Measurement of electrons from semi-leptonic heavy-flavour hadron decays with ALICE at the LHC*

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The production of heavy quarks, i.e charm and beauty, in proton-proton (pp) collisions allows to test perturbative Quantum ChromoDynamics (pQCD) calculations. pQCD calculations in the framework of fixed-order plus next-to-leading-logarithm resummation (FONLL) [1, 2] are in good agreement with previous experiments at lower center-of-mass energies ($\sqrt{s}$). Furthermore, pp results serve as a reference for heavy-ion collisions. In such collisions, the study of heavy quarks can provide insight into partonic energy loss in the Quark Gluon Plasma (QGP) phase. In addition, the measurement of the elliptic flow, defined as the second harmonic component of the fourier expansion of the azimuthal particle distribution with respect to the reaction plane, carries information on the degree of thermalisation of heavy quarks at low p_{T}, as well as on the path length dependence of their energy loss in the QGP at high p_{T}.

ALICE [3] is well suited for the measurement of electrons at mid-rapidity. The measured specific energy deposition in the Time Projection Chamber (TPC), the main tracking detector in the central barrel, allows the identification of electrons up to a momentum of about 6 GeV/c. In addition, at low momentum (p <2 GeV/c), the velocity measurement provided by the Time Of Flight Detector (TOF) situated around the TPC can be employed to separate kaons and protons from electrons. At intermediate and higher p, where with the TPC pions can not be separated from electrons, the Transition Radiation Detector (TRD) and ElectroMagnetic Calorimeter (EMCal) are mandatory to prepare a pure sample of electrons. Both provide the possibility to trigger on electrons to enhance the statistics in the data sample. The results summarized here are from different analyses combining the particle identification capabilities of these detectors.

The sample of electrons contains background from various other sources, e.g. Dalitz decays or the conversion of real photons, which needs to be subtracted. The background can be estimated either using a cocktail based on the π^0 measurement [6] or by reconstructing the photonic background using an invariant mass technique. The background estimates from the two methods are in agreement.

In pp collisions at $\sqrt{s}$ = 7 TeV, the p_{T}-differential cross section of electrons from semi-leptonic heavy-flavour hadron decays was measured with ALICE at mid-rapidity ($|\mathrm{y}| < 0.5$) for 0.5 GeV/$c < p_{\mathrm{T}} <$ 8 GeV/c [4]. This p_{T} range includes $\approx$ 50% of the charm and $\approx$ 90% of the beauty cross section at mid-rapidity. Fig. 1 shows that a FONLL calculation [5] is in good agreement with the data. The preliminary results at $\sqrt{s}$ = 2.76 TeV, the same center-of-mass energy as used in Pb-Pb collisions, show a similar agreement.

Using tracks with a large distance to the primary event vertex, the cross section of electrons from beauty hadron decays was extracted in pp collisions at $\sqrt{s}$ = 7 TeV [7] and at $\sqrt{s}$ = 2.76 TeV. Both measurements were performed at mid-rapidity in a p_{T} range from 1 to 8 GeV/c. Results were confirmed by an alternative method, using azimuthal electron-hadron correlations. Moreover, they are well described by FONLL calculations. The total beauty cross sec-

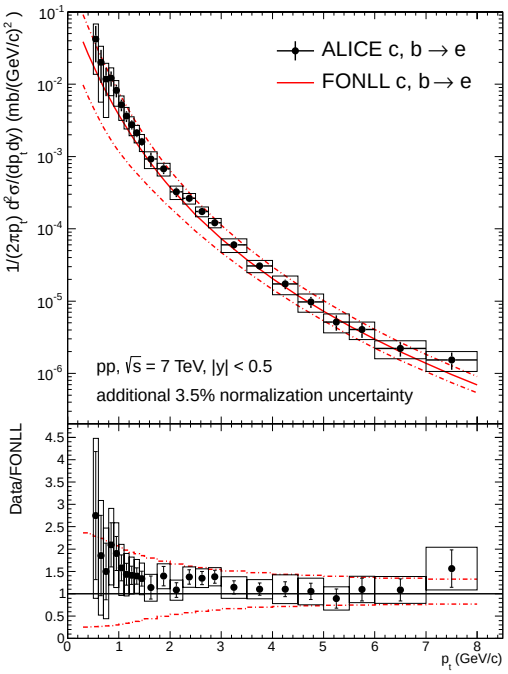

Figure 1: p_{T}-differential cross section of electrons from semi-leptonic heavy-flavour hadron-decays in pp-collisions at $\sqrt{s}$ = 7 TeV [4] in comparison with a FONLL pQCD calculation [5].

