Jet-Hadron Correlations Examined with Monte Carlo Models

R. Ehlers, Kirill Lapidus, M. Oliver
Yale University, RHI group
Introduction: Jet-Hadron Correlations

Azimuthal distribution of hadrons in jet-triggered events

Near-Side Peak:
- surface biased
  (trigger conditions)

Away-Side Peak:
- longer in-medium path
- shower broadening
- softening of the FF

Reference:
“vacuum” AS peak, measured in pp collisions
Experimental Measurements

STAR jet-hadron measurement
- hint for the AS peak broadening in AuAu collisions w.r.t. pp reference
- systematics doesn’t allow for a conclusive statement
- data well described by YaJEM

On-going analysis:
- PbPb at 2.76 TeV
- also feasible with new 5.02 TeV data

Need for theoretical predictions!


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Models

**JEWEL** — explicit pQCD treatment of hard parton scattering on partons of the medium (recoils can be kept or discarded)


**YaJEM** — scattering on constituents is not modeled explicitly

Hard parton acquires virtuality from the medium:

\[ \Delta Q^2 = \kappa \int \epsilon^{3/4} (\xi) \, d\xi \]

enhanced radiation \(\Rightarrow\) broadening and softening of the shower

Free parameter \(\kappa\) must be tuned to reproduce exp. data \((R_{AA})\)

**Models**

**JEWEL 2.0.2**
- complete event generator
- 1+1 Bjorken-type hydro
- hard scatterings from PYTHIA

**YaJEM 1.15**
- not an event generator
- in-medium showering routine
- “user” has to implement own workflow:
  - hydro input — $\epsilon(x,y,z,t)$
    - (1+1) hydro — from JEWEL
    - (2+1) hydro — superSONIC
  - hard scattering events
    (vertex, energy, parton type)

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Simulation and Analysis Setup

- AuAu@200 GeV, \( b = 0 \)
- \( T_{\text{in}} = 370 \text{ MeV}, T_{\text{fin}} = 170 \text{ MeV} \)
- \( t_{\text{in}} = 0.5 \text{ fm} \)

Jet reconstruction:
- FastJet, antikt, \( R = 0.4 \)
- constituents \( p_T > 2 \text{ GeV} \)
- hard track \( p_T > 6 \text{ GeV} \)

- PbPb@2.76(5) TeV, \( b = 0 \)
- \( T_{\text{in}} = 470 \ (500) \text{ MeV}, T_{\text{fin}} = 170 \text{ MeV} \)
- \( t_{\text{in}} = 0.5 \text{ fm} \)

Jet reconstruction:
- FastJet, antikt, \( R = 0.2 \)
- constituents \( p_T > 3 \text{ GeV} \)
- hard track \( p_T > 6 \text{ GeV} \)
Hadron $R_{AA}$ AuAu @ 200 GeV

- YaJEM tuned to reproduce hadron $R_{AA}$ at RHIC, $\kappa \sim 2$
- JEWEL — default parameters v2.0.2
- Models agree very well in $p_t$ range (15,40) GeV
Surface Bias: AuAu @ 200 GeV

YaJEM \textit{TRANSPARENT MEDIUM}

- XY-distribution of hard scattering vertices
- w/o jet quenching hard scattering vertices are distributed according to the overlap function
Surface Bias: AuAu @ 200 GeV

YaJEM 2+1 hydro

- Constituents $p_T > 2$ GeV & hard track $p_T > 6$ GeV
- Leading jet 20-40 GeV
- $< X > = -1.4$ fm

- Average hard scattering $p_t$ satisfying the trigger cond.

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Surface Bias: AuAu @ 200 GeV

YaJEM 2+1 hydro

constituents $p_T > 2$ GeV & hard track $p_T > 6$ GeV
leading jet 10-15 GeV

$\langle X \rangle = -1.4$ fm

constituents $p_T > 2$ GeV & hard track $p_T > 6$ GeV
leading jet 20-40 GeV

$\langle X \rangle = -1.66$ fm

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Surface Bias: AuAu @ 200 GeV

YaJEM 1+1 hydro

leading jet 20-40 GeV constituents $p_T > 2$ GeV & hard track $p_T > 6$ GeV

$< X > = -2.1$ fm

JEWEL 1+1 hydro

$< X > = -1.6$ fm

› same hydro input used for two models
› same qualitative picture, details differ
Surface biases for AuAu@200

\[ s = \frac{N_{\text{vertices}} (x < 0)}{N_{\text{vertices}} (x > 0)} \]

- Surface bias depends on the trigger configuration
- Many more variables: R, hard track requirement, ...

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pp@200 AS fits jet 20-40 GeV

$p_t = (0.2,1) \text{ GeV}$

$p_t = (1,2) \text{ GeV}$

$p_t = (2,3) \text{ GeV}$

$p_t = (4,6) \text{ GeV}$
AuAu@200 AS fits jet 20-40 GeV

$p_t = (0.2,1)$ GeV

$p_t = (1,2)$ GeV

$p_t = (2,3)$ GeV

$p_t = (4,6)$ GeV
AS widths: AuAu @ 200 GeV

constituents $p_T > 2$ GeV & hard track $p_T > 6$ GeV

leading jet 20-40 GeV

- test of the YaJEM implementation ✔
- different results for JEWEL with and without recoils

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Hadron $R_{AA}$ PbPb @ 2.76 TeV

- Model parameters fixed at RHIC energies

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Surface Bias: PbPb @ 2.76 TeV

JEWEL 1+1 hydro

- less pronounced surface bias at LHC
AS widths: PbPb @ 2.76 (5) TeV

constituents $p_T > 3$ GeV & hard track $p_T > 6$ GeV
leading jet 20-40 GeV

- increased effect to be expected at LHC
Summary and outlook

- YaJEM workflow implemented
- Jet-hadron correlations and surface biases studied with YaJEM and JEWEL
- Predictions for LHC are made
- New high-precision data are awaited

- Other observables (dijets, ...)
- Other models (q-PYTHIA, AdS/CFT MC?)
Backup slides
Jet $R_{AA}$ AuAu @ 200 GeV

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Surface Bias: AuAu @ 200 GeV

YaJEM 1+1 hydro

leading jet 10-15, 2 GeV, 6 GeV

< X > = −1.8 fm

leading jet 20-40, 2 GeV, 6 GeV

< X > = −2.1 fm
Jet $R_{AA}$ PbPb @ 2.76 TeV

$R_{AA}$

$p_t^{JET}$ [GeV/c]

- YaJEM 2+1
- YaJEM 1+1
- JEWEL+PYTHIA

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Hadron $R_{AA}$ PbPb @ 5 TeV

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Jet $R_{AA}$ PbPb @ 5 TeV

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Medium as seen by a parton

\[ \int \varepsilon^{3/4}(\xi_1) d\xi_1 \]

AuAu@200, b = 0

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Shower profile

$q_E = 20 \text{ GeV}, \ 2 \text{ GeV const cut}$

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Surface Bias: AuAu @ 200 GeV

YaJEM 2+1 hydro

constituents $p_T > 2$ GeV & hard track $p_T > 6$ GeV
leading jet 20-40 GeV

$\langle X \rangle = -1.66$ fm $R = 0.4$

constituents $p_T > 2$ GeV & hard track $p_T > 6$ GeV
leading jet 20-40 GeV

$\langle X \rangle = -1.75$ fm $R = 0.2$

trigger jet direction

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