The Ridge and Di-hadron Correlations from the Beam Energy Scan

Liao Song for the STAR Collaboration

University of Houston

29th September 2015
Di-hadron correlations and ridge

★ Different orders of flow harmonics extracted using di-hadron correlations. Two methods used: Fourier decomposition method and Gaussian fitting method.
★ Does the ridge survive in all centralities and collision energies in the BES?

STAR Collaboration, Phys.ReV.C80(2009)064912

ALICE Collaboration PLB 708.(2012)249-264
dv$_1$/dy of net proton in the BES


- STAR observed double sign change for proton dv$_1$/dy - Possible signature of 1st order phase transition and softening of the EOS.
- Is there also evidence of this from higher order harmonics v$_2$ and v$_3$?
- Auvinen and Petersen (PRC 88 (2013) 064908) suggested v$_3$ could be suppressed relative to v$_2$. Hadronic interactions could wash out the softening of the EOS for v$_2$, making v$_3$ more sensitive to the first order phase transition.
Data sets and event/track selection

Au+Au $\sqrt{s_{NN}} = 7.7 - 39$ GeV

<table>
<thead>
<tr>
<th>energy (GeV)</th>
<th>vertex z cut</th>
<th>No. Evt</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.7</td>
<td>±70cm</td>
<td>4M</td>
</tr>
<tr>
<td>11.5</td>
<td>±50cm</td>
<td>12M</td>
</tr>
<tr>
<td>14.5</td>
<td>±50cm</td>
<td>20M</td>
</tr>
<tr>
<td>19.6</td>
<td>±40cm</td>
<td>36M</td>
</tr>
<tr>
<td>27</td>
<td>±40cm</td>
<td>70M</td>
</tr>
<tr>
<td>39</td>
<td>±40cm</td>
<td>130M</td>
</tr>
</tbody>
</table>

Track cuts:
- $|\eta| < 1$
- $0.2 < p_T < 2$ GeV/c
- number of TPC hits $> 15$
- fitted hits/maximum possible hits $> 0.52$
- DCA $< 2$ cm

TPC: the main detector used in the analysis

the STAR detector
Di-hadron correlations in BES energies

\[ C(\Delta \phi, \Delta \eta) = \frac{N_{same}(\Delta \phi, \Delta \eta)}{N_{mixed}(\Delta \phi, \Delta \eta)} \]

To quantify the ridge, we make a projection of \( \Delta \Phi \) for large \( \Delta \eta \).
ΔΦ projection of di-hadron correlations

(1<|Δη|<2) Fourier decomposition method

★ Near-side ridge persists down to the lowest energies for central collisions.
★ Ridge subsides in peripheral collisions at the lowest energies.

Liao Song for the STAR Collaboration
Quark Matter 2015
Both $v_2\{2\}^2$ and $v_3\{2\}^2$ show monotonically increasing trends vs. the collision energy.
$v_3 \{2\}^2/v_2 \{2\}^2$ vs. energy

Fourier decomposition method

$\langle v_3^2 \rangle/v_2^2$ STAR Preliminary

$\triangledown$ 0-5%

$\Delta$ 10-20%

$\blacktriangle$ 30-40%

$1 < |\Delta \eta| < 2$

2.76 TeV data from ALICE, 

$\star$ $v_3 \{2\}^2/v_2 \{2\}^2$ in 0-5% central collisions shows a dip vs. beam energies. It is not seen in all more peripheral bins.

$\star$ Next slides will investigate $v_3\{2\}^2$ extracted from Gaussian fitting method.
Energy and $\Delta \eta$ dependence of $v_3 \{2\}^2$

Gaussian fitting method

The two component Gaussian fitting range covers $|\Delta \eta|<2$. The wider Gaussian gives the dashed curve: $v_3 \{2\}^2$

- $v_3 \{2\}^2$ persists down to lowest energies in central collisions.
- At low energies, $v_3 \{2\}^2$ disappears in peripheral collisions.
- Consistent with the Fourier decomposition method shown earlier.
Energy dependence of $v_3^2$²

Gaussian fitting method

2.76 TeV data from ALICE, Phys. Rev. Lett. 107, 032301 (2011)

Over the range -2<Δη<2. Short range HBT-like correlations removed

★ Strong $v_3^2$² even at lowest energies.

★ $v_3^2$² approximately constant from 7.7 to 19.6 GeV.

★ Large increase from RHIC to LHC.
Energy dependence of $v_3 \{2\}^2/n_{ch,PP}$

Gaussian fitting method

$n_{ch,PP}=(2/N_{part})dN_{Ch}/d\eta$ is the multiplicity per participant pair, used as an estimation of the density of the system.

- Scaling $v_3 \{2\}^2$ by multiplicity reveals interesting trend.
- Minima are prominent for all centrality intervals up to 0-50% most central.
- Dips in $dv_1/dy$ and $v_3 \{2\}^2/n_{ch,PP}$ occur around the same beam energy.
Summary

★ Di-hadron correlations and anisotropic flow coefficients from Fourier decomposition method and Gaussian fitting method were presented. The two methods are consistent.

★ Ridge and $v_3 \{2\}^2$ persist to lowest beam energies for central Au+Au collisions and become zero for peripheral collisions at the lowest energies.

★ Minima observations:
  ✦ Local minimum observed when $v_3 \{2\}^2$ is scaled by $v_2 \{2\}^2$ only in the 0-5% most central collisions;
  ✦ Local minimum also observed when $v_3 \{2\}^2$ is scaled by $n_{ch,PP}$ for all centrality bins in the 50% most central collisions;
  ✦ Both of these minima are in the range of 11.5 to 19.6 GeV in beam energy.
THANK YOU!
$V_n(2)^2$

Au+Au 0-5%

- $v_2^2$ from Fourier decomposition
- $v_2^2$ from Gaussian fitting
- $v_3^2$ from Fourier decomposition
- $v_3^2$ from Gaussian fitting

$\sqrt{s_{NN}}$ (GeV)