Measurement of semi-inclusive jet fragmentation functions in Au+Au collisions at $\sqrt{s_{\mathrm{NN}}}$ = 200 GeV in STAR

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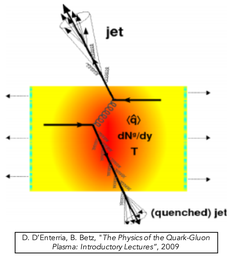
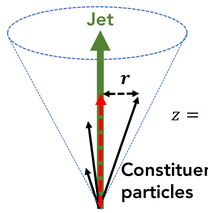
Abstract

In this poster, we report a measurement of the jet fragmentation functions in peripheral Au+Au collisions at $\sqrt{s_{\mathrm{NN}}}$ = 200 GeV by the STAR experiment at RHIC, using a semi-inclusive population of jets recoiling from trigger hadrons of large transverse energies. The mixed-event technique along with the semi-inclusive approach is used in the measurement in order to remove uncorrelated background contributions. The fragmentation functions are further corrected for background fluctuations and instrumental effects via unfolding, and the results are compared with PYTHIA predictions.

Introduction

- Jets probe the strongly interacting QCD medium
  - Hard-scattered partons are generated at the early stages of heavy-ion collisions
  - Interactions between jets and the QCD medium modify the parton shower relative to that in vacuum



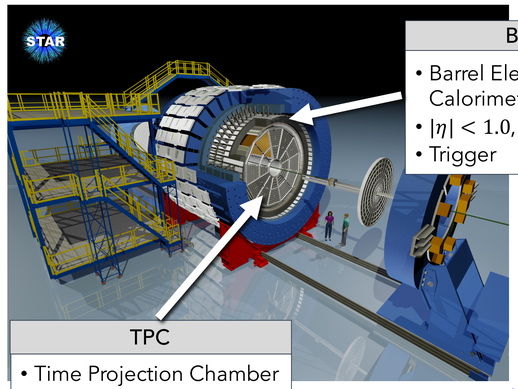


$$z = \frac{p_{\mathrm{T,track}}\cos(r)}{p_{\mathrm{T,jet}}}$$

- Jet fragmentation function[1], $\frac{1}{N_{\mathrm{jet}}}\frac{\mathrm{d}N}{\mathrm{d}z}$
  - Distribution of longitudinal momentum fraction of particles with respect to the jet
  - How does it change in Au+Au collisions at $\sqrt{s_{\mathrm{NN}}}$ = 200 GeV relative to the vacuum reference?

1. The name of this function is following the convention in relativistic heavy ion physics, although there is a more standard definition: http://pdg.lbl.gov/2019/reviews/rpp2018-rev-frag-functions.pdf

STAR Detector



BEMC
- Barrel Electromagnetic Calorimeter
- $|\eta| < 1.0,\ 0 < \varphi < 2\pi$
- Trigger

TPC
- Time Projection Chamber
- $|\eta| < 1.0,\ 0 < \varphi < 2\pi$
- Momentum, dE/dx

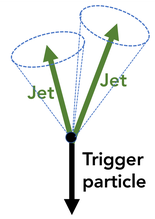
EM neutral constituents → *Full Jet*

Charged constituents → *Charged Jet*

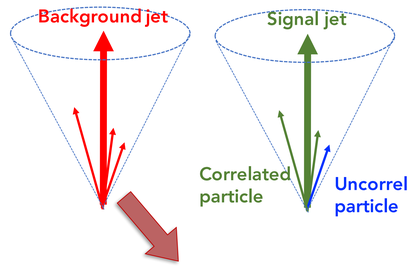
- Both charged and full jets can be measured in STAR
- Charged jets reconstructed with the anti-k_{T} algorithm and R = 0.4 are used for the current measurement

Corrections

- Jet fragmentation functions[1] = $\frac{1}{N_{\mathrm{jet}}(p_{\mathrm{T,jet}})}\frac{\mathrm{d}N\ (p_{\mathrm{T,jet}},z)}{\mathrm{d}z}$ for tracks within $\Delta r_{\mathrm{jet-track}} < \mathrm{R} = 0.4$



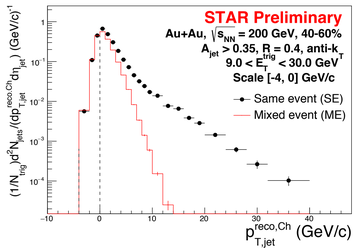
- Semi-inclusive approach[2]
  - Charged jets are selected in the recoil region with respect to high momentum trigger particles (BEMC tower with $9.0 < E_{\mathrm{T}} < 30.0$ GeV), $|\varphi_{\mathrm{trig}} - \varphi_{\mathrm{jet}}| > \pi - \pi/4$
  - This enables us to suppress the uncorrelated background contributions



