP) in Pb-Pb collisions. Heavy quarks are ideal probes to explore the QGP formation and properties, since they experience the full collision history and are expected to be abundantly produced at the LHC. It is of great importance to measure the heavy flavour cross section not only in Pb–Pb collisions, but also in pp collisions. ALICE measures heavy quark production both at central and forward rapidity, using hadronic decays of D mesons and semi-leptonic decays of D and B mesons. We report on the measurements of heavy quark production in pp collisions at $\sqrt{s} = 7$ TeV.

1 Introduction

Heavy quarks are a well-suited tool to probe the high-density state of strongly-interacting matter formed in heavy ions collisions at ultra-relativistic energies, because they are produced in the early stage of the collision and they can subsequently interact with the medium, via the mechanisms of elastic and inelastic parton energy loss [1]. In pp collisions, besides providing the reference for the Pb–Pb results, the measurement of charm and beauty cross sections has a great interest per se, as a test of perturbative QCD calcualtions of heavy quark production at LHC energies. The design of ALICE [2] allows for the measurement of open heavy flavour down to low momenta, both in the hadronic (at central rapidity, -0.5 $< y <$0.5) and leptonic decay channels (at forward rapidity, 2.5 $< y <$4). We describe heavy-flavour production measurements for 7 TeV pp collisions. Measurements have been performed also for pp collisions at $\sqrt{s} = 2.76$ TeV [3], but are not covered here. In section 2 the detector, its performance and the data samples relevant for the analyses presented here are briefly described. Section 3 presents the results of open charm reconstruction and the inclusive cross section measurement via hadronic channels at central rapidity. In sections 4 and 5 the heavy-flavour inclusive cross section measurement in leptonic channels are summarized: electrons in the central rapidity region, muons at forward rapidity.

2 ALICE detector and data taking

The ALICE detector is composed of a central barrel, with tracking, vertexing and particle identification (PID) detectors, and a forward muon spectrometer, where muons are reconstructed and identified. The detectors of the central barrel (-0.9 $< \eta <$0.9) used for the heavy-flavour analyses presented here are the Inner Tracking System (ITS), the Time Projection Chamber (TPC), the Time Of Flight (TOF), the Transition Radiation Detector (TRD) and the ElectroMagnetic CALorimeter (EMCAL). The main goal of the ALICE muon spectrometer is the study of quarkonia states and inclusive heavy-flavour production in the muon channel. It covers the rapidity range -4.0 $<\eta<$-2.5 and provides a muon trigger. The following data samples are used for the analyses described here: 5 nb^{-1} integrated luminosity at 7 TeV for D mesons analysis; 2.6 nb^{-1} integrated luminosity at 7 TeV for single electrons; 16.5 nb^{-1} at 7 TeV for single muons.

3 Open charm via hadronic decay channels

Open charm mesons ($\mathrm{D}^0 \rightarrow \mathrm{K}^-\pi^+$, $\mathrm{D}^+ \rightarrow \mathrm{K}^-\pi^+\pi^+$, $\mathrm{D}^* \rightarrow \mathrm{D}^0\pi^+$ and $\mathrm{D_s} \rightarrow \mathrm{K}^-\mathrm{K}^+\pi^+$ and baryon (Λ_c) have a very short mean proper decay lenght $c\tau$, that ranges from 60 μm for Λ_c to 300 μm for D^+. The decay length of these particles is very small and the combinatorial background is high already in pp collisions, making the measurement challenging. These particles are exclusively reconstructed using their hadronic decay channels into 2, 3 or 4 charged particle final states. D mesons candidates are selected both applying topological cuts and identifying their charged decay pions and kaons with TPC and TOF. From the resulting invariant mass distrubution, the raw yield is obtained. The corrections for efficiency and acceptance are determined using Monte Carlo simulations. The measured fraction of prompt charm is inferred from FONLL predictions, that reproduce well beauty production measured in the CMS [5] and LHCb [6] experiments. The p_t differential cross section for the charmed meson $\mathrm{D}^+ \rightarrow \mathrm{K}^-\pi^+\pi^+$ is shown in the left panel of figure 1 [9], in the momentum range $1 < p_\mathrm{t} < 24$ GeV/c, together with the comparison with two different pQCD based calculations [7, 8]: the agreement is good within the uncertainties. The p_t differential cross section for the charmed mesons D^0, D^+, D^* and $\mathrm{D_s}$ are shown in the right panel of figure 1.

