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Overview of Recent Correlation Measurements with ALICE

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Abstract—Two-particle angular correlations is a robust tool that allows to study different physical properties of the system created in the high-energy collisions of both protons and heavy ions. ALICE experiment enable correlation measurements of identified particles for different collision systems, including less common probes, like ϕ mesons, D mesons and deuterons. In this document selected ALICE correlation measurements with identified particles are reported.

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INTRODUCTION

The ALICE detector at the Large Hadron Collider at CERN has been optimized for excellent particle identification and tracking capabilities with the aim of studying the Quark–Gluon Plasma (QGP), a deconfined state of hadronic matter produced in ultra-relativistic heavy-ion collisions at the LHC.

One of the key observables used in the study of the QGP is two-particle correlations which allows the exploration of the underlying physics phenomena of particle production in collisions of both protons and heavy ions. Studying distributions of angles in $\Delta\eta\Delta\varphi$ space (where $\Delta\eta$ is the pseudorapidity difference and $\Delta\varphi$ is the azimuthal angle difference between two particles) opens up the possibility to study a number of physics mechanisms, including baryon production, strangeness production, mechanisms of energy loss, quantum statistics and others.

In this proceedings correlation measurements will be reported as a yield of associated particles per trigger particle, expressed as ratio of the signal constructed using pairs from same event, over reference constructed using pairs from different events

$$\frac{1}{N_{\mathrm{trig}}}\frac{\mathrm{d}^2N_{\mathrm{assoc}}}{\mathrm{d}\Delta\eta\mathrm{d}\Delta\phi}=\frac{1}{N_{\mathrm{trig}}}\frac{\mathrm{d}^2N_{\mathrm{same}}}{\mathrm{d}\Delta\eta\mathrm{d}\Delta\varphi}\bigg/\frac{1}{\alpha}\frac{\mathrm{d}^2N_{\mathrm{mixed}}}{\mathrm{d}\Delta\eta\mathrm{d}\Delta\varphi}, \quad (1)$$

where α is a normalization factor.

This document presents selected ALICE correlation measurements, using identified particles in the broad momentum range, for different collision systems.

JET-LIKE HADRON-ϕ(1020) CORRELATIONS IN p–Pb

Measurements of strange particle yields [1] reported an enhancement of ϕ mesons with respect to other charged hadrons in p–Pb collisions. Two-particle angular correlations allow to separate jet-like production of particles from the bulk of the underlying event and therefore can help to answer the question, if the enhancement is connected to a change of the jet fragmentation and jet medium modification or rather to the change of soft production in the underlying event.

In Fig. 1 a yield of associated particles per trigger particle is reported for p–Pb collisions at $\sqrt{s_{NN}}$ = 5.02 TeV, where associated particles are φ mesons reconstructed from K^+K^- pairs, while trigger particles are high-p_{T} hadrons ($4.0 < p^h_{\mathrm{T,trig}} < 8.0$ GeV/c) that are used as a jet proxy. Both near-side ($\Delta\varphi \approx 0$) and away-side ($\Delta\varphi \approx \pi$) peaks, typically associated with jet production, are clearly visible for all three studied centrality ranges.

To obtain associated yield in jet and bulk the integration was performed of both peaks, as well as the underlying-event background. Figure 2 shows the integrated yield ratios of h–ϕ over h–h. Ratio shows increase in strangeness in respect to non-strange hadrons as function of multiplicity. Underlying-event ratios show a consistently higher strangeness production than inclusive measurement. Production in jets increases with multiplicity, and is systematically lower than inclusive measurements. More information can be found in [2].

