Method of semi-inclusive jet mass measurement in Au+Au collisions at $\sqrt{s_{\mathrm{NN}}}$= 200 GeV with STAR

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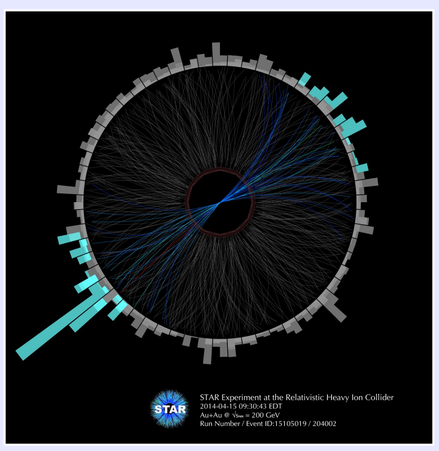
ABSTRACT

In central heavy-ion collisions, distinguishing jets produced by hard scattering from those originating from combinatorial background is largely limited, especially for jets with low transverse momenta ($p_{\mathrm{T,jet}}$). To address this challenge, methods for measurements of semi-inclusive recoil jets with respect to a trigger particle have been devised, leading to measurements of jet yields to the unprecedentedly low $p_{\mathrm{T,jet}}$ values. We aim to extend the scope of the semi-inclusive approach into measurements of jet mass (M_{jet}), and develop a 2-dimensional correction framework as a function of ($p_{\mathrm{T,jet}}$, M_{jet}). In this poster, we discuss the method of semi-inclusive jet mass measurements, and provide the closure test result based on simulation. Jets from PYTHIA events are embedded into Au+Au collision background at $\sqrt{s_{\mathrm{NN}}}$ = 200 GeV obtained from a thermal model. Correction procedures, including the subtraction of combinatorial jet contributions via a mixed-event technique and 2-dimensional unfolding, are tested.

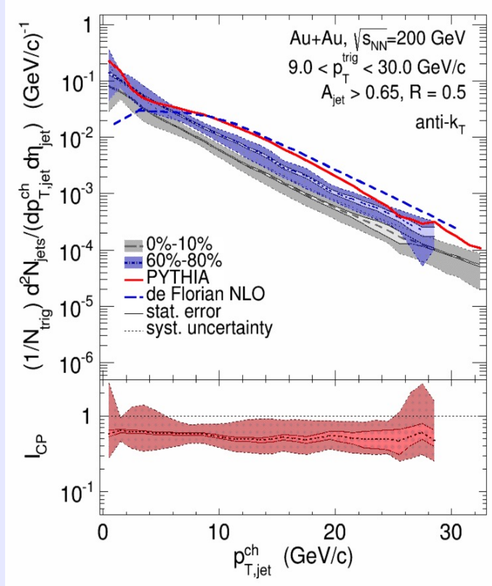
Introduction

- **Jet**
  - ✓ Collimated bunch of final-state particles
  - ✓ Good proxy of hard scattered parton
- **Jet mass (M_{jet})**
  - $M_{\mathrm{jet}} = \sqrt{E_{\mathrm{jet}}^2 - p_{\mathrm{jet}}^2}$
  - ✓ Crucial probe of parton virtuality evolution in both pp and AA collisions



- **Challenges in central heavy-ion collisions**
  - ✓ Combinatorial jets from heavy-ion background
  - ✓ Particularly dominant contribution in low $p_{\mathrm{T,jet}}$ region
- **Semi-inclusive recoil jets measurements**
  - ✓ Correlated recoil side jets with respect to high- p_{T} trigger particles (e.g. γ, charged hadrons)
  - ✓ Enable to measure p_{T} spectra down to low $p_{\mathrm{T,jet}}$
  - ✓ Event mixing
- **Goal of this study**
  - ✓ **Searching how the parton virtuality has been modified by medium-induced effect in heavy-ion collisions (compared to the one in vacuum)**
  - ✓ **Validation of new measurement framework (closure test)**

Phys. Rev. C 96, 024905 (2017)



Analysis details

Flow chart

Complete	On-going	Upcoming
Jet p_{T} closure test • Mimic of previous measurements (h+jet, STAR)	Jet mass closure test • Developing the framework for new measurements	Data analysis • STAR 200 GeV Au+Au collisions

Data set

- ✓ PYTHIA 8 pp events with the Hard-QCD process at 200 GeV
- ✓ Thermal background
  - heavy-ion background based on a thermal model (p_{T} spectrum following the published charged-particle spectrum)
  - detector effects not included in the current work
- ✓ $pp \oplus$ thermal background vs pp