* Work supported by GSI, BMBF, HGS-HIRe, and Helmholtz Alliance HA216/EMMI

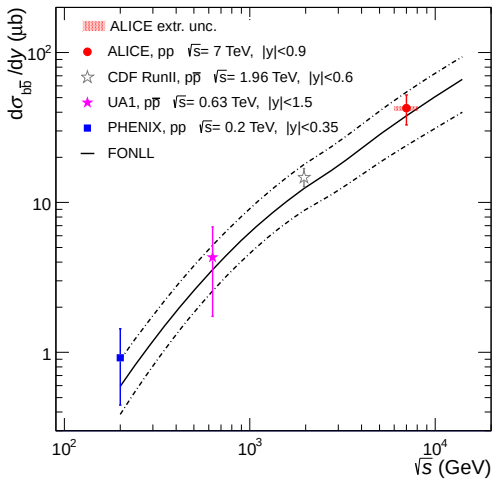

Figure 2: $\mathrm{d}\sigma_{\mathrm{b\bar{b}}}/\mathrm{d}y$ at mid-rapidity as a function of $\sqrt{s}$ in pp and p$\bar{\mathrm{p}}$ collisions [8]. The black solid (dashed) line indicates the FONLL calculation (uncertainty).

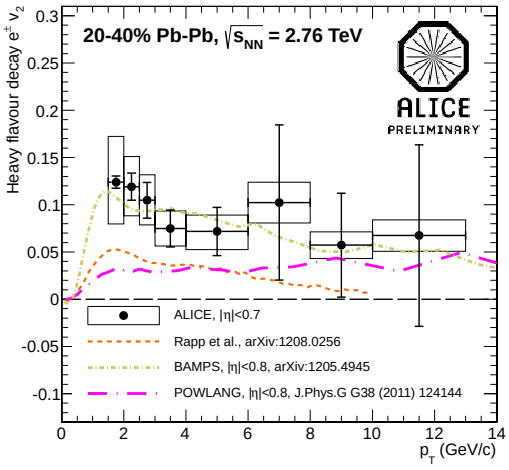

Figure 3: Elliptic flow v_2 of electrons from heavy-flavour hadron decays in 20-40% central Pb-Pb collisions, compared to different theoretical models [9].

tion per unit of rapidity is plotted in Fig. 2, together with measurements at lower $\sqrt{s}$ in pp and p$\bar{\mathrm{p}}$ collisions. The ALICE measurement is the weighted average of the results from the non-prompt J/ψ [8] and the beauty electron [7] analyses. A FONLL prediction is in good agreement with the various measurements.

In the 10% most central Pb-Pb collisions at $\sqrt{s_{\mathrm{NN}}} = 2.76$ TeV, a strong suppression of electrons from heavy-flavour hadron decays is observed in the p_{T} range from 3 to 18 GeV/c for $|y| < 0.5$ [9]. Since the yield is expected to be dominated by beauty hadron decays in the high-p_{T} region, this indicates that beauty quarks experience substantial energy loss. A similar suppression was observed for muons from heavy-flavour hadron decays at forward-rapidity, as well as for D mesons at mid-rapidity. The suppression increases from peripheral to central collisions [10]. In addition, the elliptic flow v_2 of electrons from heavy-flavour hadron decays was measured using the event-plane method in mid-central (20-40%) Pb-Pb collisions in the p_{T} range from 1.5 to 13 GeV/c at mid-rapidity. A non-zero v_2 is observed at low p_{T} (see Fig. 3), consistent with a non-zero v_2 of D mesons in 30-50% central Pb-Pb collisions [11]. Both results are compatible with measurements in Au-Au collisions at $\sqrt{s_{\mathrm{NN}}} = 0.2$ TeV [12]. In Fig. 3 various transport model calculations are compared with the experimental results. Current models are only partially successful in reproducing the measured suppression and v_2 of D mesons and of leptons from heavy-flavour hadron decays simultaneously.

In preparation for the p-Pb run taking place in the year 2013 at the LHC, an electron trigger using the Transition Radiation Detector (TRD) was commissioned with the 2012 pp data set at $\sqrt{s} = 8$ TeV. The trigger selects electron candidates with $p_{\mathrm{T}} > 3$ GeV/c using a likelihood method. The TRD triggered p-Pb data will provide an electron measurement at intermediate and high p_{T}.

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