Search for jet quenching effects in high-multiplicity proton-proton collisions at $\sqrt{s} = 13$ TeV

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Motivation: quark-gluon plasma in small collision systems?

Evidence of collective effects

Jet quenching in high particle multiplicity pp collisions

- Inclusive measurements → undefined Glauber scaling
- Semi-inclusive measurements → increase of hadron-jet system acoplanarity

No significant evidence of jet quenching

Energy loss-limit

400 MeV@ 90% CL

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pp collisions at $\sqrt{s} = 13$ TeV

- Data from 2016 - 2018
- Online triggers:
  - Minimum bias (MB): 0.098 pb$^{-1}$
  - High-multiplicity (HM): 13 pb$^{-1}$

- Offline event activity (EA) selection:
  - $V0M = V0A + V0C$

- Scaled multiplicity: $V0M/\langle V0M \rangle$
  - $\langle V0M \rangle$ - mean of MB distribution → Enables comparison of runs with differing V0 gain, and with theory

- HM trigger are limited from above to exclude pile-up events
  - $5 < V0M/\langle V0M \rangle < 9 \approx 0.1\%$ of MB cross section

V0A: $2.8 < \eta < 5.1$

V0C: $-3.7 < \eta < -1.7$

ALICE preliminary

$pp \sqrt{s} = 13$ TeV

- ALICE measured MB
- $5 < V0M/\langle V0M \rangle < 9$
- $5 \approx 0.1\%$ cumulant

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Semi-inclusive recoil jet analysis

- Anti-$k_T$ charged-track jets recoiling from a high-$p_T$ trigger hadron
- Jet $p_T$ is corrected according to area-based $\rho A$ approach
- TT - uncorrelated jet yield removed on statistical basis with data driven approach (see details [1]):

$$\Delta_{\text{recoil}} = \frac{1}{N_{\text{trig}} \cdot dP_{T\text{jet}}^{ch}} \left| \frac{dN_{\text{jet}}}{d\Delta\varphi} \right|_{TT(20,30)} - \frac{1}{N_{\text{trig}} \cdot dP_{T\text{jet}}^{ch}} \left| \frac{dN_{\text{jet}}}{d\Delta\varphi} \right|_{TT(6,7)}$$

- $\Delta_{\text{recoil}}$ can be constructed as a function of TT-jet opening angle

Jet $p_{T\text{jet}}^{ch} \in (20, 30)$ GeV/c

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Acoplanarity versus event activity: raw data and PYTHIA 8

Raw data
- Estimated uncertainty from tracking efficiency
- Significant suppression and broadening of HM data w.r.t. MB

PYTHIA 8 data
- PYTHIA 8 Monash exhibit qualitatively similar suppression effect as raw data
- The effect may be not caused by jet quenching

Use PYTHIA 8 generator to explore origin of the effect
PYTHIA 8 simulations: recoil jet $\eta$ distribution vs. event activity

- **VOM** is defined as the number of charged, final state particles within V0A & V0C acceptances

V0A: $2.8 < \eta < 5.1$ and V0C: $-3.7 < \eta < -1.7$

- **Increase of event activity bias enhances** the probability to find a recoil jet in V0
- **Lower enhancement in V0A is caused by asymmetric coverage of V0 arrays**

**Recoil jets vs. near-side jets**

- Near-side jets are in the same hemisphere as trigger-track
- Event activity selection biases recoil jets
PYTHIA 8 simulations: Number of high-$p_t$ recoil jets vs. event activity in ALICE central barrel

- HM events have suppressed probability to have 1 hard recoil jet in ALICE central barrel w.r.t. MB
- HM trigger enhances multi-jet events
Summary

Raw ALICE Data:
- Suppression and broadening of high-particle multiplicity acoplanarity distribution w.r.t. minimum bias
- Qualitatively similar effect is observed in PYTHIA 8 events

New PYTHIA 8 studies:
- High-multiplicity bias enhances probability to have a high-$p_T$ recoil jet in V0 acceptance
- Forward high-multiplicity trigger induces bias towards multi-jet final states $\rightarrow$ increased acoplanarity at high-particle multiplicity is due to standard QCD effect; Obscures possible jet quenching signal
- Multi-jet bias must be taken into account when imposing high-particle multiplicity bias in small collision systems