Measurement of semi-inclusive γ_{dir}+jet and π^0+jet distributions in central Au+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV by the STAR experiment

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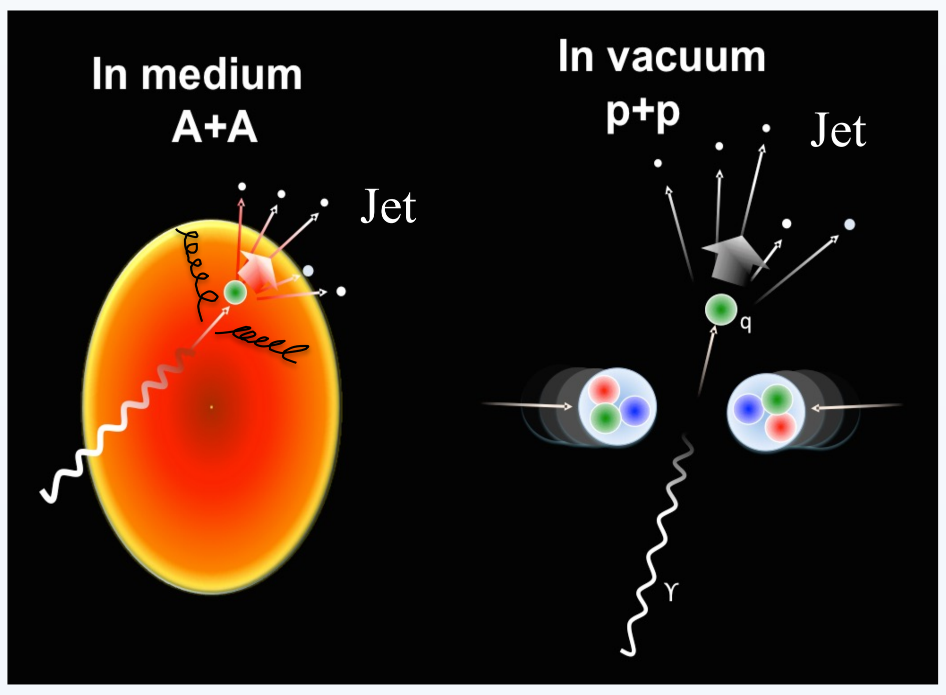
Abstract

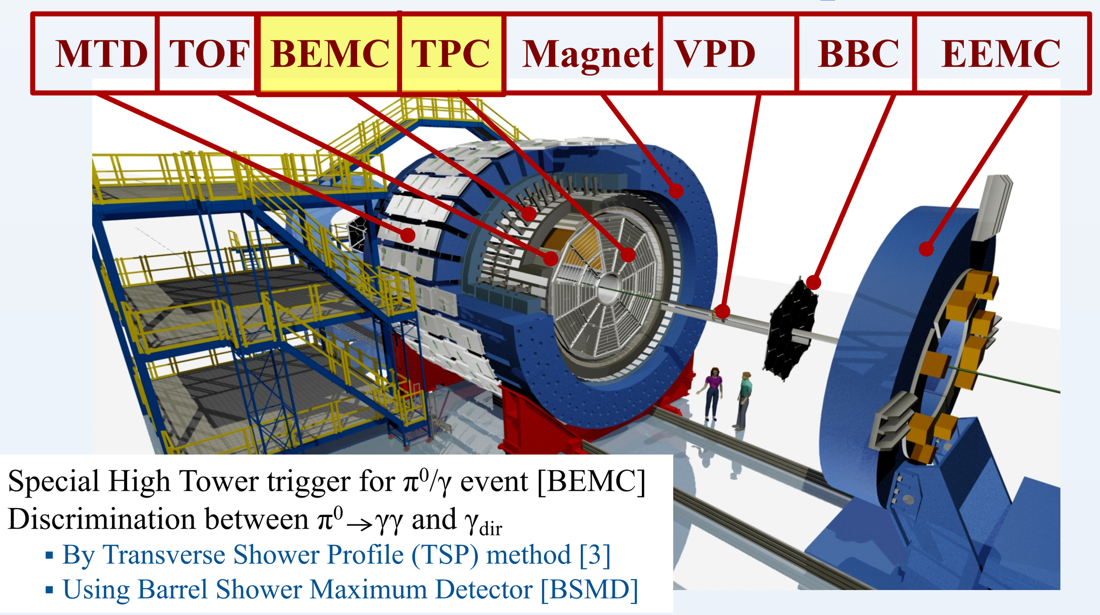
We present the semi-inclusive measurement of charged jets recoiling from direct-photon and π^0 triggers in central Au+Au collisions at 200 GeV center of mass energy per neucleon, using a dataset with integrated luminosity 13 nb^{-1} recorded by the STAR experiment in 2014. The photon and π^0 triggers have $9 < E_T^{trig} < 15$ GeV. Charged jets are reconstructed with the anti-k_T algorithm with resolution parameters R=0.2 and 0.5. A mixed-event technique developed previously by STAR is used to correct the recoil jet yield for uncorrelated background, enabling recoil jet measurements over a broad $p_{T,jet}$ range with large jet radius. We report the corrected semi-inclusive recoil jet yields for both triggers and compare them to those in p+p collisions. Such measurements have different trigger bias, in terms of both the path-length distribution and quark/gluon contributions to the recoil jet population.