Jet reconstruction

- ✓ R = 0.3
- ✓ Charged particle jets
- ✓ Anti-k_{T} algorithm
- ✓ k_{T} algorithm (background, ρ, estimation)

Trigger selection

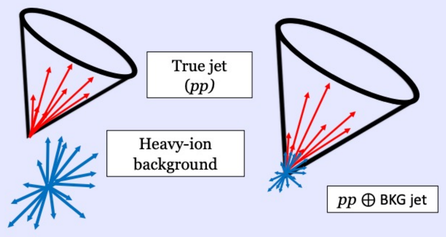
- ✓ Charged hadrons
- ✓ $9 < p_{\mathrm{T,trigger}} < 30$ GeV/c

Recoil jets selection

- ✓ $|\Delta\phi| < \pi/4$

Same event (SE)

- ✓ Raw recoil jet distribution of $pp \oplus$ thermal background
- ✓ What we want to correct



Mixed event (ME) technique

- ✓ Data-driven method for background effect correction
- ✓ Event mixing class (multiplicity bin)
- ✓ Shifting ρ_{ME} was applied to make it similar to ρ_{SE}
- ✓ Mixed-event (ME) spectrum : uncorrelated background distribution
- ✓ **SE – ME distribution**
  - Contribution of combinaotroal jets in SE was reduced by subtracting ME

Closure test

- ✓ Validation of analysis chain
- ✓ Comparison between PYTHIA (true) and corrected SE-ME

Correction (unfolding)

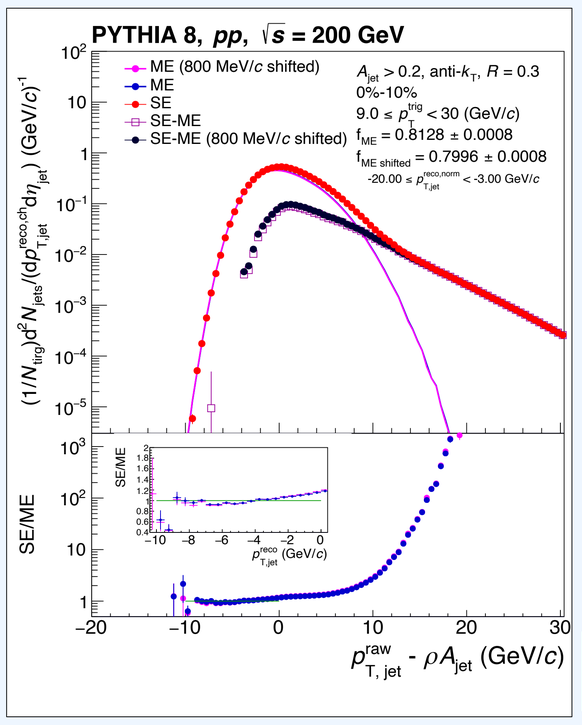
- ✓ Bayesian unfolding via RooUnfold package
- ✓ Correction for smearing effect of background fluctuation

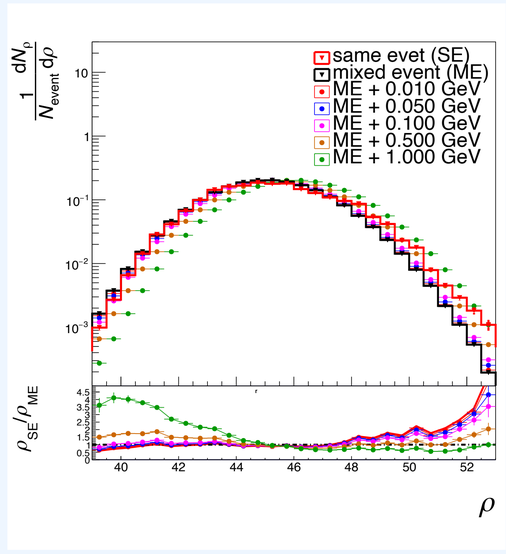
SUPPORTED IN PART BY THE
U.S. DEPARTMENT OF ENERGY | Office of Science

The STAR Collaboration
https://drupal.star.bnl.gov/STAR/presentations

Result I
1D–closure test

- **Raw recoil jet spectra**





- SE : recoil side jets yield
- ME : recoil jet yield of background event
- SE – ME : Yield-corrected spectrum
  - Expected that combinatorial jets were subtracted

