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Measurement of intra-jet properties and their multiplicity dependence in small collision systems with ALICE

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Jets, produced from the hard-scattered (high p_{T}) partons in high-energy collisions, provide an important benchmark for perturbative quantum chromodynamics (pQCD) predictions. Measurements of the intra-jet properties in pp collisions provide a test of pQCD calculations and help to constrain the Monte Carlo models. Jet measurements in p–A collisions are sensitive to cold nuclear matter effects. Recent studies in small collision systems at high multiplicity exhibit signatures of collective effects that could be associated with hot and dense QCD matter known to be formed in heavy-ion collisions. In presence of such QCD matter the internal jet properties are also expected to be modified. Therefore, these measurements in high-multiplicity pp and p–A collisions are important to establish whether deconfined QCD matter is indeed generated in such small systems. In this contribution, we report recent ALICE measurements of charged-particle jet properties, including mean charged-constituent multiplicity and fragmentation distribution for leading jets, in minimum bias pp collisions at $\sqrt{s}$ = 13 TeV and minimum bias p–Pb collisions at $\sqrt{s_{\mathrm{NN}}}$ = 5.02 TeV. In addition, the multiplicity dependence of these jet properties in pp collisions at $\sqrt{s}$ =13 TeV is also presented. Results are compared to the predictions from various Monte Carlo generators.

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1. Introduction

Measurements of the intra-jet properties are sensitive to the details of parton shower and hadronization which are expected to get modified in the presence of a dense partonic medium. These measurements in small collision systems like proton-proton (pp) collisions, especially in high-multiplicity events, are important in order to look for the onset of quark-gluon plasma (QGP)-like effects. In p–Pb collisions, study of jet properties will help to investigate the presence of cold nuclear matter [1] effects to advance the current understanding of particle production mechanisms. In this work, we present the multiplicity dependence of intra-jet properties of leading charged-particle jets, the mean charged-particle multiplicity ($\langle N_{\mathrm{ch}} \rangle$) and fragmentation function ($z^{\mathrm{ch}} = p_{\mathrm{T}}^{\mathrm{particle}} / p_{\mathrm{T}}^{\mathrm{jet,ch}}$) in pp collisions at $\sqrt{s}$ = 13 TeV. We also present measurement of these observables in minimum bias p–Pb collisions at $\sqrt{s_{\mathrm{NN}}}$ = 5.02 TeV. The obtained results are compared with predictions from PYTHIA8 Monash2013 [2] and EPOS LHC [3] for pp collisions and DPMJET [4] for p–Pb collisions.

2. Analysis details

In this analysis, events are required to have a vertex z-position relative to the nominal interaction point of $|z_{\mathrm{vtx}}| < 10$ cm. Minimum Bias (MB) events are selected using the ALICE MB trigger condition which requires the coincidence in the V0A and V0C forward scintillator arrays [5]. High multiplicity (HM) events are selected using the HM trigger condition which requires the sum of V0A and V0C amplitudes to be higher than 5 times the mean MB signal. Charged particles with $p_{\mathrm{T}} > 0.15$ GeV/c, pseudorapidity $|\eta| < 0.9$ and azimuthal angle $0 < \varphi < 2\pi$ are used to reconstruct charged-particle jets with FastJet 3.2.1 [6] using the anti-k_{T} algorithm for jet resolution parameter $R = 0.4$. Instrumental effects are corrected using a 2-D Bayesian unfolding technique [7] implemented in the RooUnfold [8] package. The underlying event contribution is estimated using the perpendicular-cone method [9] and subtracted on a statistical basis after unfolding. In this analysis, the main contributors to the total systematic uncertainty are the uncertainty on the tracking efficiency and the MC event generator dependence.

3. Results and discussion

Figure 1 shows $\langle N_{\mathrm{ch}} \rangle$ as a function of jet p_{T} in minimum bias pp (left) and p–Pb (right) collisions respectively. It is observed that $\langle N_{\mathrm{ch}} \rangle$ increases with the jet p_{T} for both pp and p–Pb collisions. For pp collisions, EPOS LHC underestimates the data whereas PYTHIA8 Monash 2013 [2] explains the data within systematic uncertainties and for p–Pb collisions, DPMJET (GRV94 [10]) explains the data within systematic uncertainties except at low jet p_{T}. Figure 2 shows the z^{ch} ($p_{\mathrm{T}}^{\mathrm{particle}} / p_{\mathrm{T}}^{\mathrm{jet,ch}}$) distributions (fragmentation functions) in different p_{T} intervals in pp (left) and p–Pb collisions (right), respectively. In pp collisions, the projected jet p_{T} bins are between 10 – 20 GeV/c, 20 – 30 GeV/c and 40 – 60 GeV/c, while for p-Pb collisions, the z^{ch} distribution is shown in the jet p_{T} range 20 – 30 GeV/c and 40 – 60 GeV/c because at low jet p_{T} the background deteriorates the jet reconstruction. z^{ch} scaling is observed for different jet p_{T} in pp and p–Pb collisions however, in pp the scaling does not hold at the highest and lowest z^{ch} values. Fig. 3 (left) shows $\langle N_{\mathrm{ch}} \rangle$ (HM)/$\langle N_{\mathrm{ch}} \rangle$ (MB) as a function of leading $p_{\mathrm{T}}^{\mathrm{jet,ch}}$ and Fig. 3 (right) shows the ratio of z^{ch} distributions obtained

