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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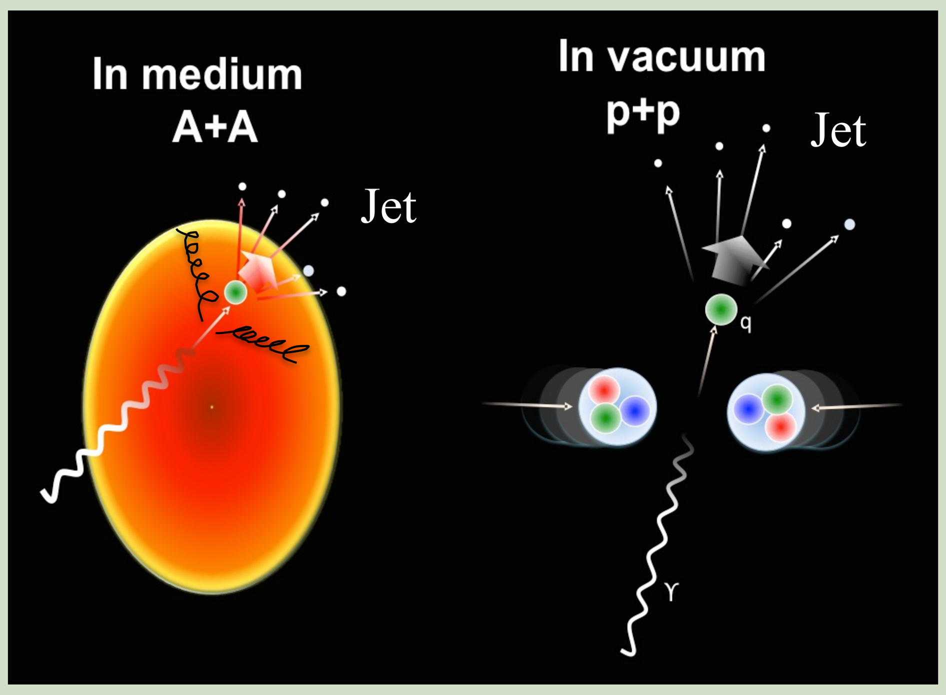
Abstract

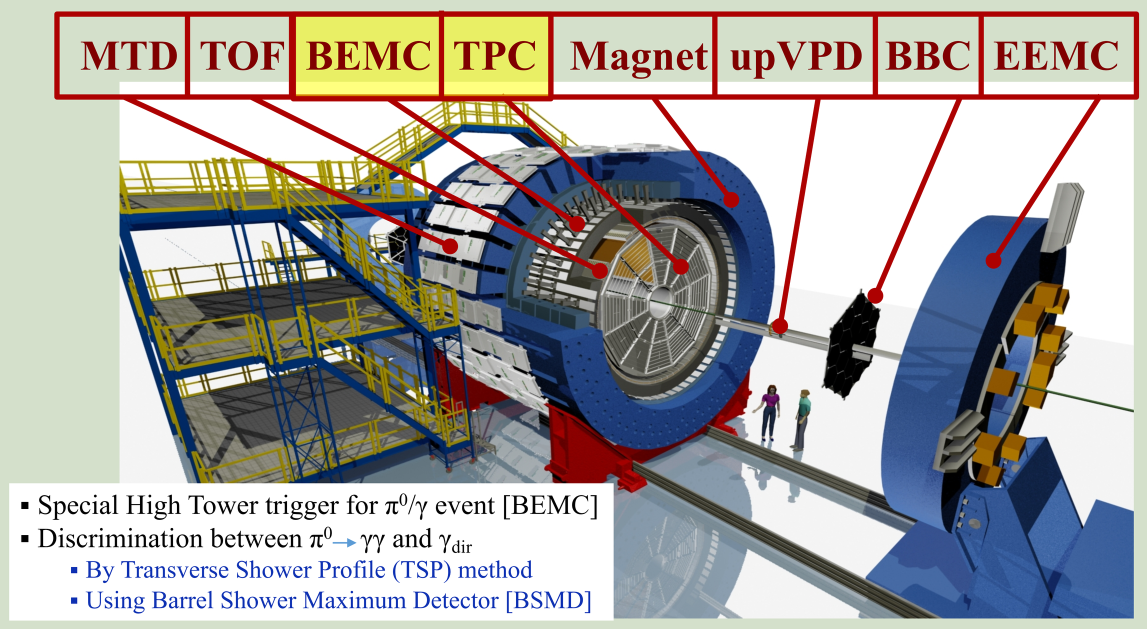
We present the semi-inclusive measurement of charged jets recoiling from direct-photon and π0 triggers in central Au+Au collisions at 200 GeV center of mass energy, using a dataset with integrated luminosity 13 nb−1 recorded by the STAR experiment in 2014. The photon and π0 triggers have $9 < E_T^{trig} < 15$ 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 for p+p collisions. These measurements have different trigger bias, in terms of both the path-length distribution and quark/gluon mix of the recoil jet population, and their corrected recoil spectra are compared.



