Multiplicity dependence of two-particle correlation in $\sqrt{s}=7\text{TeV}$ pp collisions at LHC-ALICE experiment

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Outline

1. Introduction
2. Analysis method
   - Definition of two-particle correlation
   - Event estimator
   - Multiplicity dependence of Assoc. yields per Trig.
   - Long range $\Delta \eta$ dependence of two-particle correlation.
   - Extraction of double ridge from High - Low
3. Results
   - Yields integration with multiplicity
4. Summary
A Large Ion Collider Experiment

EMCAL
Neutral particles, jets

TRD
Tracking, e-π separation

HMPID
PID

PMD
Photon multiplicity

PHOS
Photons, neutral particles

ZDC (at ±115 m w.r.t IP)

V0 Trigger

T0 Trigger

L3 Magnet

ACORDE
Cosmic trigger

ITS
Tracking, PID

Dipole magnet

Absorber

MUON arm

T0 Trigger

L3 Magnet

TOF
PID

FMD
Forward multiplicity

TPC
Tracking, PID

http://aliweb.cern.ch/

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Introduction

- 2-D Two-particle angular correlation functions for (a) p + p, the central 10% (b) Cu + Cu and (c) Au + Au collisions at $\sqrt{s_{NN}} = 200$ GeV in PHOBOS.

An ordinary (?) pp collisions

v2?

v2
Definition of correlation function

Same pair

\[ S(\Delta \phi, \Delta \eta) = \frac{1}{N_{\text{same}}} \frac{d^2N_{\text{same}}}{d\Delta \phi \, d\Delta \eta} \]

1 \leq p_T, \text{Trig} < 4\text{GeV}/c
1 \leq p_T, \text{Assoc} < 4\text{GeV}/c

Minimum Bias

mixing Background

\[ B(\Delta \phi, \Delta \eta) = \frac{1}{N_{\text{mix}}} \frac{d^2N_{\text{mix}}}{d\Delta \phi \, d\Delta \eta} \]

0.015
0.01
0.005
0.004
0.002
0.006

0.015
0.01
0.005
0.004
0.002
0.006

Minimum Bias

\( \Delta \phi = \phi_A - \phi_T \)

\( \Delta \eta = \eta_A - \eta_T \)

work in progress

Correlation

\[ C(\Delta \phi, \Delta \eta) = \frac{S(\Delta \phi, \Delta \eta)}{B(\Delta \phi, \Delta \eta)} \]

Associ. Yield per Trig.

\[ \text{Yield}(\Delta \phi, \Delta \eta) = \frac{N_{\text{same}}}{N_{\text{trig}}} C(\Delta \phi, \Delta \eta) \frac{1}{\text{efficiency}} \]

Associ. Yield per Trig.

\[ \Delta \phi = \phi_{\text{Assoc}} - \phi_{\text{Trig}} \]

\[ \Delta \eta = \eta_{\text{Assoc}} - \eta_{\text{Trig}} \]
Event definition

V0R=V0A 2,3 Ring+V0C 0,1Ring

⇒ 2.8<η_A<3.4 + -3.7<η_C<-2.7
⇒ Aliroot “V0S”

Mean number of track (|η|<0.9)

<table>
<thead>
<tr>
<th>Low Mult</th>
<th>Mid Mult</th>
<th>High Mult</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.72±0.000</td>
<td>4.34±0.000</td>
<td>9.11±0.001</td>
</tr>
<tr>
<td>16.99±0.001</td>
<td>21.80±0.001</td>
<td></td>
</tr>
</tbody>
</table>

V0R Event estimator

Counts

1Low Mult    79.3 - 100.0%
2Low Mult    48.4 - 79.3%
1Mid Mult    4.8 - 48.4%
1High Mult   0.8 - 4.8%
2High Mult   0.0 - 0.8%

Work in progress

Table 3.1: ALICE experimental data, mean number of track with three different track cuts.
Single distribution of $\eta$ by various event estimators

$2.8 < \eta < 5.1$

$-3.7 < \eta <-1.7$

$\eta$ in high multiplicities are less jet biased than low multiplicities.

$|\eta|<0.9$

Measuring correlations in small systems has advantages (strong correlated particle production) and disadvantages (biased event centrality selection).

- In order to avoid jet biased multiplicity selection, hybrid event estimator (V0R) is applied.
- TPC event estimator show self-/auto correlation, such as wing shape.

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2.8<$\eta_A$<3.4 + -3.7<$\eta_C$<-2.7
Multiplicity dependence of two-particle correlation
- Assoc. yields per Trig.

- **Background** increase with increasing multiplicities.
- Near side jets \( ((\Delta \phi, \Delta \eta) \approx (0,0)) \) increase with increasing multiplicities.
- **Ridge structures** in the highest multiplicity and 2\(^{nd}\) highest multiplicity in \( \Delta \phi \approx 0 \).
Long range correlation function

- after flat background (Avg.ZYAM) subtraction, near-side jet is gone for low multiplicities, but not at high multiplicities.