1. Motivation

- Jet quenching is an important signature of the hot and dense QCD matter produced in heavy-ion collisions [1].
- A direct photon (γ_{dir}) produced in coincidence with a recoil jet (γ_{dir}+jet) is a good probe to study the parton energy loss in the QGP [2].
- Comparison between γ_{dir}+jet vs π^0+jet provides quantitative understanding of parton energy loss in the QCD medium
  - Energy loss as a function of path length, color factor, parton energy, etc.
  - Redistribution of lost energy inside the medium; by varying jet radius

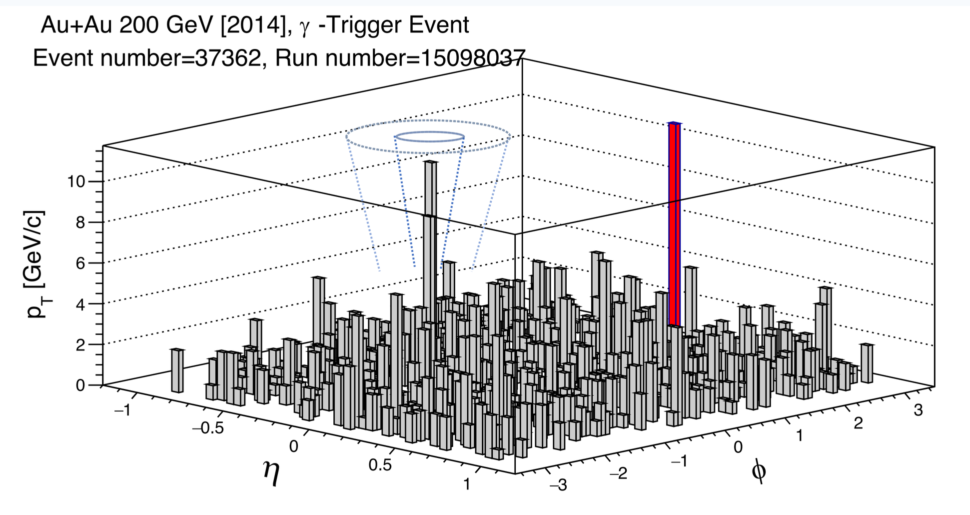
2. STAR detector setup



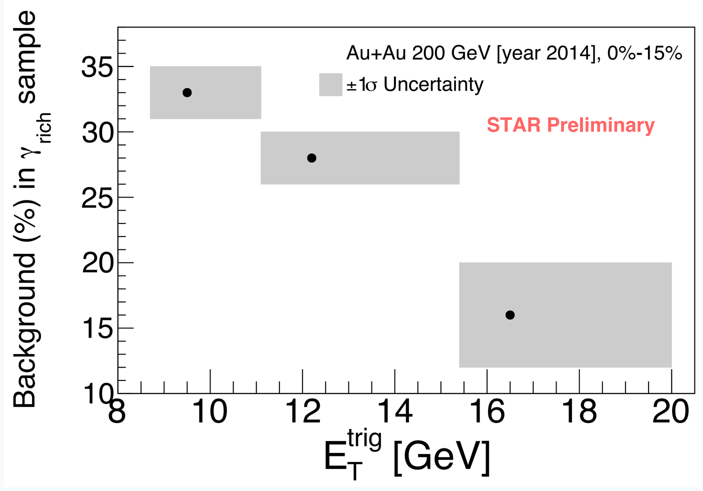
- Special High Tower trigger for π^0/γ event [BEMC]
- Discrimination between $\pi^0 \to \gamma\gamma$ and γ_{dir}
  - By Transverse Shower Profile (TSP) method [3]
  - Using Barrel Shower Maximum Detector [BSMD]

3. Analysis details

γ_{rich} trigger event



- **Purity of direct photon for different trigger E_T^{trig} bins**



γ_{rich} trigger events: enriched-γ_{dir} trigger events with admixture of photons from π^0.

