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D-meson production in pp and Pb-Pb collisions measured with ALICE at the LHC

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Heavy Flavour: effective probes of the QGP



- Produced in initial hard scattering (high Q^2) processes
- $\tau_{c/b} \sim 0.01 0.1 \text{ fm}/c < \text{QGP}$ formation time (~0.1-1 fm/c)
 - Experience the whole system evolution interacting with the medium formed in Pb-Pb collisions

In pp collisions:

- Provide baseline for Pb-Pb collisions
- Test perturbative QCD calculations

In Pb-Pb collisions:

CNPC 2019, X.Peng

- Study of charm and beauty energy-loss mechanism in the medium
 - Colour-charge and quark-mass dependence
- Participate in the collective motion and thermalisation of the medium
- Modification of hadronisation mechanism in the medium

Coalescence mechanism?

b quark c quark beam beam





The ALICE detector







Prompt D-meson reconstruction



$D^{0} \to K^- \pi^+$	BR ~ 3.93%	cτ ~ 123 μm
$D^+ \to K^- \pi^+ \pi^+$	BR ~ 9.46%	cτ ~ 312 μm
$D^{*+} \rightarrow D^{0}(K^-\pi^+)\pi^+$	BR ~ 2.66%	-
$D_s^+ \to \varphi(K^-K^+)\pi^+$	BR ~ 2.27%	cτ ~ 150 μm



- Decay topology selections and PID used to reduce the combinatorial background
- Signal is extracted via an invariant-mass analysis
- Feed-down from beauty-hadron decays are subtracted exploiting FONLL calculations. In Pb-Pb collisions, with further assumptions on feed-down nuclear modification factor





Non-prompt D⁰ reconstruction

- Use ML based method (BDT) to combine and optimize topological cuts on SV to achieve high fraction non-prompt D⁰
 - Two step BDT-based cut applied, first step aims to increase nonprompt D⁰ fraction, second step used to suppress the combinatorial background





New data-driven approach applied to extract non-prompt D⁰ fraction

[1] J. High Energ. Phys. (2012) 2012: 137

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D⁰ meson $p_{\rm T}$ -differential cross section in pp collisions at $\sqrt{s} = 5.02$ TeV



- Fully-corrected cross section down to $p_{\rm T}$ = 0 (1) GeV/c for prompt (non-prompt) D⁰
- FONLL[1] prediction can simultaneously reproduce the prompt and non-prompt D⁰ data within uncertainties, but data lie on the upper edge of the FONLL uncertainty across all p_T

D-meson corrected $p_{\rm T}$ -spectra in Pb-Pb collisions at $\sqrt{s_{\rm NN}} = 5.02$ TeV











- Improved measurement (in terms of precision) of D-meson R_{AA} using 2018 data w.r.t 2015 data
 - > Better constraint to model calculation especially at low $p_{\rm T}$



- Similar D-meson, π^{\pm} and charged-particle R_{AA} result for $p_T > 10$ GeV/c in 0-10% and 30-50%
- D-meson R_{AA} larger than that of charged pions at low p_T for 0-10% and 30-50% centrality classes
 - > Not straightforward interpretation: N_{part} vs N_{coll} scaling at low p_{T} , different fragmentation and initial spectra shapes, possible mass and Casimir factor effects, different impact of coalescence and radial flow



PHSD: Phys. Rev. C93 no. 3, (2016) 034906



D-meson ν_2







- **Positive** D-meson v_2 in $p_T > 2 \text{ GeV}/c$
 - > Charm quark sensitive to medium collective motion
- Measurement of $D_s^+ v_2$
 - > Compatible with that of non-strange D mesons within uncertainties
- Hadronisation via quark recombination included in both TAMU and PHSD models. Both show a good agreement with data at low- and intermediate- $p_{\rm T}$



- Models in which charm quarks pick up collective flow via recombination or subsequent elastic collisions in expanding medium better describe both v_2 and R_{AA} at low $p_T(MC@sHQ, PHSD, POWLANG)$
- Improved precision of the measurement can provide important constraints on models and help to extract

information about the medium properties. For models describing reasonably the data

> $v_2 \rightarrow 1.5 < 2\pi T D_s(T) < 7$ at $T_c \rightarrow \tau_{charm} = 3-14$ fm/c







- D mesons results in pp collisions at $\sqrt{s_{\rm NN}} = 5.02 \,{\rm TeV}$:
 - Non-prompt D⁰ measured for the first time in ALICE -> both prompt and non-prompt D⁰ lie on the upper edge of the uncertainty of FONLL
- D mesons results in Pb-Pb collisions at $\sqrt{s_{
 m NN}} = 5.02$ TeV :
 - > D^0 , D^+ , D^{*+} , D_s^+ : increasing suppression from mid-central to central collisions
 - ➢ Ratio of D_s^+ w.r.t non-strange D-meson results: hint of enhancement in Pb-Pb w.r.t pp → coalescence and strangeness enhancement?
 - > D^0 , D^+ , D^{*+} , D_s^+ , ν_2 : strong coupling of charm quark with the medium