Reaction plane and pseudo rapidity dependence of inclusive photon - hadron $\Delta \phi - \Delta \eta$ correlation in Au+Au $\sqrt{s_{NN}}=200$ GeV collisions at RHIC-PHENIX

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Outline

- Jet Physics in Heavy Ion collisions
- Trigger Selected $\Delta \phi$ correlation
- Physics Motivation
- Analysis
- Consistency check of $\Delta \phi - \Delta \eta$ correlation
- Summary
Jet physics in heavy ion collisions

- Jet like correlation is a useful probe to understand the mechanism of hot matter evolution in heavy ion collisions!!
  - Jet quenching
  - Mach Cone like structure
- As next step, trigger selected correlation study has started.
Trigger selected jet like $\Delta \phi$ correlation

- Au+Au 200 GeV Hadron–Hadron (Run7)
- Centrality: 20–50%
- $P_{T}^{\text{Trig}}: 2–4\text{GeV}$ $P_{T}^{\text{Assoc.}}: 1–2\text{GeV}$
- By selecting trigger relative angle from reaction plane, correlation shape at away side changes.

$\phi_{s} = \phi_{\text{Trig.}} - \Phi_{R.P.} \left[-\pi/2, \pi/2\right]$
Trigger selected ridge like $\Delta \phi$ correlation

- Au+Au 200GeV Hadron – Hadron
- Centrality : 20–60%
- $\text{Pt}_{\text{Trig}} : 3$–$4\text{GeV}$, $\text{Pt}_{\text{Asso}} : 1$–$1.5\text{GeV}$
- $|\Delta \eta| > 0.7$, $\phi_{\text{Trig}} - \Phi_{\text{R.P.}} < 0$
- Focus on only red line
- Near side peak shifts to “+” $\Delta \phi$ direction when trigger angle moves from inplane to out of plane.
Physics Motivation

- It has been observed that $\Delta \phi$ correlation with respect to R.P. has right/left asymmetry given by almond-like geometry and/or elliptic expansion.
- We might be able to discuss the mechanism of QGP expansion/geometry in $\eta$ direction by the following analysis.
- To this aim, we confirm if there is existence of reaction plane and trigger $\eta$ dependence in $\Delta \eta$ correlation at $\Delta \phi=0$.
  - Backward/Forward asymmetry with respect to selected trigger $\eta$
  - Reaction Plane dependence
Analysis

- AuAu 200GeV taken by RHIC–PHENIX in Run7
- Inclusive Photon – Hadron $\Delta \phi$–$\Delta \eta$ correlation w.r.t. R.P. and trigger $\eta$
  - Trigger is Inclusive Photon at pT : 2–4GeV
  - Associate is Charged Hadron at pT : 1–2GeV
  - The reason why I chose inclusive photon is that Inclusive photon – Hadron analysis is the first step towards Direct photon – Hadron Analysis.
- v2 modulated background was subtracted with ZYAM method.
- Trigger particle binning
  - R.P. is divided into 8 regions
  - $\eta$ is also divided into 8 regions

![Diagram showing in-plane and out-of-plane divisions](image)
Consistency check of $\Delta\phi - \Delta\eta$ correlation at central

- Trigger: Inclusive Photon
- Associate: Charged Hadron
- $p_{T,\text{trig}}$: 2~4 [GeV]
- $p_{T,\text{asso}}$: 1~2 [GeV]
- Centrality: 0~20 %

**Run7**

**Run4**

- We checked consistency of $\Delta\phi - \Delta\eta$ correlation between Run7 and Run4
- The left plot is the sum of the trigger selected $\Delta\phi - \Delta\eta$ correlation
- We can see the a certain level of consistency between those.
Consistency check of $\Delta\phi - \Delta\eta$ correlation at peripheral

**Trigger:** Inclusive Photon  
**Associate:** Charged Hadron  
$p_{T_{\text{trig}}} : 2\sim4$ [GeV]  
$p_{T_{\text{asso}}} : 1\sim2$ [GeV]  
**Centrality:** 50\sim93 \%  

Run7

- PHENIX work in progress

Run4

- $Au+Au \sqrt{s_{NN}} = 200$ GeV
- $p_{T} < (2.0,3.0)$ GeV/c
- $p_{T} = (1.0,2.0)$ GeV/c
- Centrality 60-90%

We checked consistency of $\Delta\phi - \Delta\eta$ correlation between Run7 and Run4:
- the left plot is the sum of the trigger selected $\Delta\phi - \Delta\eta$ correlation
- We can see the a certain level of consistency between those.
Summary & Outlook

