Measurement of azimuthal correlations of D mesons with charged particles in pp collisions at $\sqrt{s} = 13$ TeV with ALICE at the LHC

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Abstract. The ALICE (A Large Ion Collider Experiment) detector at the LHC (Large Hadron Collider) is dedicated to the study of the properties of the hot and dense QCD matter (Quark–Gluon Plasma) produced in the nucleus-nucleus collisions at high energy. Heavy quarks (charm and beauty), having large masses, are produced in the hard-parton scattering in the early stages of the collision. Therefore, they experience the whole evolution of the hot and dense medium, representing an important tool for its characterization. The study of angular correlations between D mesons and charged particles in Pb–Pb collisions gives insight about the energy loss of charm quarks and the medium-induced modification of its fragmentation into jets. Moreover, pp collisions help to understand the production mechanisms, fragmentation and hadronization of charm quarks and acts as a reference for p–Pb and Pb–Pb measurements. In this article, the measurement of azimuthal correlations between D^0 meson and charged particles in pp collisions at $\sqrt{s} = 13$ TeV is presented. The collisional energy dependence of the correlations is extracted from the comparison with the results at $\sqrt{s} = 7$ TeV. The data are also compared with simulations performed with different event generators.

1 Introduction

The collisions of heavy ions at ultrarelativistic energies provide an excellent way to study the hot and dense QCD medium formed under extreme conditions: the Quark–Gluon Plasma (QGP). The ALICE detector at the LHC is designed for the study of the QGP properties. Heavy quarks (charm and beauty), having large masses, are produced in the initial stages of the collision in hard parton scatterings. Hence, they experience the whole evolution of the hot and dense medium, representing an important tool for its characterization. The study of angular correlations between D mesons and charged particles in different collision systems provides information about the possible medium-induced modification of charm quark fragmentation into jets. In pp collisions, this measurement allows the study of the production mechanisms, fragmentation and hadronization of charm quarks. In addition, it acts as a reference for p–Pb and Pb–Pb collisions.

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2 Analysis method

The main detectors used for the analysis are: ITS (Inner-Tracking-System), for tracking and vertexing, TPC (Time-Projection-Chamber), for particle tracking, TOF (Time-Of-Flight), for particle identification, and the V0 detector for triggering and multiplicity. The various subsystems of the ALICE apparatus and their performance are described in more detail in [1, 2].

2.1 Signal extraction

The D (D^0, D^+, D^{*+}) mesons and their charge conjugates are fully reconstructed at mid-rapidity from their hadronic decay channels: $D^0 \rightarrow K^- + \pi^+$ (BR: 3.89 ± 0.04%), $D^+ \rightarrow K^- + \pi^+ + \pi^+$ (BR: 8.98 ± 0.28%), $D^{*+} \rightarrow D^0 + \pi^+$ (BR: 67.7 ± 0.5%). The D meson candidates are selected exploiting the displaced decay vertex topology and particle identification on the daughter tracks. Finally the D meson raw yields are extracted by fitting the invariant-mass distribution of the candidates [3].

2.2 Azimuthal correlation and corrections

Each selected D meson is correlated with charged tracks produced in the collision with pseudorapidity $|\eta| < 0.8$ (excluding the daughter particles) both under the signal peak and in two sideband regions, to build correlation distributions in the difference between the two particles in pseudorapidity $\Delta\eta$ and azimuthal angle $\Delta\varphi$. The effects due to limited detector acceptance and inhomogeneities are corrected via the event-mixing technique. Then, the background from combinatorial D meson candidates are removed by defining a background region in the sidebands of the invariant-mass distribution as the interval $4 < |m - m^{\rm pdg}| < 8$, where $m^{\rm pdg}$ is the mass of D meson taken from PDG database [4]. Subsequently the angular correlation distribution for background candidates in this region is extracted and normalized with respect to the background in the signal region estimated from the mass fit. This normalized background correlation distribution is then subtracted from the raw signal to obtain the signal correlation distribution. Then, the distributions are corrected for D meson reconstruction efficiency and selection efficiency, and associated track reconstruction efficiency. After that the $(\Delta\eta, \Delta\varphi)$ corrected distributions are projected onto $\Delta\varphi$, normalized by the number of trigger particles and multiplied by the fraction of primary particles in the sample (purity). The contribution of the correlations from D mesons originated from B-hadron decays are also removed. Finally, results of the three D meson species are averaged, and a fit is performed with a function composed of two Gaussian (one for the "near-Side" peak at $\Delta\varphi \sim 0$ and one for the "away-Side" peak at $\Delta\varphi \sim \pi$) and a constant term (baseline) to characterize the charm jet-induced correlation peaks.