- In the recoil region, there are signal jets, correlated to the trigger particle, and background jets, uncorrelated to the trigger particle
- In signal jets, there are uncorrelated particles

Correction for background jets

- For $N_{\mathrm{jet}}(p_{\mathrm{T,jet}})$,
  $N_{\mathrm{jet}}(p_{\mathrm{T,jet}}) = N_{\mathrm{jet}}^{\mathrm{SE}}(p_{\mathrm{T,jet}}) - N_{\mathrm{jet}}^{\mathrm{ME}}(p_{\mathrm{T,jet}})$
  (Jets in same events; Jets in mixed events)
- $N_{\mathrm{jet}}^{\mathrm{ME}}(p_{\mathrm{T,jet}})$ are fitted to $N_{\mathrm{jet}}^{\mathrm{SE}}(p_{\mathrm{T,jet}})$ in the negative $p_{\mathrm{T,jet}}$ range, where uncorrelated jets dominate

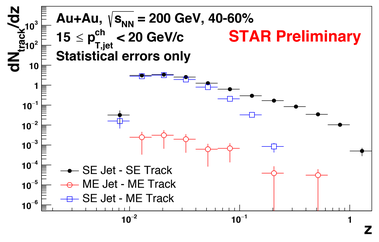


- For $\mathrm{d}N\ (p_{\mathrm{T,jet}},z)/\mathrm{d}z$, contributions from uncorrelated jets are estimated using $\mathrm{d}N^{\mathrm{ME}}\ (p_{\mathrm{T,jet}},z)/\mathrm{d}z$ scaled according to the background jet fraction in each $p_{\mathrm{T,jet}}$ bin

Correction for uncorrelated particles

- For $\mathrm{d}N\ (p_{\mathrm{T,jet}},z)/\mathrm{d}z$, contributions from uncorrelated particles are estimated by placing SE jets into mixed events and combining with ME tracks

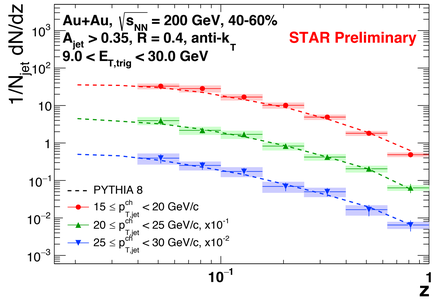
- Contributions from background jets and uncorrelated particles in signal jets are subtracted accordingly



Corrected $\mathrm{d}N/\mathrm{d}z$ = Black – Red – Blue

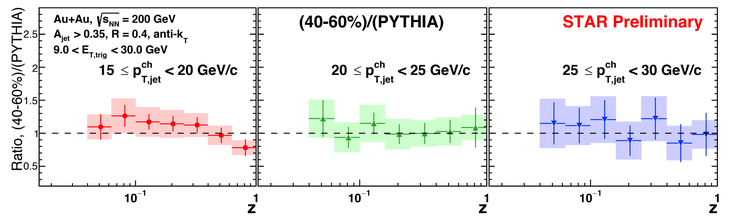
Results

- $N_{\mathrm{jet}}(p_{\mathrm{T,jet}})$ and $\mathrm{d}N(p_{\mathrm{T,jet}},z)/\mathrm{d}z$ are separately unfolded via 1-D and 2-D Bayesian unfolding for instrumental effects and background fluctuations



- Fully corrected charged jet fragmentation functions for 40-60% centrality class and three $p_{\mathrm{T,jet}}$ ranges
  - ✓ Variations of fragmentation function priors in unfolding are not included in the systematic uncertainties

- Ratios of jet fragmentation functions, (Au+Au 40-60%)/(PYTHIA 8)



  - ✓ PYTHIA 8 is tuned to LHC, and needs further parameter tuning for RHIC[3]
  - ✓ The Ratio remains near 1 → Tangential jet selection with a high-p_{T} trigger particle and recoil jets? Short path-length in medium or little jet-medium interactions in 40-60% centrality? …

Summary and Outlook

- Fully corrected semi-inclusive charged jet fragmentation functions in 40-60% central Au+Au collisions at $\sqrt{s_{\mathrm{NN}}}$ = 200 GeV are studied
- The results for three $p_{\mathrm{T,jet}}$ ranges are comparable to PYTHIA 8, but PYTHIA 8's reliability at RHIC energies is under question
- Results for central Au+Au and p+p collisions are on their way

References

[1] ATLAS Collaboration, Eur. Phys. J. C 77 (2017) 379
[2] STAR Collaboration, Phys. Rev. C 96 (2017) 24905
[3] STAR Collaboration, arXiv:2003.02114

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