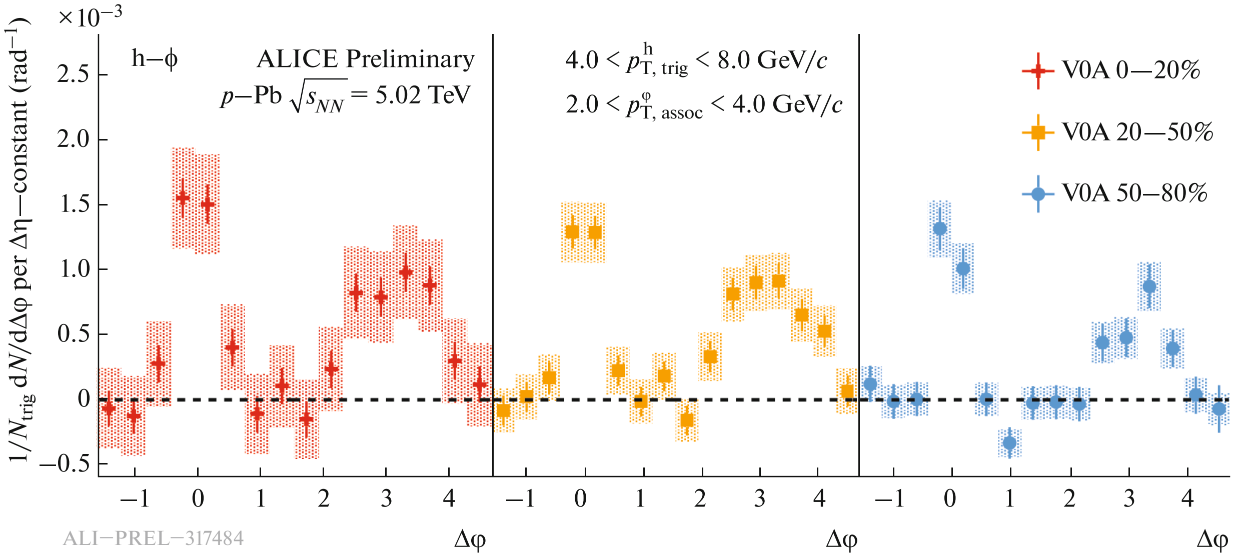

Fig. 1. 1D h–ϕ angular correlation for p–Pb for different multiplicity class events. Each correlation is projected from the 2D correlation for $|\Delta\eta| < 1.2$. The correlation is plotted after subtraction of the estimated flat background.

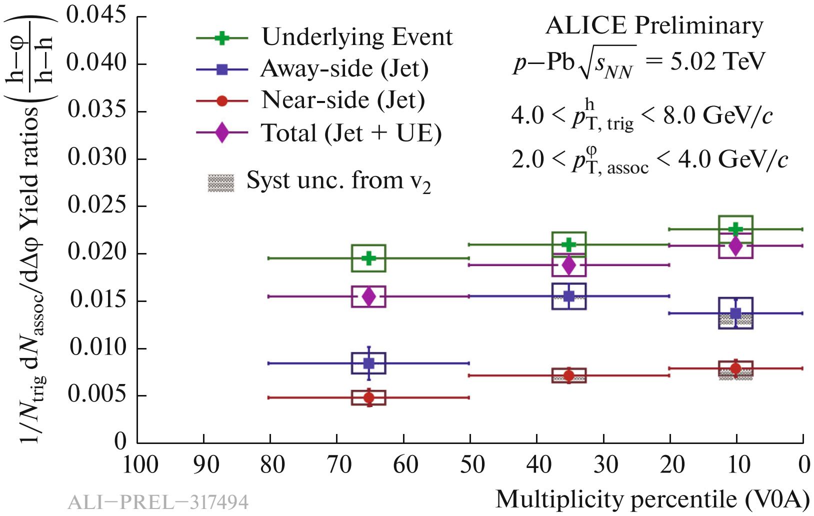

Fig. 2. Pair-wise yield ratios for (h–ϕ)/(h–h) correlated pairs. The 1D angular correlation is separated into near-side, away-side, underlying event, and total regions. Yields of correlated pairs are measured in each of these regions and the ratio is taken for different multiplicity classes.

HEAVY-FLAVOUR CORRELATIONS

Heavy quarks (charm and beauty) are produced in hard scattering processes taking place in the initial stages the collision, therefore they experience the full evolution of the QGP. Performing D-hadron correlations gives access to complementary information w.r.t. "standard" HF observables. Measurements of heavy quark correlations in pp collisions in addition to serving as a reference for heavy-ion measurements allow to investigate heavy-flavour quark fragmentation properties and are sensitive to the relative contribution of different LO and NLO heavy-quark production processes [3]. Performing measurements using p–Pb collisions allows to study cold nuclear matter effects, and investigate possible modifications of angular correlations which could derive from initial-state effects (e.g. CGC) or possible final-state effects (e.g. hydrodynamics).

Azimuthal correlations of D mesons and charged particles in pp ($\sqrt{s}$ = 5.02, 7 and 13 TeV) and 5.02 TeV p–Pb collisions were calculated by ALICE [4, 5]. In Fig. 3 averaged D^0, D^*, D^+-hadron correlation distribution is presented for both $\sqrt{s}$ = 5.02 TeV pp collisions as well as for p–Pb collisions for a chosen p_T range. Results are shown after the subtraction of the baseline. Significant near-side (particles from jet containing the trigger D-meson) and away-side (particles from fragmentation of the other HF jet) peaks are