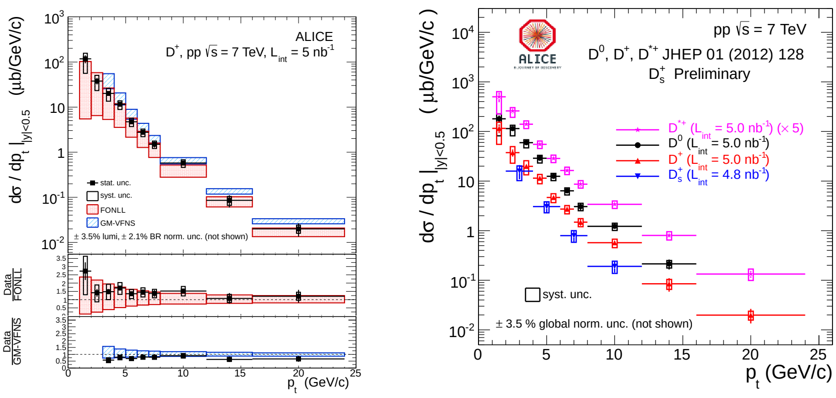

Figure 1: Left panel: Differential production cross section for D^+ in pp collisions at $\sqrt{s} = 7$ TeV (points), compared with two different pQCD based calcutations (blue and red bands [7−9].Right Panel: Cross section for the four D mesons in pp collisions at $\sqrt{s} = 7$ TeV.

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4 Electrons from heavy-flavour hadron decays

The inclusive heavy-flavour cross section can be obtained using electrons in the central barrel, since heavy flavour hadrons have a large branching ratio to leptons (about 10%). The electron identification strategy [10] is based on the TPC and TOF detectors and is effective for tracks with momentum up to 6 GeV/c. To extend the p_{t} range of the measurement up to 8 GeV/c, the PID is exploited also in the TRD, bringing the hadron contamination down to 2% in the whole momentum range. An alternative approach is to combine the information coming from the TPC with the energy deposit in the EMCAL to identify electrons. This PID strategy allows to obtain a good electron sample in the range $3 < p_{\mathrm{t}} < 7$ GeV/c. The charm and beauty decays are not the only sources that contribute to the inclusive electron spectrum. The background sources can be modeled in a cocktail which allows to obtain a sample dominated by beauty-decay electrons, from which a small contribution of background and charm-decay electrons is subsequently subtracted. The inclusive cross section for heavy-flavour decay electron production in pp collisions at $\sqrt{s} = 7$ TeV is shown in the left panel of figure 2, compared to the FONLL prediction for charm and beauty production in the electron channel [11]. The beauty contribution can be estimated in two independent ways. A cut on high values of the electrons impact parameter can distinguish c and b decay products. As a consistency test, the charm cross section measured with the charmed mesons decays is used to produce a pure charm electron spectrum. The difference between the two spectra at high p_{t} can be attributed to the contribution from beauty decays. In the right panel of figure 2, the measurement is shown in the range $1.5 < p_{\mathrm{t}} < 6$ GeV/c and compared to FONLL predictions.

