Multiplicity dependence of jet-like two-particle correlations in pp @ √s = 7 and 13 TeV with

Igor Lakomov (CERN)
on behalf of the ALICE Collaboration

XXVI international conference on ultrarelativistic heavy-ion collisions
Quark Matter 2017
Chicago, USA, 7th February 2017
ALICE apparatus

**Time Projection Chamber (TPC)**
- main tracking system

**Inner Tracker System (ITS)**
- trigger
- tracking at low $p_T$
- vertexing

**V0**
- trigger
- multiplicity selection
MPI and two-particle correlations in pp

✧ Particle production in high-energy pp collisions at the LHC is expected to have a substantial contribution from Multiple Parton Interactions (MPI).

✧ Cross-section for 2-->2 process exceeds total pp cross-section at perturbative scales.

✧ Pair yields provide information about parton fragmentation at low $p_T$, as well as the contribution of MPI to particle production.

Away-side jet, $\Delta \varphi \approx \pi$ along $\Delta \eta$ (back-to-back jets)
Near-side jet peak, $\Delta \eta \approx \Delta \varphi \approx 0$ (jet fragmentation)
Near side ridge at high multiplicity

- Near-side ridge in small systems at high multiplicity similar to Pb-Pb (anisotropic flow).
- Origin of the ridge in small systems? (Incoherent) superposition of MPI? Collective effects?
- Multiplicity-dependent studies in pp collisions are needed.

In this talk they will be addressed in the following three multiplicity-dependent analyses:

- **Minijets analysis in pp**
- **Near-side jet peak in pp**
- **Long-range correlations in pp**
Per-trigger pair yields extraction in 1-D

- Correlation function is constructed in 1-D (no corrections to 2-D correlation function).

- Pair-yield per trigger:

\[
\frac{dN}{d\Delta \varphi} = \frac{1}{N_{\text{trig}}} \frac{dN_{\text{assoc}}}{d\Delta \varphi}
\]

- Background is subtracted using ZYAM ("zero-yield-at-minimum") method.

Near-side
Away-side
Background

ALICE, JHEP 1309 (2013) 049

Fit: $\chi^2/\text{NDF} = 1.63$
Average number of triggers, near- and away-side yields increase with multiplicity.

- Autocorrelations contribute to the strong increase in the yield.
- Away-side yield decreases with increasing energy.

The data is compared to PYTHIA6 (Perugia-2011) and PHOJET event generators:

- PYTHIA6 calculations agree fairly well with the data for all the three observables.
- PHOJET seems to disagree with the data both qualitatively and quantitatively.
Uncorrelated seeds and MPI

\[
< N_{\text{uncorrelated seeds}} > = \frac{< N_{\text{trig}} >}{< N_{\text{correlated triggers}} >} = \frac{< N_{\text{trig}} >}{1 + < N_{\text{assoc,nearside}} > + < N_{\text{assoc,awayside}} >}
\]

- number of independent particle sources, less sensitive to autocorrelations

- In Pythia the number of uncorrelated seeds scales linearly with the number of multiple parton interactions (MPI).
Number of uncorrelated seeds increases with increasing multiplicity.

At high multiplicity, hint of deviation from linear trend suggested at low multiplicities. -> a limit in MPI?

PYTHIA calculations agree with the data at three energies quite well.

PHOJET underestimates the data and shows similar shapes for all three energies.
New measurements are consistent with the previous energy-dependence studies.
Larger statistics (+ high-multiplicity trigger) should give a higher reach in multiplicity.
In order to evaluate long-range correlations in small systems an understanding of short-range (mini-)jet-like structures is necessary.

To reduce autocorrelations multiplicity is selected outside of the region where the correlations are measured.
Near-side jet peak extraction

- In order to evaluate long-range correlations in small systems an understanding of short-range (mini-)jet-like structures is necessary.
- To reduce autocorrelations multiplicity is selected outside of the region where the correlations are measured.

- Correlation function is projected onto $\Delta \eta$ and onto $\Delta \phi$. 
In order to evaluate long-range correlations in small systems an understanding of short-range (mini-)jet-like structures is necessary.

To reduce autocorrelations multiplicity is selected outside of the region where the correlations are measured.

- Correlation function is projected onto $\Delta \eta$ and onto $\Delta \phi$.

- Near side peak is isolated and fitted by generalized Gaussian:

$$f_{\text{GenGauss}}(x) = \frac{Y\beta}{2\alpha\Gamma(1/\beta)} e^{-(|x|/\alpha)^\beta}$$

$$\sigma = \sqrt{\frac{\alpha^2\Gamma(3/\beta)}{\Gamma(1/\beta)}} \quad \text{— "width"}$$
Data show a multiplicity dependence of the yields, especially at low multiplicity.

AMPT drastically overestimates the near-side jet peak yields.

The yields in AMPT also show much stronger multiplicity dependence than in the data.

PYTHIA8-Monash shows fair agreement with the data.

PYTHIA8 model with color reconnection demonstrates a decreasing yield with multiplicity in some $p_T$ bins, not observed in the data.
Near-side widths in $\Delta \eta$ in pp@7 TeV

- In general the data show little-to-no multiplicity dependence in the widths.

- The width varies from 0.2 to 0.6 depending on $p_T$ range.

- It sets the scale for the $\Delta \eta$ cuts that can be used to investigate long-range correlations in pseudorapidity.

- Models tend to overestimate the widths of the near-side jet peak at low $p_T$.

- At high $p_T$ the models are either in agreement with or slightly below the data.
ALICE also measured long-range correlations \((1.87<|\Delta\eta|<2.2)\) in pp@7 TeV as a function of multiplicity.

The background is subtracted using a ZYAM-like method: the yield is considered zero at \(\Delta\varphi = 0.8\).

The near-side and away-side yields are evaluated in the following \(\Delta\varphi\) ranges:

\[
|\Delta\varphi| < 0.8 \quad \text{and} \quad 2.4 < |\Delta\varphi| < 3.9
\]
Data show a strong multiplicity dependence of the away-side yield but smaller dependence of the near-side yield.

An enhancement of the long-range yield on the near side is seen in the data at high multiplicity which is not reproduced by PYTHIA.

Away-side yield is also not described by PYTHIA calculations.
Summary

- MPI measurements in pp from 0.9 to 13 TeV:
  - Away-side yield demonstrates strong energy dependence.
  - Number of uncorrelated seeds: hint of non-linear dependence for high multiplicities -> limit in MPI?

- Near-side jet peak measurements in pp@7 TeV:
  - Near-side yield shows multiplicity dependence at low multiplicities.
  - Little or no change in the peak widths with multiplicity.

- Long-range correlations in pp@7 TeV:
  - Data show onset of the near-side yield for multiplicity class <5%.
Thank you!
Backup slides
Near-side widths in $\Delta \phi$ in pp@7 TeV

- Models tend to overestimate the widths of the near-side jet peak at low $p_T$.
- At high $p_T$ the models are either in agreement with or slightly below the data.
- In general the data show little-to-no multiplicity dependence in the widths.
- At low-$p_T$ PYTHIA8 with color reconnection indicates a stronger decreasing trend than observed in the data.