

## Abstract

The ALICE experiment at the CERN Large Hadron Collider is focused on the study of the quark-gluon plasma (QGP), a deconfined state of the strongly-interacting matter which is formed in ultrarelativistic heavy-ion collisions. Heavy flavours, i.e., charm and beauty quarks, are produced in hard-scattering processes on a shorter timescale than the one of the QGP formation. They experience the full evolution of the system, propagating through the deconfined medium and losing energy via elastic and inelastic scatterings with the medium constituents. Therefore, heavy flavours are ideal probes of the QGP, and the measurements of open heavy-flavour hadrons provide relevant information on the QGP properties. Moreover, the comparison of the relative abundances of heavy-flavour hadron species with and without strange-quark content is a tool to investigate the role of the heavy-quark hadronisation via recombination with light quarks from the medium.

In proton–proton (pp) collisions, measurements of the production of hadrons containing charm or beauty quarks are an important benchmark of perturbative quantum chromodynamics (QCD) calculations. They test the validity of the factorisation theorem, where the heavy-flavour hadron production is described as a convolution of perturbative and non-perturbative QCD processes. Finally, these measurements provide insights on the heavy-flavour hadronisation via fragmentation in the vacuum.

This Thesis is devoted to the measurement of  $D_s^+$  mesons, containing a charm and an antistrange quark, in pp and Pb–Pb collisions. They are reconstructed in the fully-hadronic decay channel  $D_s^+ \rightarrow \phi\pi^+ \rightarrow K^-K^+\pi^+$ . Supervised machine-learning techniques are adopted to improve the measurement precision and transverse-momentum coverage. In addition, these techniques are exploited to separate prompt  $D_s^+$  mesons, produced in the charm-quark hadronisation or in the decays of excited charm-hadron states, and non-prompt ones, produced in beauty-hadron decays.

The measurements of prompt and non-prompt  $D_s^+$ -meson production in pp collisions at a centre-of-mass energy of  $\sqrt{s} = 5.02$  TeV are described by perturbative QCD calculations. The fragmentation fraction of heavy quarks into strange mesons divided by the one into non-strange mesons,  $f_s/(f_u + f_d)$ , is found to be compatible for charm and beauty quarks and with previous measurements at different centre-of-mass energies and collision systems, supporting a universal fragmentation of heavy-flavour quarks into mesons. The estimated  $c\bar{c}$  and  $b\bar{b}$  production cross sections at midrapidity are in agreement with theoretical calculations.

The production of prompt  $D_s^+$  mesons is measured in central and semicentral Pb–Pb collisions at a centre-of-mass energy per nucleon pair of  $\sqrt{s_{NN}} = 5.02$  TeV, and the  $p_T$ -integrated yield is compatible with the prediction of the statistical hadronisation model for charm hadrons. A strong suppression of the  $D_s^+$ -meson

nuclear modification factor  $R_{AA}$  at intermediate and high  $p_T$ , resulting from the charm-quark energy loss in the QGP, is observed. The  $D_s^+/D^0$  production-yield ratio measured in Pb–Pb collisions is on average higher than that in pp collisions in the interval  $2 < p_T < 8$  GeV/ $c$ . This enhancement is expected if charm quarks hadronise also via recombination in the deconfined medium, where the production of strange quarks is enhanced. The azimuthal anisotropy of prompt  $D_s^+$  mesons was studied in semicentral Pb–Pb collisions, and the measured  $D_s^+$ -meson elliptic flow  $v_2$  is found to be compatible with that of non-strange D mesons. The main features of the measured  $R_{AA}$ ,  $D_s^+/D^0$  ratio, and  $v_2$  as a function of  $p_T$  are described by theoretical calculations of charm-quark transport in a hydrodynamically expanding QGP including the hadronisation via the recombination mechanism.

The results presented in this Thesis were approved by the ALICE Collaboration and were presented in various international conferences. The measurements of the production of prompt and non-prompt  $D_s^+$  mesons in pp collisions have been published, as well as the measurements of the prompt  $D_s^+$ -meson  $R_{AA}$  and  $v_2$  in Pb–Pb collisions.

Keywords: heavy-flavour, charm, beauty, strange D mesons, nuclear modification factor, elliptic flow, hadronisation, strangeness enhancement, quark-gluon plasma, ALICE experiment, machine learning