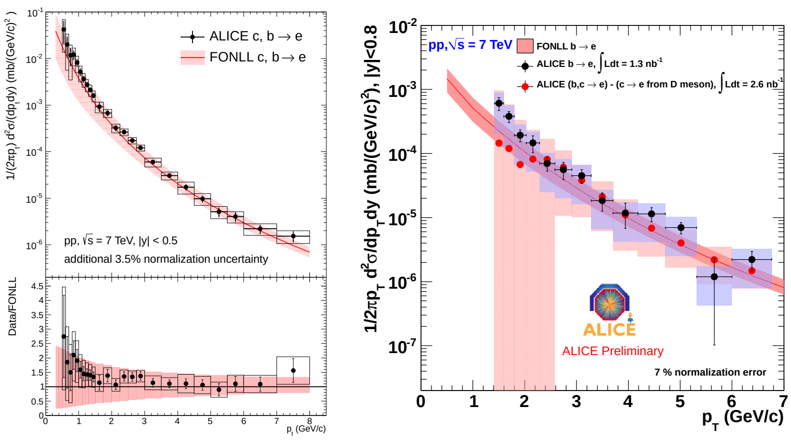

Figure 2: Left panel: Differential production cross section of electrons from heavy-flavour decays for pp collisions at $\sqrt{s} = 7$ TeV (black points), compared with FONLL predictions for $\mathrm{c}, \mathrm{b} \to \mathrm{e}$ (red line and band) [10, 11]. Right panel: Transverse momentum differential production cross section of electrons from beauty decay obtained with the impact parameter analysis (black points) and from the inclusive electron spectrum (red points). They are compared to FONLL predictions for $\mathrm{b} \to \mathrm{e}$ (red band).

5 Muons from heavy-flavour hadron decays

Open heavy-flavour production is measured at forward rapidity in the semi-muonic decay channel [12]. In the inclusive muon p_t distribution there are several contributions, that can be removed in order to isolate muons from charm and beauty decays. Hadrons that do not reach the trigger chambers at the end of the spectrometer are removed. A Monte Carlo simulation is used to estimate and subtract residual decay muons, originating from decays of light mesons before the front absorber. The p_t differential cross section of muons from heavy flavour decays

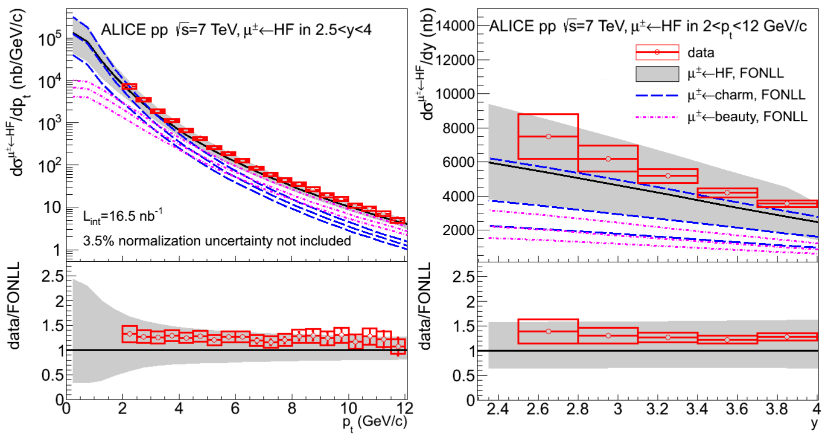

Figure 3: p_t (left panel) and y (right panel) differential cross section for muons from heavy flavour decays for pp collisions at $\sqrt{s} = 7$ TeV (points), compared to FONLL predictions (bands) [12, 7].

in $2.5 < y < 4$ and $2 < p_t < 12$ GeV/c is shown in figure 3 [12]. The measurement is compared compared FONLL predictions [7], which provide a fair description within uncertainties.

6 Conclusions

We have presented results on heavy-flavour cross sections measured with the ALICE detector in pp collisions at $\sqrt{s} = 7$ TeV. These results agree well with pQCD based model predictions and represent the essential baseline to understand heavy flavour production in heavy-ion collisions.

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