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Measurements of single and double D^0 meson production in pp collisions at $\sqrt{s}$ = 13.6 TeV

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D-meson production measurements in pp collisions are used to test perturbative quantum chromodynamics (pQCD) calculations. This contribution reports the preliminary results of the non-prompt D^0 fraction at midrapidity in the transverse momentum range $p_T < 24$ GeV, measured in pp collisions at $\sqrt{s}$ = 13.6 TeV, using data from the LHC Run 3. Results are compared to the predictions of EPOS and various modes of PYTHIA simulations. Additionally, the double production of D mesons allows to study single (SPS) and double parton scattering (DPS). Like-sign meson pairs are expected to be predominantly produced by DPS processes, while opposite-sign pairs are more likely to be created via SPS. The status of the measurement of double production of D^0 mesons in pp collisions at $\sqrt{s}$ = 13.6 TeV is also reported.

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1. Introduction

This contribution reports some of the first results of the ALICE Collaboration involving D mesons in pp collisions at $\sqrt{s} = 13.6$ TeV exploiting Run 3 data. In particular, the measurement of the non-prompt D^0 fraction and the status of the double D^0 production measurement are reported. D^0 mesons and their charge conjugates are reconstructed via their hadronic decay channel, $D^0 \rightarrow K^-\pi^+$, using the central barrel, which covers the pseudorapidity range $|\eta| < 0.9$. The main detectors employed include the Inner Tracking System (ITS), used for tracking and vertexing; the Time Projection Chamber (TPC), used for tracking and particle identification (PID); and the Time-of-Flight (TOF) detector, used for particle identification. Collisions were triggered using the Fast-Interaction-Trigger (FIT). More details are provided in Ref.[1].

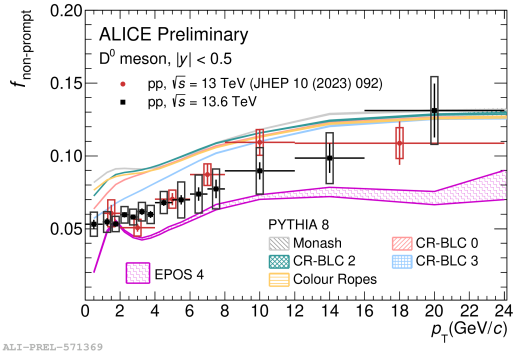
2. Non-prompt D^0-meson fraction calculation

Measurements of the fraction of non-prompt D^0 mesons allow us to test perturbative QCD (pQCD) calculations in the beauty sector. In ALICE, these measurements were already performed at midrapidity exploiting Run 2 data at $\sqrt{s} = 13$ TeV [1]. The measurement of the non-prompt D^0 fraction in pp collisions at $\sqrt{s} = 13.6$ TeV is reported here down to $p_T = 0$ and with finer granularity with respect to Run 2 data.

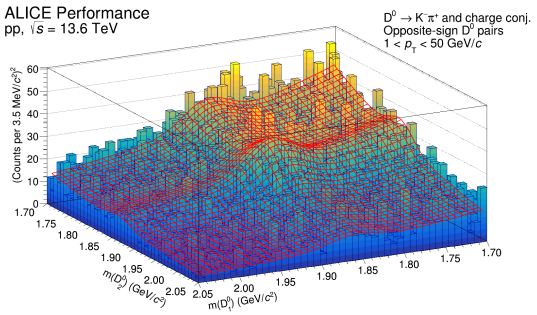
To extract the D^0 signals, a set of boosted decision tree (BDT) algorithms was employed in different p_T intervals, making use of topological variables exploiting the D^0 displaced decay topology and particle-identification information on the D^0 daughter tracks. They were used to separate between prompt D^0, non-prompt D^0, and combinatorial background candidates in the measured p_T interval. The candidates for the first two classes used in the training were obtained from Monte Carlo (MC) simulations. In contrast, background candidates were obtained from the sidebands of the data invariant-mass distribution. Once the signals were extracted, a data-driven method known as cut-variation was used to determine the non-prompt fraction. This approach considers that the D^0-meson yield is composed of a prompt and non-prompt component, whose corrected values can be computed as in Eq.1. In this equation, (Acc$\times\epsilon$) is the acceptance of the detector multiplied by the efficiency, which can be obtained from MC simulations, $N_{\text{(non-)prompt}}$ is the number of (non-)prompt candidates, and Y is the measured raw yield, extracted from the invariant-mass distribution of Kπ pairs. This method tests different BDT scores to vary the (Acc $\times$ ϵ) and the relative contribution from the prompt and non-prompt components in Eq.1 and obtain a system of equations. An iterative procedure was performed in order to solve the system by minimising the χ^2 and extract the fraction.

$$(\text{Acc} \times \epsilon)_i^{\text{prompt}} \cdot N_{\text{prompt}} + (\text{Acc} \times \epsilon)_i^{\text{non-prompt}} \cdot N_{\text{non-prompt}} = Y_i \tag{1}$$

The result of the non-prompt D^0 fraction at $\sqrt{s} = 13.6$ TeV can be seen in Fig. 1a. The Run 3 results, in black, are compared to the previous Run 2 measurement, reported in red, and are compatible with each other. Results are also compared with theoretical calculations using EPOS 4 [3] and PYTHIA 8 [2] with different tunes. As it can be observed, the measurement lies between PYTHIA and EPOS predictions. Overall, the Run 3 results extend the p_T coverage and granularity, providing tighter constraints to distinguish different hadronisation implementations.



(a) Non-prompt fraction, $f_{\text{non-prompt}}$, as a function of p_{T} in the $p_{\text{T}} < 24$ GeV/c range.



(b) Invariant-mass distribution of opposite-sign D^0 pairs, with a fit function superimposed.

Figure 1: (a) Non-prompt fraction as a function of p_{T}; (b) Invariant-mass distribution of opposite-sign D^0 pairs.

3. Double production of D^0 mesons

Double D^0-meson production measurements provide information on charm production from double-parton scattering (DPS). To distinguish the contribution to double-D^0 production from single-parton scattering (SPS) and DPS, it is possible to compare the cross-sections from opposite-sign and like-sign pairs, where the latter are expected to be dominated by DPS. This contribution presents a performance plot of the 2-dimensional invariant mass fit for opposite-sign D^0 pairs, which can be seen in 1b.

4. Conclusions

In this contribution, we presented the current status of measurements for single and double D^0 meson production using ALICE Run 3 data. First, the fraction of non-prompt D^0 mesons was estimated, yielding the preliminary results shown in Figure 1a, which are compared with earlier results and theoretical predictions. Afterwards, the analysis progress on double-D^0 production was discussed, setting the stage for upcoming results.

References

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[3] K. Werner. *Phys. Rev. C* 108 (6 Dec. 2023), p. 064903. DOI: 10.1103/PhysRevC.108.064903.