3 Results

In Fig. 1 comparison of azimuthal correlation distributions of D mesons with charged particles in pp collisions at $\sqrt{s}$ = 7 [5] and 13 TeV and p–Pb collisions at $\sqrt{s_{\rm NN}}$ = 5.02 TeV [5] after baseline subtraction, for different kinematic ranges are shown. The distribution looks compatible among the systems and for all the kinematic ranges. In Fig. 2 and Fig. 3, the $\Delta\varphi$ distribution after the baseline subtraction, near-side peak associated yield, width and baseline values measured in pp collisions are compared with the expectations from Monte Carlo simulations with different event generators. The models reproduce the data well in the near-side. In the away-side POWHEG+PYTHIA6 and PYTHIA8 are closer to the data than PYTHIA6 [6, 7].

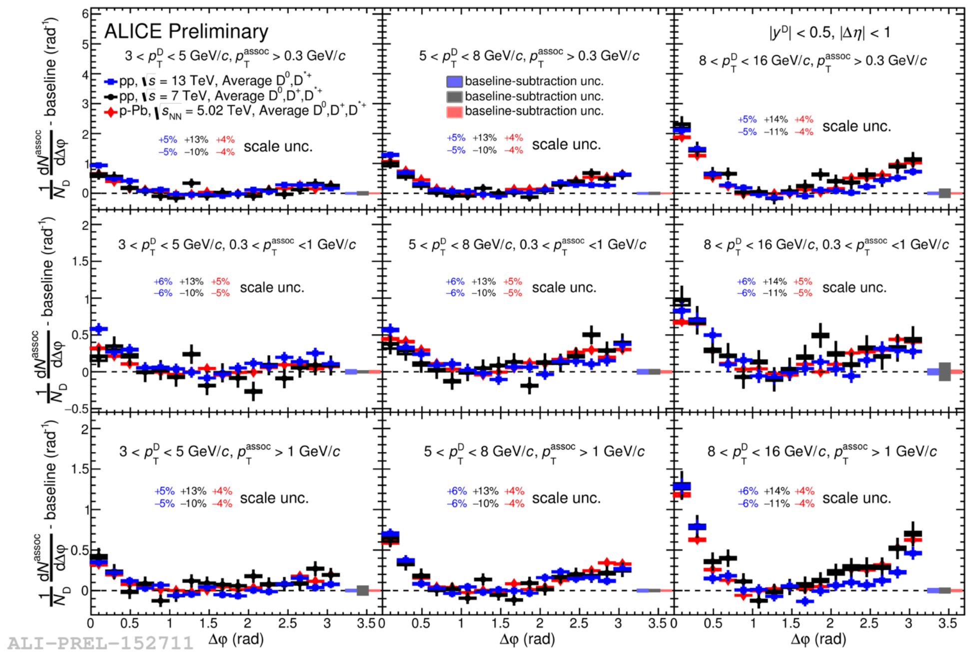

Figure 1. Comparison of azimuthal correlation distributions of *D* mesons with charged particles in pp and p–Pb collisions after baseline subtraction, for different kinematic ranges.

4 Summary and outlook

The results of azimuthal correlations between *D* mesons and charged particles in pp collisions, extracted in different kinematic ranges are shown. The measured distributions, as well as the properties of the correlation peaks are described qualitatively (well in the near-side) by simulations performed with PYTHIA and POWHEG+PYTHIA.
The statistical precision of the measurement will be improved by using the data samples from 2017 and 2018. The LHC Run 3 data set will allow us to perform this study with better precision and in different event multiplicity classes, due to the higher luminosity and the improved performance on the *D* meson reconstruction.