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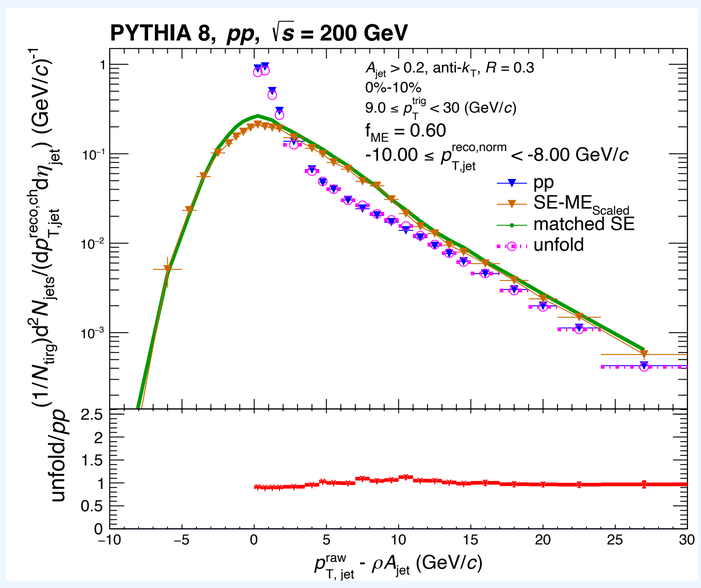
Smearing effect of δp_{T}
(What we want to correct via unfolding)

- **Corrected recoil jet yield spectra**



Checkpoints 1

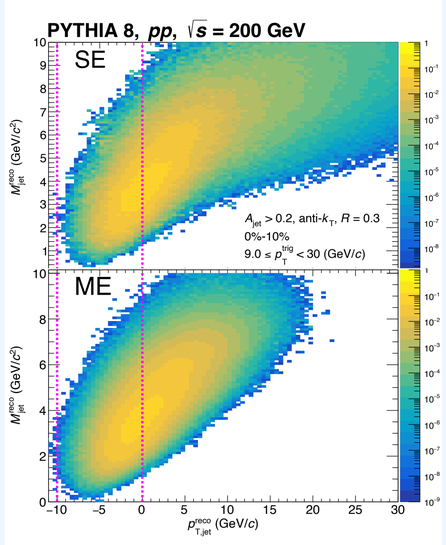
- Mimic of previous $p_{\mathrm{T,jet}}$ measurements
- $\rho = \mathrm{median}\left\{\frac{p_{\mathrm{T,jet}}}{A_{\mathrm{jet}}}\right\}$
- $\rho_{\mathrm{ME}} \sim \rho_{\mathrm{SE}}$

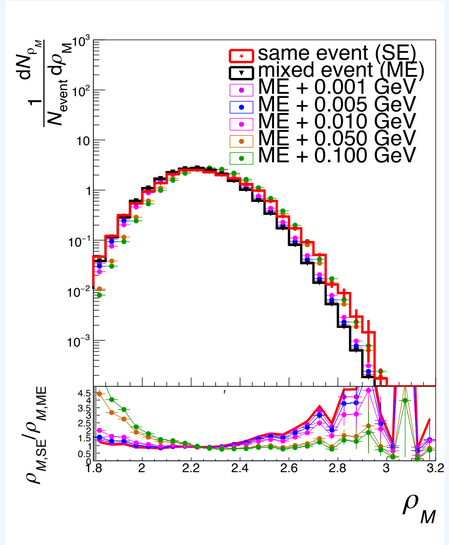
Checkpoints 2

- Are Combinatorial jets subtracted?
  - ✓ Flatness of spectrum ratio in negative $p_{\mathrm{T,jet}}$ region
- Is smearing effect of δp_T corrected?
  - ✓ True (PYTHIA) ~ unfolded yield distribution

Result II
2D-closure test

- **2-dimensional measurement framework**
  - ✓ ($p_{\mathrm{T,jet}}$, M_{jet}) Measurement
  - ✓ M_{jet} spectra -> Slices of ($p_{\mathrm{T,jet}}$, M_{jet}) distribution





Check points

- median $\left\{\frac{M_{\delta,k_{\mathrm{T}}}^{\mathrm{cluster}}}{A_{\mathrm{jet}}}\right\}$
- $\rho_{M,\mathrm{ME}} \sim \rho_{M,\mathrm{SE}}$
- Extend semi-inclusive measurements to M_{jet} measurement

Conclusion

- Jet is a unique tool for studying the properties of QGP, and M_{jet} measurements help to understand the parton virtuality evolution
- In order to deal with the large background effects in heavy-ion collisions, we extend the semi-inclusive recoil jet measurement technique to the M_{jet} measurement
- This study will be the basis for the upcoming measurement with the 200 GeV Au+Au data at $\sqrt{s_{\mathrm{NN}}}$ = 200 GeV in STAR