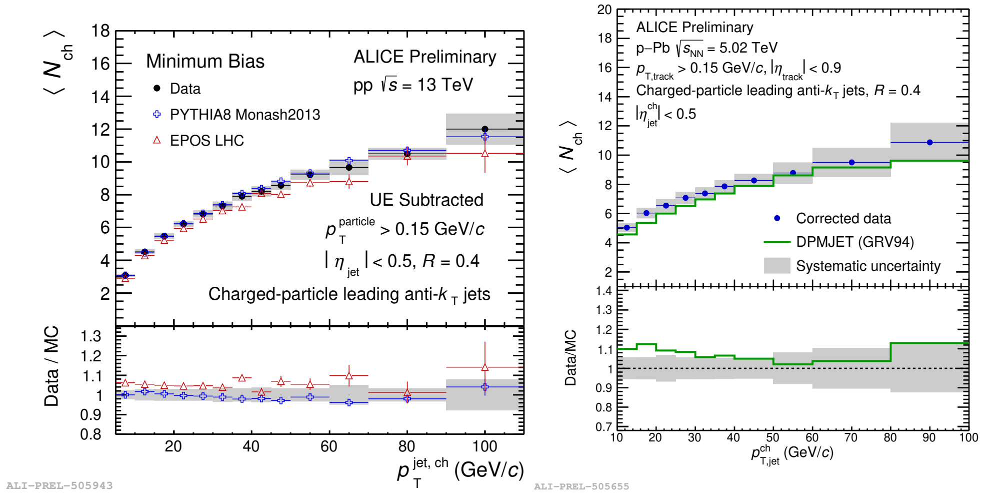

Figure 1: $\langle N_{\text{ch}} \rangle$ as a function of jet p_{T} in minimum bias pp (left) and p–Pb (right) collisions.

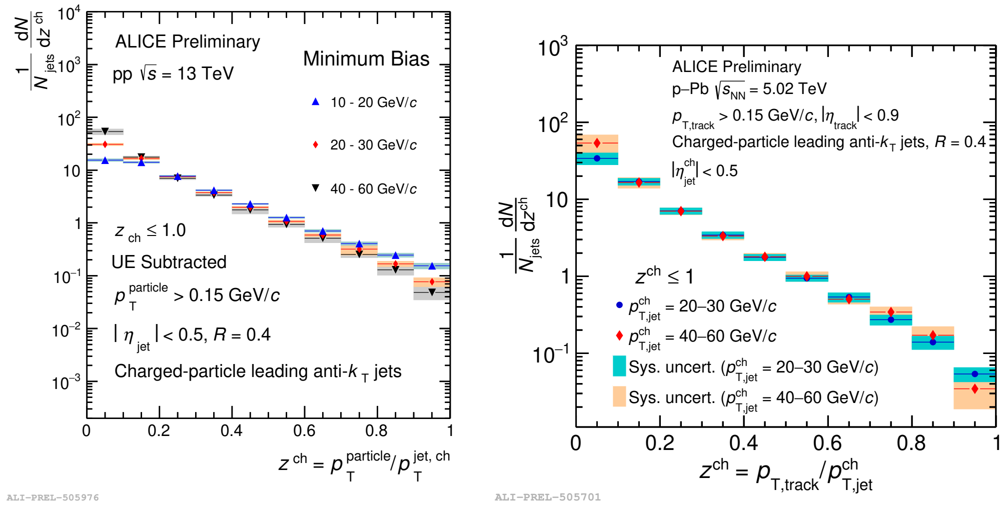

Figure 2: z^{ch} distributions for different jet p_{T} in minimum bias pp (left) and p–Pb (right) collisions.

in HM and MB events. In HM events, slightly larger values of $\langle N_{\text{ch}} \rangle$ is observed for $p_{\text{T}}^{\text{jet,ch}} < 20$ GeV/c which is qualitatively reproduced by PYTHIA8 Monash2013. It is interesting to notice that the jet fragmentation is softer in HM events compared to MB events.

4. Conclusions

We have presented the measurement of intra-jet properties in minimum bias pp and p–Pb collisions at 13 TeV and 5.02 TeV respectively. In addition, the multiplicity dependence of jet properties is also presented in pp collisions at 13 TeV. We have observed z^{ch} scaling for different jet p_{T}. A significant modification in jet fragmentation distributions in high-multiplicity events is also observed compared to minimum bias events.

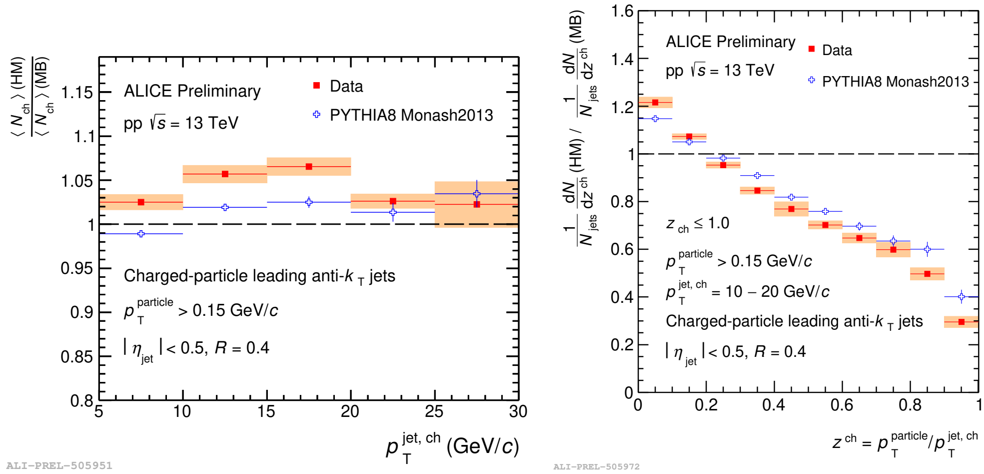

Figure 3: The ratio of $\langle N_{\mathrm{ch}} \rangle$ (left) and z^{ch} (right) distributions between HM and MB events in pp collisions

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