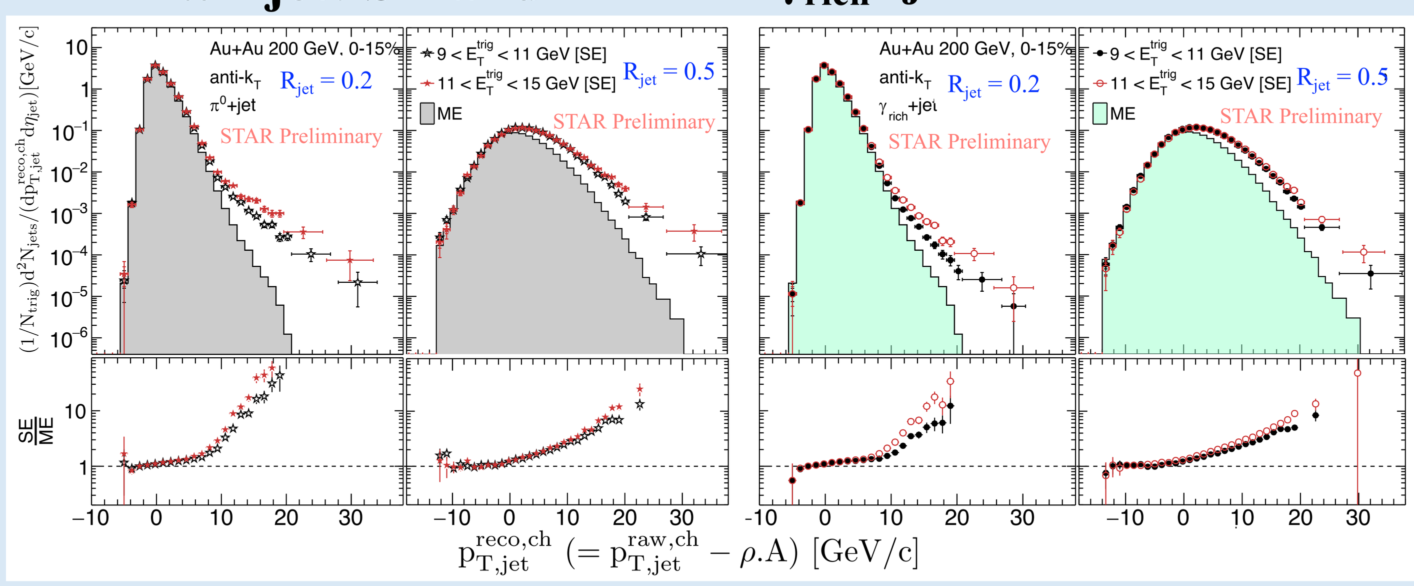
- **Full analysis chain:**

1. Discrimination between π^0/γ_{rich}-triggered events
   Transverse Shower Profile method [3]
2. Recoil charged jets from high-tower-triggered events
   Using FastJet package [4]; Recoil jet region:[π-π/4, π+π/4]; Jet radius = 0.2 and 0.5; $|\eta_{jet}|$ < 1-R
3. Subtraction of uncorrelated jet background in recoil region
   Based on the mixed-event technique [5]
4. Correction for detector and heavy-ion background fluctuations effects using unfolding technique
   Factorizing detector and heavy-ion background fluctuation effects
5. Conversion from γ_{rich}+jet to γ_{dir}+jet [4]; as γ_{rich}+jet contains admixture of π^0+jet