1. Motivation

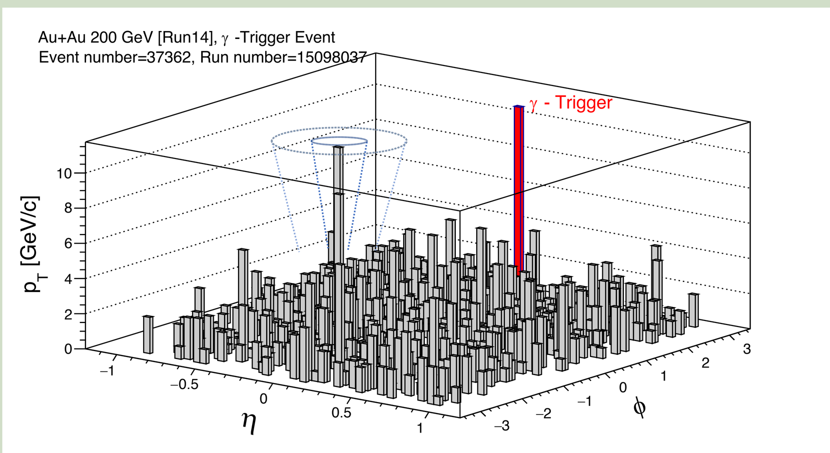
- Jet quenching is an important signature of the hot and dense QCD matter produced in heavy-ion collisions [1].
- A direct photon (γ_{dir}) produced in coincidence with a recoil jet (γ_{dir}+jet) is a good probe to study the parton energy loss in the QGP [2].
- Comparison between γ_{dir}+jet vs π^0+jet 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 [Jet radius]

2. STAR detector setup

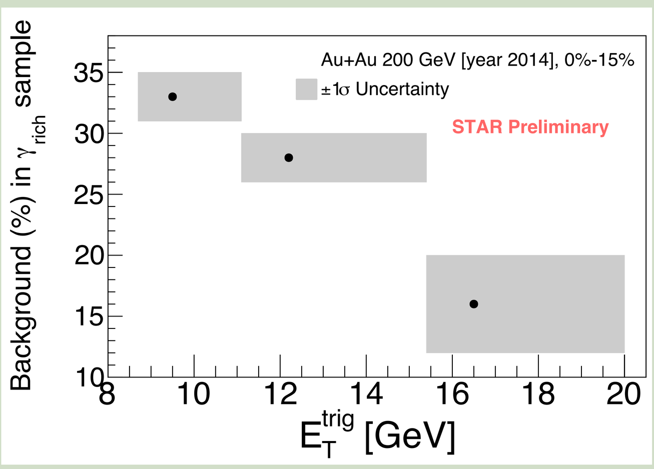


3. Analysis details

γ_{rich} trigger event



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



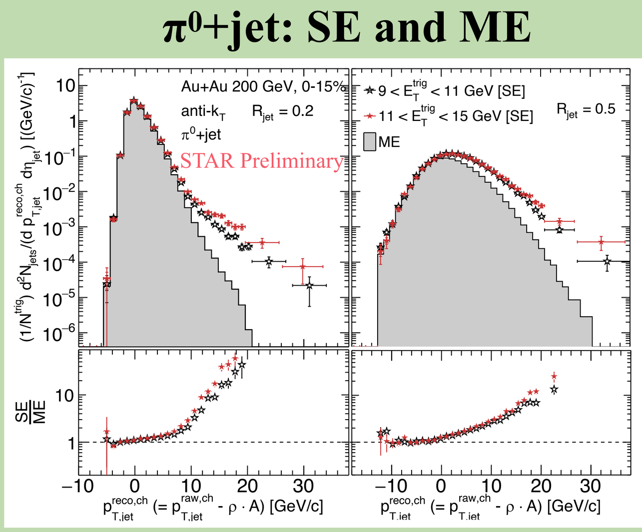
Full analysis chain:

1. Discrimination between π^0/γ_{rich}-triggered events
   Transverse Shower Profile method [4]
2. Recoil jets from high-tower-triggered events (SE)
   Using FastJet package [3]; 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 h+jet analysis[5], event-mixing technique
4. Correction for detector and heavy-ion background fluctuations effects
5. Conversion from γ_{rich}+jet to γ_{dir}+jet [4]
   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]

