Systematic Studies of Jet–medium Interactions in STAR

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**Tomography with Jets**

Path-length dependent energy loss  
Hard scattering selection

- **Di-jet momentum imbalance**  
  → shorter path length? (tangential biased di-jets)
- **Di-hadron correlations**  
  → maximum path length (trigger surface bias)

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**High-\(p_T\) hadron**
- Surface bias
- Hard-core jets
- Hard scattering selection

**High-\(p_T\) direct \(\gamma\)**
- Less bias
- No bias

*T. Renk PRC 88, 054902 (2013)*
Method for Di-jet Imbalance Study

\[ p_T^{Lead} > 20 \text{ GeV/c, } p_T^{SubLead} > 10 \text{ GeV/c, } |\Delta \phi - \pi| < 0.4 \]

HT: Neutral particle with \( p_T > 5.4 \) GeV/c

Hard-Core Di-jets
Constituents \( p_T^{cut} = 2 \) GeV/c

\[ p_{Jet} = p_{rec} \]

Matched Di-jets
Constituents \( p_T^{cut} = 0.2 \) GeV/c

\[ p_{Jet} = p_{rec} - \rho A \]

Keep this jet selection

Calculate “matched” momentum imbalance with constituent \( p_T^{cut} > 0.2 \) GeV/c.

Kun Jiang
Quark Matter 2018, Venice, Italy
Di-jet Imbalance

- Hard-core di-jets in central Au+Au significantly more imbalanced than p+p
- Momentum balance restored to p+p baseline for $R = 0.4$ with soft particles included

\[ A_J = \frac{p_T^{\text{Lead}} - p_T^{\text{SubLead}}}{p_T^{\text{Lead}} + p_T^{\text{SubLead}}} \]
Centrality Dependence of $A_J$

- Comparable between Au+Au Run 14 and Run 7 in 0-20% centrality (detector level)
- Run14: large increase in statistics
  → enable to study centrality dependence
- Apparent evolution of $A_J$ to more balanced jets in peripheral Au+Au collisions
Enhanced Away-side Momentum Flow

Projection of away-side $p_T$ onto trigger axis

\[ P_x |_{\eta_2} = \sum_{\eta_1 < \eta < \eta_2, |\phi - \phi_{\text{trig}}| > \pi/2} p_T \cdot \cos(\phi - \phi_{\text{trig}}) \cdot \frac{1}{\epsilon} \]

\( \epsilon: \) single-particle acceptance \( \times \) efficiency

- For each centrality, cut on the lowest 10% of events to enhance away-side momentum flow \( \rightarrow \) “jet” = jet + jet-like hotspots
Methodology for Two-particle Correlations

- Away-side: large recoil momentum region opposite to trigger particle
- Analyze correlations in close-region and far-region, respectively
- Flow contributions to close-region and far-region are equal \( \Rightarrow \) cancelled in their difference

\[
\text{close-region} = \text{flow} + \text{near-side “jet”} + \text{away-side “jet”} \times \text{fraction}_{\text{close}}
\]
\[
\text{far-region} = \text{flow} + \text{near-side “jet”} + \text{away-side “jet”} \times \text{fraction}_{\text{far}}
\]
\[
\text{diff} = \text{away-side “jet”} \times \text{fraction}
\]
Flow Subtracted Away-side Correlation

STAR TPC

- Near-side equal as expected
- Away-side *yield* contains unknown “fraction” factor
- Away-side *shape* can be quantified by Gaussian fit width, $\sigma$

STAR preliminary

Data provided by STAR TPC

$3<p_T^{\text{trig}}<10\text{ GeV/c}$ $2<p_T^{\text{assoc}}<3\text{ GeV/c}$

$\pi$

$\phi_{\text{trig}}$

$\eta$

$\chi^2/\text{ndf} = 34.3/46$
The away-side correlation shape is consistent with Gaussian for all centrality and $p_T$ bins.

- **50-80% $0.15<p_T^{assoc}<0.5$ GeV/c**
  - STAR preliminary
  - $\chi^2$/ndf 39.0/46

- **50-80% $2<p_T^{assoc}<3$ GeV/c**
  - STAR preliminary
  - $\chi^2$/ndf 42.3/46

- **0-10% $0.15<p_T^{assoc}<0.5$ GeV/c**
  - STAR preliminary
  - $\chi^2$/ndf 44.8/46

- **0-10% $2<p_T^{assoc}<3$ GeV/c**
  - STAR preliminary
  - $\chi^2$/ndf 38.1/46
- Moderate to high $p_T$ assoc. particles: broadening with increasing centrality
- Shape for all $p_T$ more similar in central than in peripheral collisions
Medium-induced Away-side Broadening

- Width decreases rapidly with increasing $p_T^{\text{assoc}}$ → expected for jet-like correlations
- In central collisions the decrease is not as large → stronger broadening at higher $p_T$
- Different from jet-hadron correlations:
  - Different “jet” kinematics?
  - Different trigger biases?

STAR PRL 112, 122301 (2014)
Conclusions

• Di-jet momentum imbalance:
  – Much improved statistics allow first measurement of centrality dependence at RHIC
  – $A_J$ more balanced for peripheral Au+Au data

• Away-side jet-like correlations:
  – Away-side shape with robust flow background subtraction
  – Correlation broadens with increasing centrality except low $p_T$
  – Stronger centrality dependence of broadening at higher $p_T$
Outlook

- $\gamma$-jet and $\pi^0$-jet
- $p+A$ hadron-jet

- Heavy-flavor tagged jet (Saehanseul Oh poster #375)
**$z_g$ in Au+Au**

- Groomed momentum sharing $z_g$ of hard-core di-jets: Theory calculations show good agreement

![](chart1.png)

*Li & Vitev arXiv: 1801.00008*

- More differential measurements of $z_g$ and jet sub-structure coming soon

![](chart2.png)

*N.-B. Chang et al. PLB 781 (2018) 423*
Thank you!
Backup slides
γ+jet and π₀+jet in the STAR Experiment

Au+Au 200 GeV, 0-15% central collisions

Good trigger statistics after QA
(9 < p_T^{trig} < 30 GeV/c)

Events
0 35000 70000 105000 140000
Run11 Run14

Counts [Normalized]
0 1 10 10^2 10^3 10^4
p_T^{trig} [GeV/c]

Analysis is underway and will be updated soon.
Jet-hadron

![Diagram showing the relationship between jet production and hadron yield in different channels.](image)

PRL 112, 122301 (2014)