   Using π^0+jet yield and purity of γ_{dir}
6. Major sources of systematic uncertainty
   Unfolding, mixed-event normalization region, detector effects, γ_{dir} background subtraction [contributes only to γ_{dir}+jet]

- p+p baseline: PYTHIA8 [6] is used for both triggers

4. Results and discussion

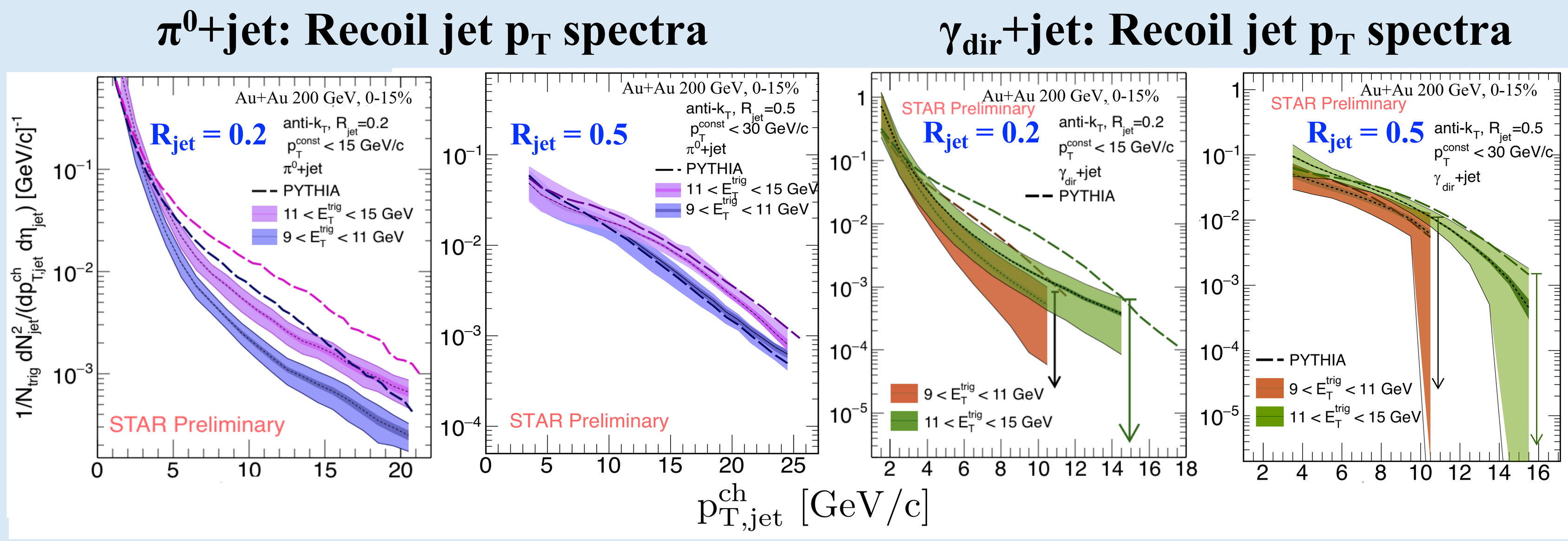
π^0+jet: SE and ME γ_{rich}+jet: SE and ME



Caption- The reconstructed jet $p_{T,jet}^{reco}$ distributions for the same event (SE) and mixed event (ME) for two triggers (E_T^{trig}) bins: 9-11 GeV and 11-15 GeV. Left and right panels are for R_{jet} =0.2 and 0.5, respectively. Lower panels shows the ratio between SE and normalized ME.