◆ Summary
  ■ We observed right/left asymmetry in $\Delta \phi$ correlation w.r.t. R.P.
  ■ We checked the consistency of $\Delta \phi - \Delta \eta$ correlation between Run7 and Run4

◆ Outlook
  ■ We started the trigger selected $\Delta \phi - \Delta \eta$ correlation analysis w.r.t. R.P. and $\eta_{\text{trig}}$
BACK UP
$\Delta \eta$ correlation shape

$\eta_{trig} = 0$

$\eta_{trig} > 0$

$\eta_{trig} \gg 0$

$0 \leq \Delta \eta = \eta_{asso} - \eta_{trig}$
Trigger Particle Binning

Regions 5~8 are folded (Δφ' = −Δφ) into 1~4

Regions 5~8 are folded (Δη' = −Δη) into 1~4

in plane

out of plane

Pseudo Rapidity

η = −0.35

η = 0

η = 0.35

Beam Axis

Reactions Plane
PHENIX detector

Azimuthal direction

Track direction

\[ \eta = -\ln \tan (\theta /2) \]

### Track direction

<table>
<thead>
<tr>
<th>Component</th>
<th>( \Delta \eta )</th>
<th>( \Delta \phi )</th>
<th>Purpose and Special Feature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Magnet: central (CM)</td>
<td>(</td>
<td>\eta</td>
<td>&lt; 0.35 )</td>
</tr>
<tr>
<td>i = 1.1 to 2.2</td>
<td>360°</td>
<td>0.72 T-m for ( \eta=2 )</td>
<td></td>
</tr>
<tr>
<td>muon (MMN)</td>
<td>1.1 to 2.4</td>
<td>360°</td>
<td>0.72 T-m for ( \eta=2 )</td>
</tr>
<tr>
<td>BBC</td>
<td>3.0 &lt; ( \eta ) &lt; 3.9</td>
<td>360°</td>
<td>start timing, fast vertex</td>
</tr>
<tr>
<td>ZDC</td>
<td>( \pm 2 ) mrad</td>
<td>360°</td>
<td>Minimum bias trigger</td>
</tr>
<tr>
<td>DC</td>
<td>(</td>
<td>\eta</td>
<td>&lt; 0.35 )</td>
</tr>
<tr>
<td>PC</td>
<td>(</td>
<td>\eta</td>
<td>&lt; 0.35 )</td>
</tr>
<tr>
<td>RICH</td>
<td>(</td>
<td>\eta</td>
<td>&lt; 0.35 )</td>
</tr>
<tr>
<td>TOF</td>
<td>(</td>
<td>\eta</td>
<td>&lt; 0.35 )</td>
</tr>
<tr>
<td>PbSe EMCal</td>
<td>(</td>
<td>\eta</td>
<td>&lt; 0.35 )</td>
</tr>
<tr>
<td>PbGl EMCal</td>
<td>(</td>
<td>\eta</td>
<td>&lt; 0.35 )</td>
</tr>
<tr>
<td>PbGl EMCal</td>
<td>(</td>
<td>\eta</td>
<td>&lt; 0.35 )</td>
</tr>
<tr>
<td>( \mu ) tracker(( \mu )TS)</td>
<td>-1.15 to -2.25</td>
<td>360°</td>
<td>( K/\pi ) separation up to 1 GeV/c by TOF</td>
</tr>
<tr>
<td>( \mu ) tracker(( \mu )TN)</td>
<td>1.15 to 2.44</td>
<td>360°</td>
<td>Tracking for muons</td>
</tr>
<tr>
<td>( \mu ) identifier(( \mu )IDS)</td>
<td>-1.15 to -2.25</td>
<td>360°</td>
<td>Muon tracker north installed for Year-3</td>
</tr>
<tr>
<td>( \mu ) identifier(( \mu )IDN)</td>
<td>1.15 to 2.44</td>
<td>360°</td>
<td>Steel absorbers and Farooq tubes for muon/hadron separation</td>
</tr>
<tr>
<td>RxNP</td>
<td>1.0 &lt; (</td>
<td>\eta</td>
<td>&lt; 2.8 )</td>
</tr>
</tbody>
</table>
1. Projected $\Delta \Phi - \Delta \eta$ correlation to the $\Delta \Phi$ direction
2. Applied ZYAM Method to projected $\Delta \Phi$ correlation and extract $b_0$
3. Adopted the $b_0$ extracted in 2. for all $\Delta \eta$ range

$$\text{Corr} = \text{Rawcorr} - b_0 \ast \text{Flow}$$