Apparent modification of the jet-like yield in proton-proton collisions with large underlying event

Gyula Bencédi (UNAM/ICN, Mexico)
co-authors: Antonio Ortiz (UNAM/ICN) and Sushanta Tripathy (UNAM/ICN)

presented work* published in J.Phys.G 48 (2020) 1, 015007

Poster Session, 10-11.01.2021

* Support for this work has been received from CONACyT under the Grant No. A1-S-2291
Motivation

- High-multiplicity proton-proton collisions show collective behavior

\[
\frac{dn}{d\phi} \propto 1 + \sum_{n} 2v_n(p_T) \cos[n(\phi - \Psi_n)]
\]

- Good agreement with relativistic viscous hydrodynamic calculations

No jet quenching found so far -> searches warranted: first measurement from ALICE collaboration: Search for jet quenching effects in high multiplicity pp collisions at 13 TeV (preliminary)

- Event activity classes based on average multiplicities
- Broadening of recoil jet acoplanarity -> characteristic of jet quenching
- Similar effect observed in the PYTHIA model (which lacks the mechanism of jet-quenching)

Goal:
Study high-multiplicity pp events in PYTHIA to understand the potential biases

Figure: Uncorrected acoplanarity distributions for ALICE data (left) and PYTHIA 8 Monash (right), Nucl.Phys.A 1005 (2021) 121924
**Methods - Observable and Event activity classifier $R_T$**

**Standard two-particle azimuthal correlation analysis to study jet-quenching effects**

$I_{AA}$: ratio of jet-like yield from AA to the one from pp collisions

- $I_{AA}$: ratio of jet-like yield from AA to the one from pp collisions
- interplay between the parton production spectrum and energy loss in the medium
- Towards (away) region: enhancement (suppression)

**PYTHIA 8 model:**

- 2->2 process + parton shower (Initial- and Final state radiation), Color Reconnection, MPI
- primary charged particles in $|\eta|<0.8$, $\sqrt{s} = 5.02$ TeV
- trigger particle: 8 GeV/c < $p_T$ < 15 GeV/c

**Study Underlying Event activity**

- (semi-hard and multi-parton interactions)
- Use relative transverse activity classifier $R_T$

$$R_T = \frac{N_{\text{trans.}}}{N_{\text{ch}}}$$

**Goal:** study how event selection based on $R_T$ biases towards and away regions

**Figure:** $I_{AA}$ for central (black) and peripheral (red) collisions, PRL 108, 092301 (2012)
Methods - jet-like signal $C(\Delta\eta\Delta\phi)$ extraction

- correlations at partonic level (due to gluon radiation or colour reconnection) are turned on and off: Initial- and Final state radiation, CR

- Monash tune: above given $R_T$ value $\langle N_{MPI} \rangle$ saturates -> towards region “picks up” particles from jet fragments -> activity biased

$R_T$ bin 1 2 3 4 5

$\langle N_{MPI} \rangle$

- selection on $R_T$, a third structure in the transverse region ($\pi/3 < |\Delta\phi| < 2\pi/3$): associated yield increases with $R_T$

- contribution to the towards and the away regions has to be removed: using mixed event technique

- Underlying event subtracted using Zero Yield at Minimum method

- evolution of jet signal with $R_T$ is studied

$$C(\Delta\eta, \Delta\phi) = B(0,0) \frac{S(\Delta\eta, \Delta\phi)}{B(\Delta\eta, \Delta\phi)}$$

Figure. Average number of multi-parton interactions as a function of $R_T$
$R_T > 2.5$: distributions have peak at $\Delta \phi \sim 2$ rad
-> region where NMPI saturates: presence of a third jet -> selection bias

-> experimentally also observed ArXiv 1910.04457: particle production strong increase with $R_T$

-> Quantify the effect: calculate the ratio of yields from different $R_T$ classes to the $R_T$-integrated one -> $I_{pp}$
Results - II.

\[ I_{pp} = 1 \text{ w/o radiations} \]

\[ \Rightarrow \text{negl. difference w/ UE subtraction} \]

\[ \Rightarrow I_{pp} \text{ increase with } R_T \text{ incl. radiations: similar to heavy-ion results} \]

\[ \Rightarrow \text{Radiation plays significant role} \]

\[ I_{pp} = 1 \text{ w/o radiations} \]

\[ \Rightarrow \text{w/ UE subtraction: different behavior w.r.t. towards region} \]

\[ \Rightarrow I_{pp} = 1 \text{ after UE subtraction: event selection bias negligible} \]

\[ \text{Takeaway message} \]

High-multiplicity pp events can be made bias-free using event classification based on \( R_T \) and study observables in the away region.