- Recoil charged jets dominate (above ~10 GeV/c) over the uncorrelated jets for different E_T^{trig} bins and jet radii.
- A clear trigger dependence can been seen.

π^0+jet: Recoil jet p_T spectra γ_{dir}+jet: Recoil jet p_T spectra

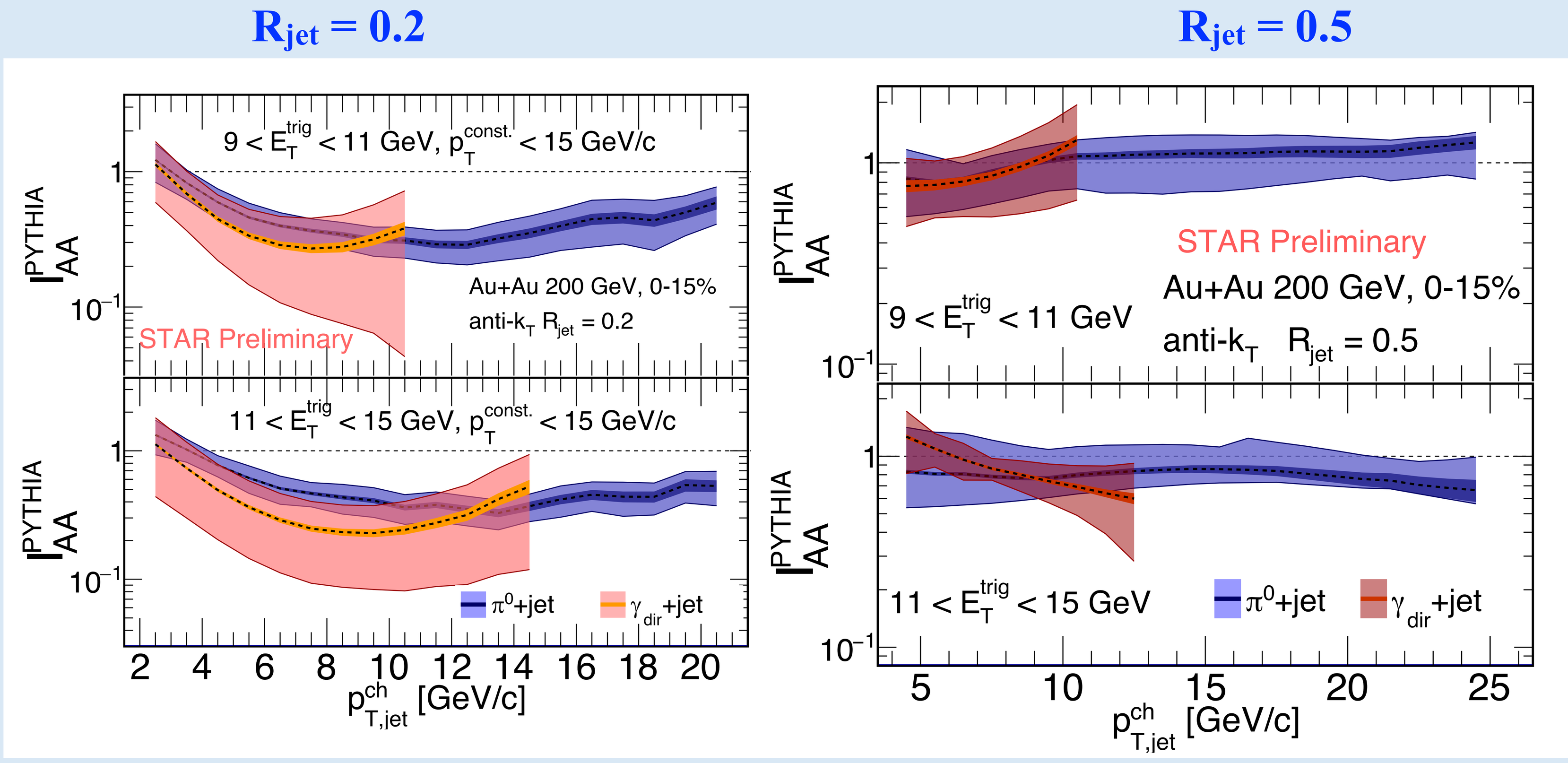


Caption- Fully corrected semi-inclusive recoil charged jet $p_{T,jet}^{ch}$ spectra for the above two E_T^{trig} bins. Dashed lines are PYTHIA8 expectation. Left panel (R_{jet}=0.2) and Right panel (R_{jet}=0.5). Lighter (darker) bands represent systematic (statistical) uncertainties.

- A clear difference between recoil-jet spectra for different trigger E_T: 9-11 GeV and 11-15 GeV.
- Recoil jet p_T is suppressed with respect to PYTHIA8.
- γ_{dir}+jet: downward arrow represents upper limit in the yield at: $p_{T,jet}^{ch}$ = 11 GeV/c for 9-11 GeV, $p_{T,jet}^{ch}$ = 15 GeV/c for 11-15 GeV.

γ_{dir}+jet vs π^0+jet: Recoil jet suppression for two jet radii

$R_{jet} = 0.2$ $R_{jet} = 0.5$



Caption- I_{AA}^{PYTHIA} as a function of $p_{T,jet}^{ch}$ for γ_{dir}- (red band) and π^0-trigger (blue band). Top: $9 < E_T^{trig} < 11$ GeV. Bottom: $11 < E_T^{trig} < 15$ GeV. Lighter and darker bands represent systematic and statistical uncertainties, respectively.

Recoil jet yield suppression with respect to p+p:

$$I_{AA}(p_{T,jet}^{ch}) = \frac{Y(p_{T,jet}^{ch})^{Au+Au}}{Y(p_{T,jet}^{ch})^{p+p}}$$