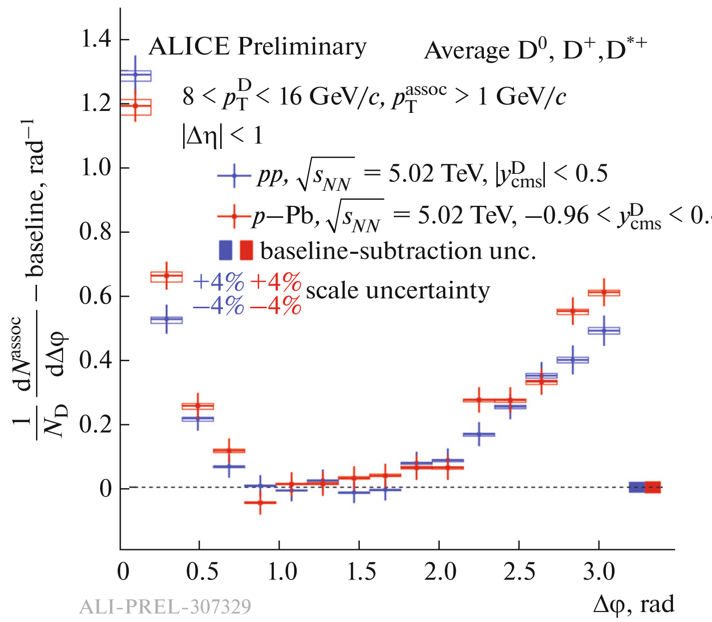

Fig. 3. Azimuthal correlation distribution in pp collisions at $\sqrt{s}$ = 5.02 TeV and p–Pb at $\sqrt{s_{NN}}$ = 5.02 TeV for chosen range of p_T^D and of p_T^{assoc}. Distribution is compatible between pp and p–Pb collisions.

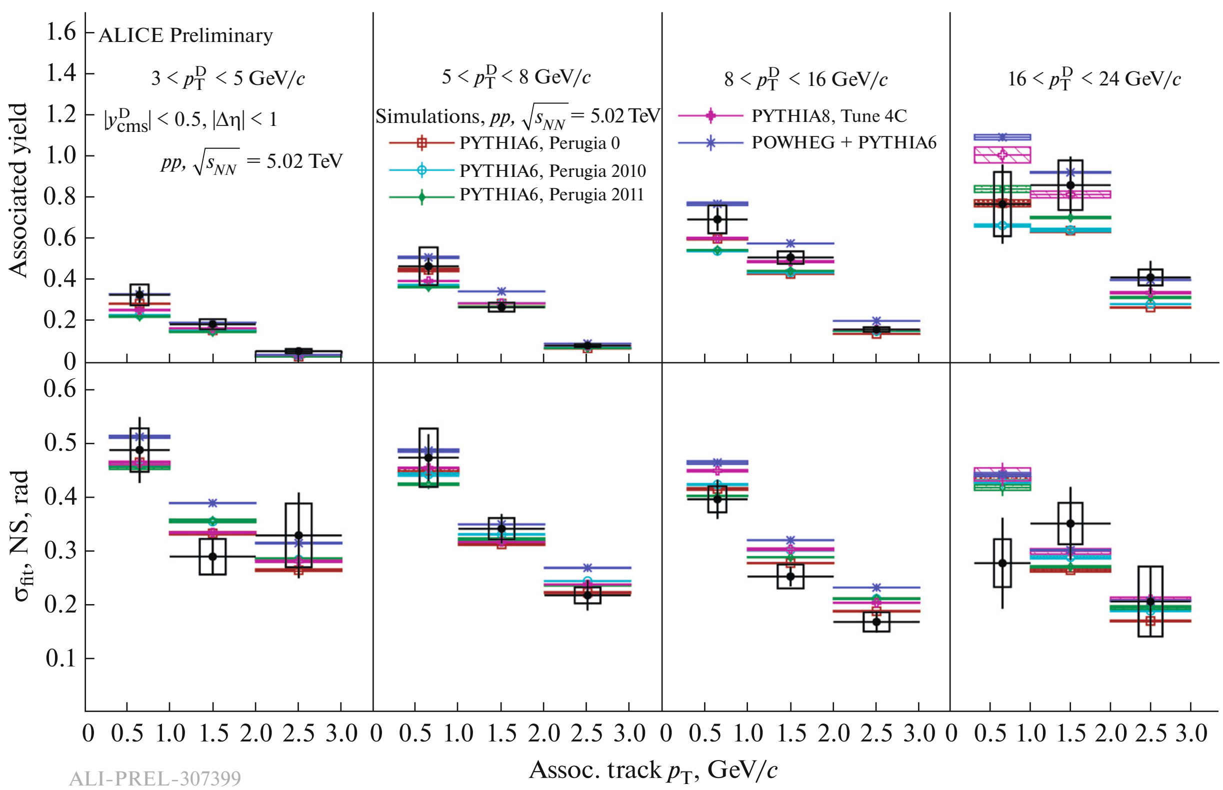

Fig. 4. Comparison of near-side peak yields (top row) and widths (bottom row) extracted from D–h correlation distributions with MC models in pp collisions at $\sqrt{s}$ = 5.02 TeV as a function of p_T^D and p_T^{assoc}. Near-side peak properties are described by the Monte Carlo generators within the uncertainties.

present. It can be seen that pp and p–Pb baseline-subtracted correlation distributions are consistent within uncertainties.