References

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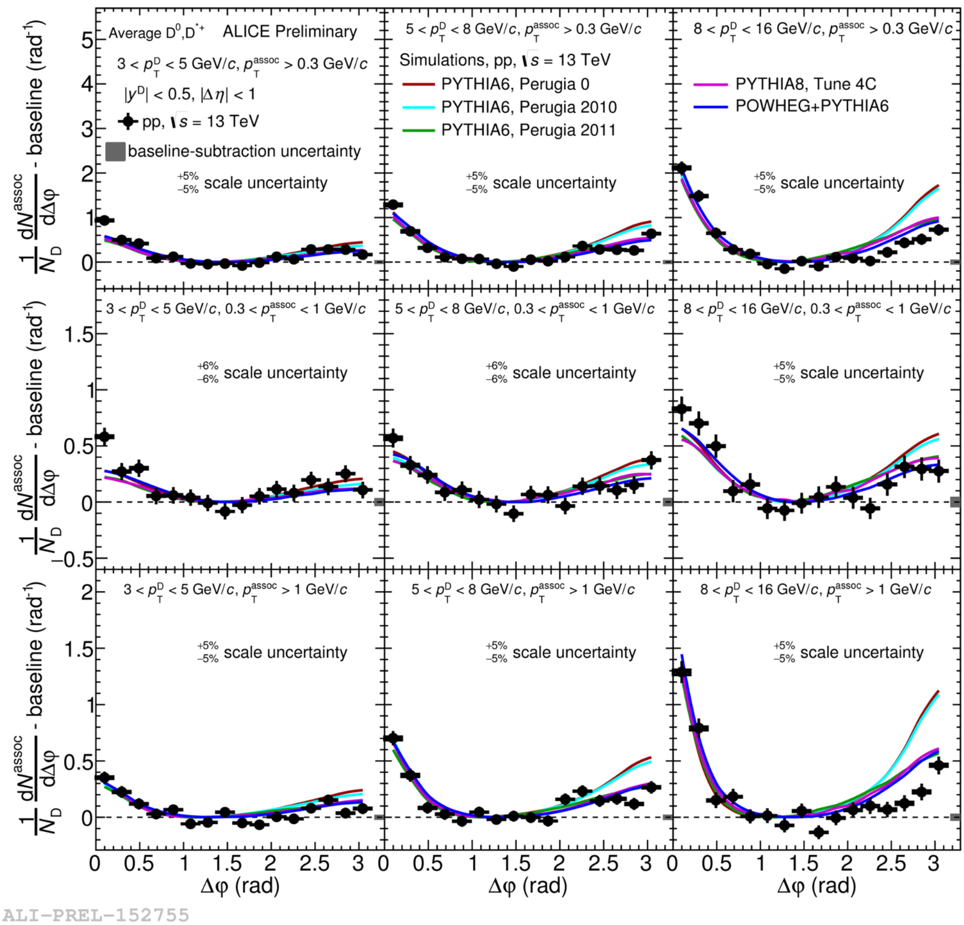

Figure 2. Comparison of $\Delta\varphi$ correlation distributions in pp collisions and with expectations from Monte Carlo simulations performed with different event generators, after the baseline subtraction.

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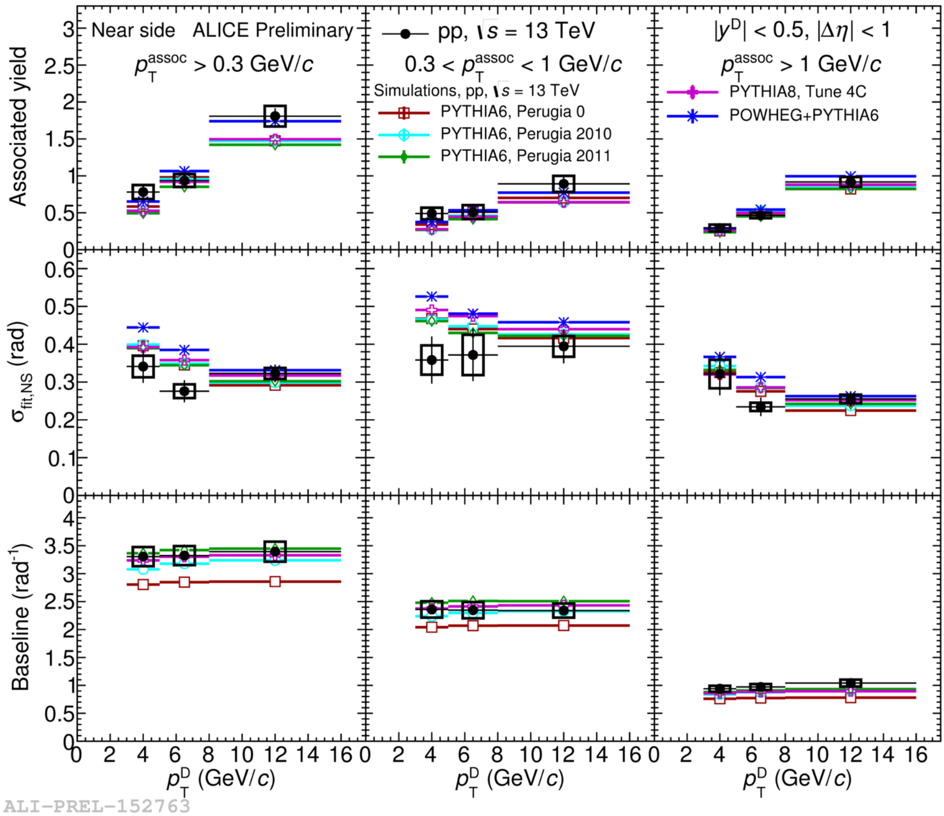

Figure 3. Comparison of near-side peak associated yield (top row), near-side peak width (middle row) and baseline (bottom row) values measured in pp collisions with the expectations from Monte Carlo simulations with different event generators.