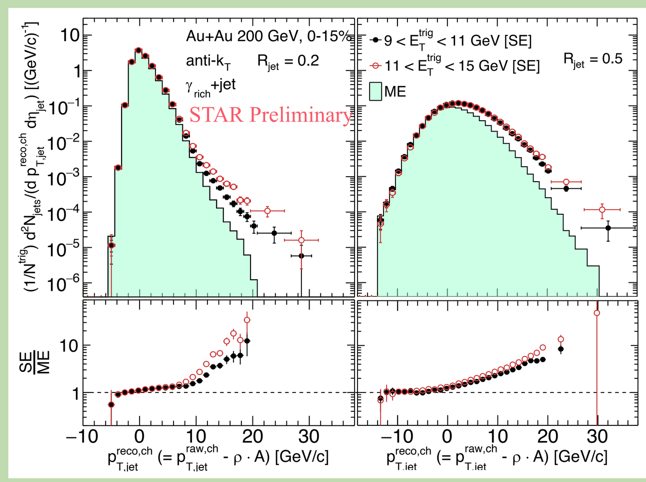
γ_{rich} trigger events: enriched-γ_{dir} trigger events with some admixture of photons from π^0.

4. Results and discussion

π^0+jet: SE and ME



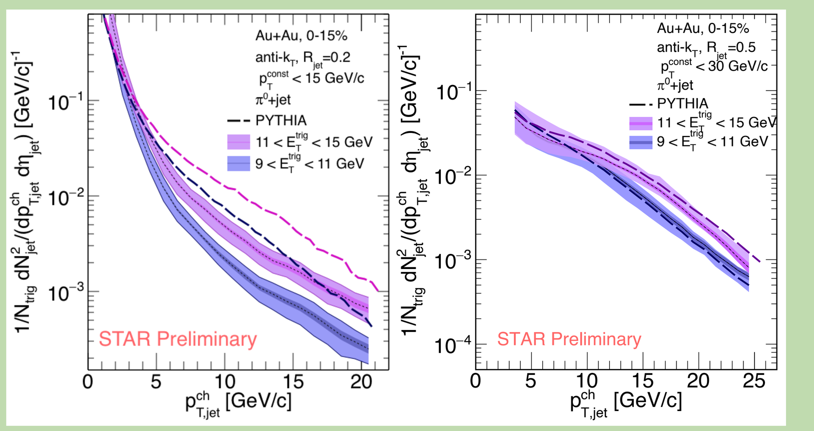
γ_{rich}+jet: SE and ME



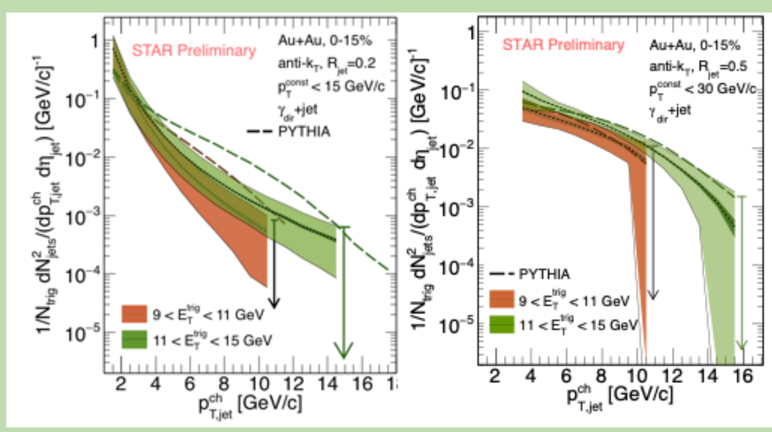
Caption- γ_{rich}+jet :The reconstructed jet $p_{T,jet}^{reco}$ distributions are shown for the same event (SE) and mixed event (ME) for two triggers E_T^{trig} bins: 9-11 GeV and 11-15 GeV. Left and right panels represent for R_{jet} =0.2 and 0.5, respectively. Lower panels shows the ratio between SE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

