Open Charm production in proton-proton collisions at $\sqrt{s}$ = 13 TeV using Pythia 8

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1. Introduction

Charm and beauty are heavy quarks with observed masses of 1.28 GeV/c^2 and 4.18 GeV/c^2 respectively. They are produced in initial hard scattering processes. Due to their small formation time ($\Delta t \sim 0.1 fm/c$) as compared to the formation time of QGP ($\Delta t \sim 0.3 fm/c$) at the LHC, they experience all the stages occuring during the time evolution of the hot and dense medium produced in heavy-ion collisions. Therefore, the measurement of open charm and beauty production allows probing QGP properties and investigating the color charge and mass dependence of the parton in-medium energy loss. Moreover, due to their large masses ($m_c, m_b \gg \Lambda_{QCD}$) their pp production cross-sections are calculable within the domain of perturbative QCD constituting an excellent test of pQCD calculations. In this analysis, we have studed the production of open charm flavour hadrons (D^0, D_s^+ and Λ_c^+) through the p_T spectra and the self normalised yield as a function of relative charged particle density. In addition to that the ratio of strange to non-strange mesons is calculated. Also baryon to meson ratio has been calculated to investigate the possibility of hadronization of the charm quarks. The analysis is performed with the *pp* data generated by PYTHIA 8 Monte Carlo event generator at $\sqrt{s} = 13$ TeV.

2. Event Generation and Analysis Methodology

The results reported in this contribution are obtained by simulating inelastic events using hard QCD mode (HardQCD: hardccbar (hardbbbar)=on) with PYTHIA 8 event generator. PYTHIA 8 has proved to be quite successful in explaining the heavy-flavor particle production at the LHC energies. This configuration includes the processes $q\bar{q} \to b\bar{b}$, $gg \to b\bar{b}$, $q\bar{q} \to c\bar{c}$ and $gg \to c\bar{c}$. In addition to that Color Reconnection tune, CR2 (called Gluon-move model) is used which considers Tune:pp = 14 and which include reconnection beyond leading colour. In the CR2 model only the gluons are allowed to participate in the reconnection process. For each gluon all the reconnections formed to all MPI systems are considered (in addition to the ones for softer MPIs), therefore in principle it affects more significantly the colour flow from the hard interaction. A cut of $p_T \geq 0.5$ GeV/c (using PhaseSpace:pTHatMinDiverge) is used to avoid the divergences of QCD processes in the limit $p_T \to 0$. Study of D^0, D_s^+, and Λ_c^+ production are done at the mid-rapidity ($|y| < 0.5$) and in the kinematic range [1,24] GeV/c. D^0, D_s^+, and Λ_c^+ are selected by using their respective pdg values. This analysis is performed by generating 175 million pp events at $\sqrt{s}$= 13 TeV. The charged-particle multiplicity, N_{ch} is measured at the mid-rapidity ($|\eta|$ <1.0). The analysis has been performed in the four multiplicity classes [1-15],[16-30],[31-60],[61-100]. The mean values for the charged particle density in each multiplicity bin are shown in the table.I.

N_{ch}	$< dN_{ch}/d\eta >$
[1-15]	3.76
[16-30]	11.72
[31-60]	23.14
[61-100]	39.88

TABLE I: Multiplicity classes and average charged-particle density.

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3. Results

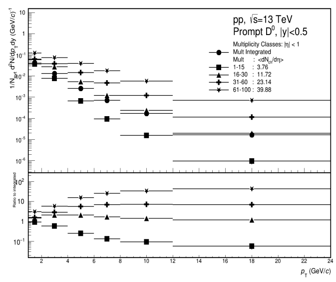

FIG. 1: D^0-meson: (Top) Corrected spectra (Top) and Ratio (Bottom).

Fig.1 to .3 shows the transverse p_T spectra for D^0, D_s^+ and Λ_c^+, respectively, on the top for all the multiplicity classes as well as the integrated multiplicity case [1,200]. A clear trend with multiplicity is seen for all studied hadrons. The spectra increases as we go from low multiplicity to high multiplicity region. This can also be seen from the ratios of spectra in different multiplicity bins to the spectra in the integrated multiplicity bin. Besides, it can be seen that besides the decrease or increase, which seem similar for the four studied hadrons, a softening or hardening in the p_T spectra is observed as well, which prominant in the low multiplicity events, whereas in case of high multiplicity events, hardening of the spectra is clearly visible.
The ratio of strange D-meson (D_s^+/D^0) show

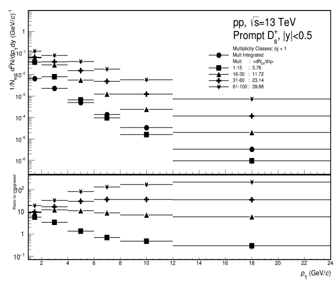

FIG. 2: D_s^+-meson: (Top) Corrected spectra (Top) and Ratio (Bottom).

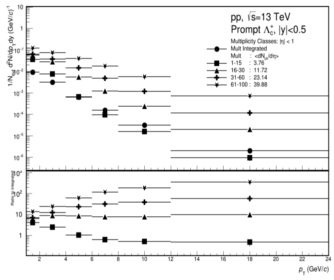

FIG. 3: Λ_c^+-meson: (Top) Corrected spectra (Top) and Ratio (Bottom).

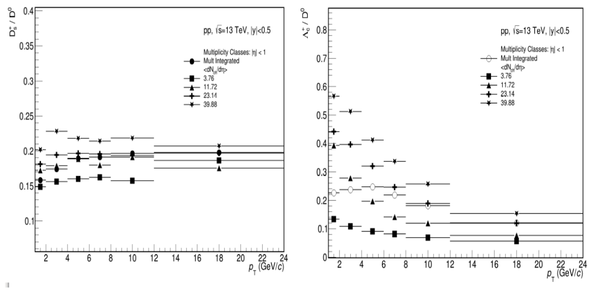

FIG. 4: Λ_c^+-meson: (Top) Corrected spectra (Top) and Ratio (Bottom).

an enhancement with respect to the multiplicity. Fig.4 (left) shows the ratio of D_s^+ with respect to the D^0. The enhancement is not so strong at high p_T but is somehow considerable at low p_T. Fig.4 (right) shows the ratio of Λ_c^+ with respect to D^0. The Λ_c^+/D^0 ratios indicate a strong multiplicity dependence when compared to strange-to-nonstrange ratios (fig.4) (left). The enhancement of Λ_c^+/D^0 ratio with multiplicity may indicate a contribution from jets in hard events resulting to the increase in the density of quarks and gluons.

Acknowledgments

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References

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