The effects were further quantified with fitting procedure and compared with Monte Carlo models. Figure 4 show integrated near-side associated yield

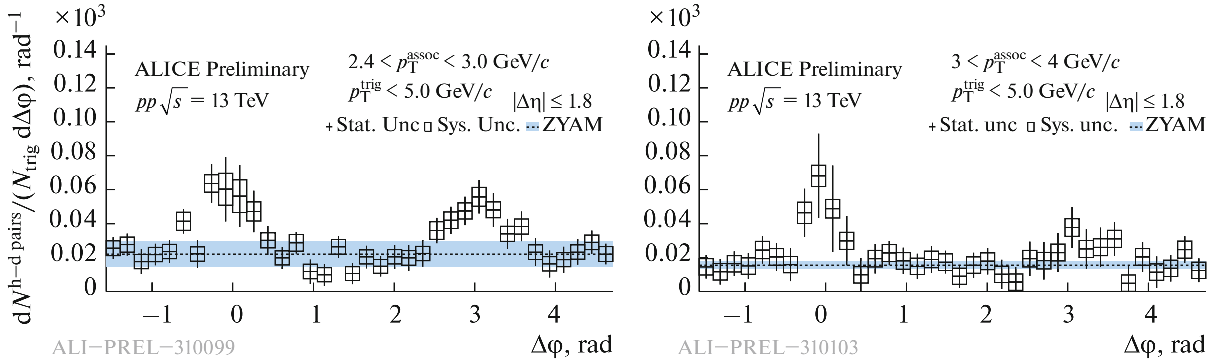

Fig. 5. The correlation of azimuthal angle $\Delta\varphi$ between a high-p_T trigger hadron with $p_T > 5.0$ GeV/c and a deuteron associate with $2.4 < p_T < 3$ GeV/c (left panel) and $3 < p_T < 4$ GeV/c (right panel).

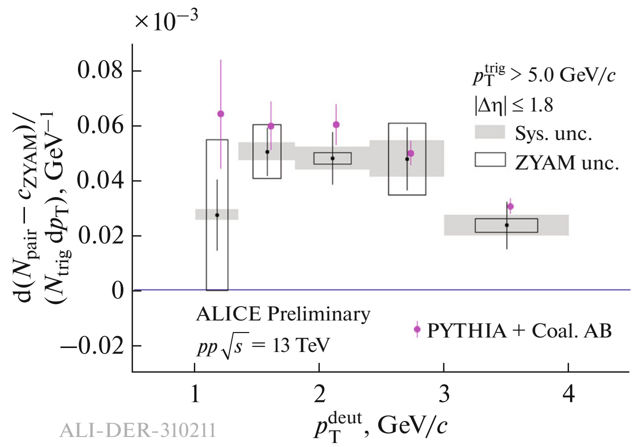

Fig. 6. Deuteron per-trigger yields after uncorrelated Zero-Yield-at-Minimum subtraction. Systematic uncertainty is represented with shaded boxes. Statistical uncertainty is represented with vertical bars. Uncertainty associated with the ZYAM method is represented with open boxes. PYTHIA with coalescence after burner results are shown in violet.

(top panel) as well as the near-side peak width (bottom panel) for both $\sqrt{s} = 5.02$ TeV *pp* collisions data as well as different generators. Both correlation distributions (not shown) as well as the integrated near-side yields in pp collisions after baseline subtraction are well described (within uncertainties) by expectations from PYTHIA6 (with different Perugia tunes), PYTHIA8 and POWHEG+PYTHIA generators in all kinematic ranges.

HADRON-DEUTERON CORRELATIONS

Two-particle correlations can also be used to help us understand mechanisms of formation of deuterons inside jets. In ALICE $\Delta\eta\Delta\varphi$ angular correlations were calculated for high-p_T hadron–deuteron pairs using $\sqrt{s} = 13$ TeV *pp* collisions [6]. High transverse-momentum particle ($p_T > 5$ GeV/c) was used as a proxy for the presence of a jet at mid-rapidity.

As can be seen in Fig. 5 a discernable near-side peak exists near $\Delta\varphi = 0$ and away-side peak near $\Delta\varphi = \pi$. Figure 6 reports integrated per-trigger correlated yields. Separation of 2–4 standard deviations from zero are observed for data points between 1.5 and 4 GeV/c. Therefore, it can be concluded that measurable population of deuterons being produced around the jet proxy.

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