Measurement of D-meson production as a function of charged particle multiplicity in proton—proton collisions at $\sqrt{s} = 13$ TeV with ALICE at the LHC

Yoshini Bailung* for the ALICE Collaboration

1Department of Physics, Indian Institute of Technology Indore

*Corresponding author Email: yoshini.bailung@cern.ch

Physics Motivation

• Important test of
  • pQCD calculations.
  • multi-parton interactions.
• Investigate the interplay between hard and soft components in a pp collision.
• Investigate the increase of particle yields with multiplicity.
  • Role of auto-correlation effects already introduce stronger than linear increase with multiplicity.

New measurements performed in pp collisions at $\sqrt{s} = 13$ TeV with improved precision

The ALICE detector

• Inner Tracking System/Silicon Pixel Detector (ITS)/(SPD) — Vertexing, Tracking and Particle Identification (PID)
• Time Projection Chamber (TPC) — Tracking and PID
• Time of Flight (TOF) — PID

S.G. Weber et al., EPJ C 79, (2019) 1, 36
Measurement of D-meson production as a function of charged particle multiplicity in proton–proton collisions at $\sqrt{s} = 13$ TeV with ALICE at the LHC

Methodology

- Charged-particle multiplicity: estimated at mid rapidity as the number of tracklets ($N_{\text{tracklets}}$) in the SPD.
- $N_{\text{tracklets}}$ to $dN_{ch}/d\eta$ conversion via $N_{\text{tracklets}}$ vs $N_{ch}$ correlation distribution.
- D-meson raw yield extracted after PID and topological selections via invariant mass fit.
- D-meson self-normalized yield is defined as

$$Y_{\text{mult}}^{\text{corr}} = \left( \frac{Y_{\text{mult}}}{\epsilon_{\text{mult}} \times N_{\text{event}}/\epsilon_{\text{mult}}^{\text{trg}}} \right) / \left( \frac{Y_{\text{mult int}}}{\epsilon_{\text{mult int}} \times N_{\text{event int}}/\epsilon_{\text{mult int}}^{\text{trg}}} \right)$$

$Y_{\text{mult}}$ is the extracted raw yield, $\epsilon_{\text{mult}}$ is the acceptance $\times$ efficiency, $N_{\text{event}}$ is the number of events, and $\epsilon_{\text{mult}}^{\text{trg}}$ is the trigger efficiency for a particular multiplicity interval. The numerator is normalized to the corresponding quantity for the multiplicity integrated sample.

Datasets
- 2016, 2017, 2018 Minimum bias triggered data (32 $nb^{-1}$)
- 2018 High multiplicity SPD triggered data (0.8 $pb^{-1}$)

D-meson decay channels
- $D^0 \rightarrow K^-\pi^+$
- $D^+ \rightarrow K^-\pi^+\pi^+$
- $D^{*+} \rightarrow D^0\pi^+$

Quark Matter 2022, 4-10 April
Measurement of D-meson production as a function of charged particle multiplicity in proton–proton collisions at $\sqrt{s} = 13$ TeV with ALICE at the LHC

**Results**

- Self-normalized yields show **stronger than linear increase** as a function of $dN_{ch}/d\eta/\langle dN_{ch}/d\eta \rangle$ and **steeper rise** at higher $p_T$
- Agreement between D-meson self-normalized yields in pp collisions at $\sqrt{s} = 13$ TeV and 7 TeV

Quark Matter 2022, 4-10 April
Measurement of D-meson production as a function of charged particle multiplicity in proton—proton collisions at $\sqrt{s} = 13$ TeV with ALICE at the LHC

**Results**

- Similar trend of self-normalized yield for D-meson, electrons from heavy flavour hadron decays, and $J/\psi$ at mid-rapidity, both at low and high $p_T$.
- A large contribution from auto-correlation effects.
Measurement of D-meson production as a function of charged particle multiplicity in proton—proton collisions at $\sqrt{s} = 13$ TeV with ALICE at the LHC

Comparisons with models

- EPOS3 generator assuming flux tube initial conditions followed by a hydrodynamical evolution, shows a faster than linear increase which is qualitatively comparable to data.

- EPOS3 without the hydro component underestimates the measurements.

- CGC Pomeron3, using a colour dipole framework, with the contribution of a three pomeron fusion correction, shows a departure from a linear multiplicity dependence but overestimates the increasing trend.

Conclusions

- Average D-meson self-normalized yields measurements vs multiplicity in pp collisions at $\sqrt{s} = 13$ TeV show stronger than linear increase with strong $p_T$ dependence → Large contribution from auto-correlation is expected.

- Average D-mesons in pp at $\sqrt{s} = 7$ TeV, $J/\psi$ and $c, b \to e$ in pp at $\sqrt{s} = 13$ TeV are compatible in similar $p_T$ and multiplicity intervals.

- EPOS with hydro predictions fairly describes the results, EPOS without hydro underestimates and 3-pomeron CGC model overestimates the results.