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\[ 0.6 < |\Delta \eta| \leq 1.0 \quad 1.0 < |\Delta \eta| \leq 1.4 \quad 1.4 < |\Delta \eta| < 1.8 \]
Long range correlation function, **Pythia**
- after flat background subtraction, near-side jet dies out at larger $\Delta \eta$

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$0.6 < |\Delta \eta| \leq 1.0$

$1.0 < |\Delta \eta| \leq 1.4$

$1.4 < |\Delta \eta| < 1.8$
Double ridge

V0R

RecV0R

work in progress

Pythia

High - Low

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High - Low

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Pythia

Double ridge

V0R

RecV0R

1 ≤ p_{T, Trig} < 4 GeV/c
1 ≤ p_{T, Assoc} < 4 GeV/c

[0%-5%] - [50%-100%]
Yields integration with multiplicity

- Integrated yields in near side increase with increasing multiplicity.
- Integrated yields in away side are constant with $\Delta\eta$.
- $\Delta\eta$ dependence is clearly different between data and pythia model, especially with large rapidity.

- \textbf{work in progress}
Summary

• Multiplicity dependence of the correlation functions measured in $\Delta \eta$
  ➔ Ridge/Double ridge at $\Delta \phi \approx 0$ and $\pi$ in 0-5% high multiplicity.

• Integrated yield increases with multiplicity.

• Pythia can not reproduce ridge structure.

Key words: pp high multiplicity, ridge, hydrodynamical evolution
Backup
Renormalizing factor
Strategy for p2 parameter

Fitting function \( F(\Delta \varphi) = a + bf(\Delta \varphi) \)

Fourier fit \( p2 \) parameter = \( v_2^2 \) parameter

\( f(\Delta \varphi) \) by rescaling [0-1] the lowest multiplicity data

\begin{align*}
C(\Delta \varphi, \Delta \eta) \rightarrow C(\Delta \varphi) & \rightarrow \text{Fitting function} \rightarrow R(\Delta \varphi) \rightarrow \text{Fourier fit} \rightarrow p2 \text{ parameter} \\
\end{align*}

\( \Delta \varphi = \varphi_A - \varphi_T \)

\( 1.5 \leq |\Delta \eta| \leq 1.8 \)

\( \text{Fitted } F(\Delta \varphi) \)
Fitted $F(\Delta \phi)$ and Fourier fit in $1.5 \leq |\Delta \eta| < 1.8$

Shapes ($C(\Delta \phi)$) become narrower with increasing multiplicities

- **1Low Mult**
  - $p_2 = 0.000 \pm 0.000\%$
  - $|\Delta \eta| < 1.8$

- **2Low Mult**
  - $p_2 = 0.210 \pm 0.261\%$
  - $|\Delta \eta| < 1.8$

- **Mid Mult**
  - $p_2 = 0.197 \pm 0.246\%$
  - $|\Delta \eta| < 1.8$

- **1High Mult**
  - $p_2 = 0.394 \pm 0.250\%$
  - $|\Delta \eta| < 1.8$

- **2High Mult**
  - $p_2 = 0.497 \pm 0.258\%$
  - $|\Delta \eta| < 1.8$

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$P_2$ parameter \((V_2^2)\) in \(1.5 \leq |\Delta \eta| < 1.8\)

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\(p_2\) parameter

\(= 0.2 - 0.5\%\)

\(p_2\) parameter

\(= -0.9 - -0.5\%)\)
P2 parameter

With respect to the lowest multiplicity

$1.2 \leq |\Delta \eta| < 1.5$

• $1.5 \leq |\Delta \eta| < 1.8$

$1 \leq p_{T, \text{Trig}} < 4 \text{GeV/c}$

$1 \leq p_{T, \text{Assoc}} < 4 \text{GeV/c}$

ALICE MC Pythia

With respect to MB

$1.2 \leq |\Delta \eta| < 1.5$

• $1.5 \leq |\Delta \eta| < 1.8$

$1 \leq p_{T, \text{Trig}} < 4 \text{GeV/c}$

$1 \leq p_{T, \text{Assoc}} < 4 \text{GeV/c}$

ALICE MC Pythia

V0R

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$P_2$ parameter ($V_2^2$) in TPC-V0 (2<|Δη|<4)

$1 \leq p_T, \text{Trig} < 4\text{GeV/c}$

V0C 0,1 rings
V0A 2,3 rings

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$V_0R$

\begin{itemize}
  \item ALICE
  \item Pythia
\end{itemize}

\begin{itemize}
  \item $P_2$ parameter
 \item in progress
\end{itemize}

\begin{itemize}
  \item $P_2$ parameter
 \item work in progress
\end{itemize}

\begin{itemize}
  \item $P_2$ parameter
 \item =0 $- 0.09\%$
\end{itemize}

\begin{itemize}
  \item $P_2$ parameter
 \item =-0.09 $- -0.06\%$
\end{itemize}

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The $p^2$ extraction

$ab, ac = p^2$ of TPC-V0

$bc = p^2$ of V0-V0

$ab \times \frac{ac}{bc} = a^2$

$a^2 = v^2$ of TPC

work in progress
Due to the most tight track cut in TPC

work in progress
Data set

- LHC10d and LHC10e (AOD 147)
- Pythia, LHC10f6a

- Event selection
  kMB
  \(|\text{Vertex}_z| < 10\text{cm}\)

- Track selection
  (X) the hybrid track cut (IsHybridGlobalConstrainedGlobal()).
  (O)track cuts 1 is the BIT(4) (kTrkGlobalNoDCA).
  (OK)track cuts 2 is the BIT(5) (kTrkGlobal).