$Y(p_{T,jet}^{ch})^{Au+Au}$ and $Y(p_{T,jet}^{ch})^{p+p}$ represent recoil jet yield per trigger as a function of $p_{T,jet}^{ch}$ in Au+Au and p+p collisions, respectively, For p+p baseline, PYTHIA8 result is used.

- Recoil jet with a jet resolution parameter of R_{jet} =0.2 shows strong suppression whereas a negligible suppression is observed for R_{jet}=0.5, within uncertainties.
- I_{AA}^{PYTHIA} values are comparable between the two E_T^{trig} bins.
- The same level of suppression is seen between γ_{dir}+jet and π^0+jet for different E_T^{trig} bins and the two jet resolution parameters within uncertainties.

5. Summary

- First γ_{dir}+jet and π^0+jet measurement at RHIC within $9 < E_T^{trig} < 15$ GeV is presented in central Au+Au collisions at center of mass energy 200 GeV
- Recoil jet with jet radius 0.2 is strongly suppressed at high jet p_T whereas a noticeable recovery of jet energy loss is observed at jet radius 0.5 for both the γ_{dir} and π^0 trigger cases; consistent with the previous h+jet analysis [5]
- Recoil jet suppression is seen to be independent of E_T^{trig}; whereas γ_{dir}+jet and π^0+jet show similar level of suppression

References

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6. PYTHIA8: T. Sjöstrand, S. Askb, J. R. Christiansen, et al.,Comput. Phys. Commun. 191 (2015) 159-177; arXiv:1410.3012; With default setting for π^0+jet and γ+jet

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