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

π^0+jet: Recoil jet p_T spectra



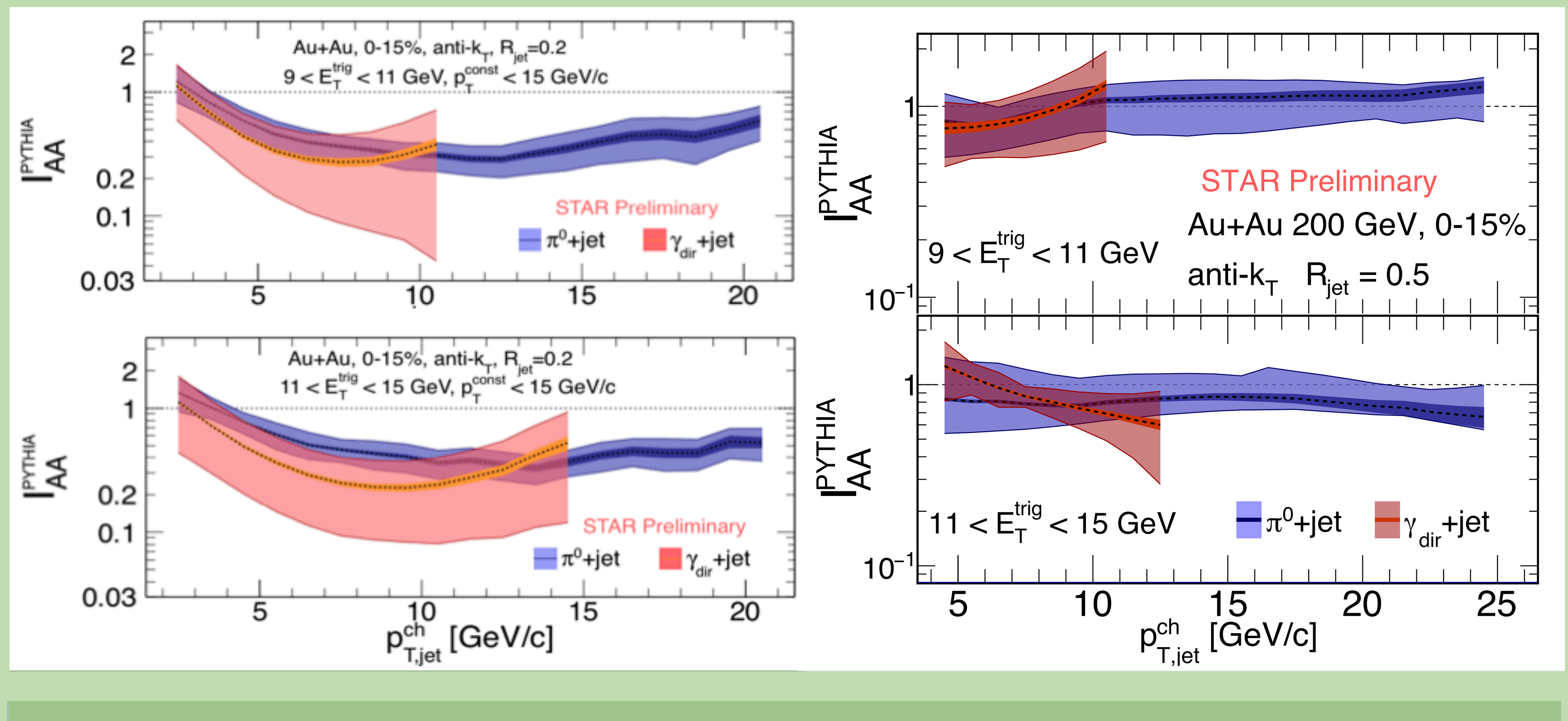
γ_{dir}+jet: Recoil jet p_T spectra



Caption- Fully corrected semi-inclusive γ_{dir} trigger recoil charged jet p_T, jet spectra for the above two E_T^{trig} bins. Dashed lines are PYTHIA8 expectation. Left panel (R=0.2) and Right panel (R=0.5). Systematic (lighter band) and statistical (darker band) uncertainty. γ_{dir}+jet: Downward arrow represents the large uncertainty.

A clear difference between recoil-jet spectra for different trigger E_T: $9 < E_T^{trig} < 11$ GeV vs. $11 < E_T^{trig} < 15$ 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 $9 < E_T^{trig} < 11$ GeV, $p_{T,jet}^{ch} = 15$ GeV/c for $11 < E_T^{trig} < 15$ GeV.

γ_{dir}+jet vs π^0+jet: Recoil jet suppression for R_{jet} = 0.2 and 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) recoil charged jet. Top: $9 < E_T^{trig} < 11$ GeV. Bottom: $11 < E_T^{trig} < 15$ GeV. Lighter and darker bands represent systematic and statistical uncertainties, respectively. Right and left panels represent R_{jet}=0.2 and 0.5, 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 jet $p_{T,jet}^{ch}$ for Au+Au and p+p collisions, respectively. For p+p baseline, PYTHIA8 result is used.

Recoil jet with jet radius 0.2 shows strong suppression whereas a negligible suppression is observed for jet radius 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 jet radii within uncertainties.

References

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2. X.-N. Wang, Z. Huang, and I. Sarcevic, Phys. Rev. Lett. 77, 231 (1996)
3. M. Cacciari, G. P. Salam, and G. Soyez, Eur. Phys. J. C (2012) 72:1896
4. L. Adamczyk et al. (STAR Collaboration), Phys. Lett. B 760 (2016) 689-696
5. L. Adamczyk et al. (STAR Collaboration), Phys. Rev. C 96 (2017) no.2, 024905

5. Summary and outlook

- 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
- 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.
- The measurement within $15 < E_T^{trig} < 20$ GeV for γ_{dir}+jet is ongoing

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