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Guiyang, China

Semi-inclusive hadron+jet measurement in Ru+Ru and Zr+Zr collisions at $\sqrt{s_{NN}}$ = 200 GeV with the STAR experiment

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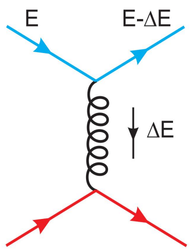
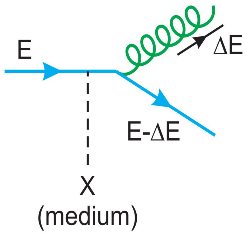
Jet quenching in QGP

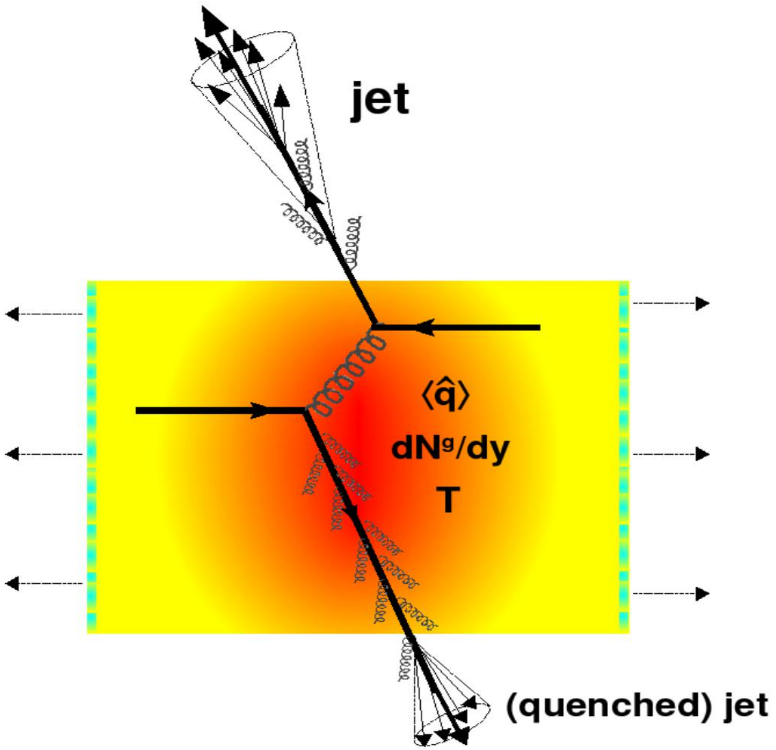
Hard probe: Jets
- Produced at early stage of the collisions
- Cross section in vacuum is calculable using pQCD

Parton energy loss in medium:
- Collisional and radiative energy losses





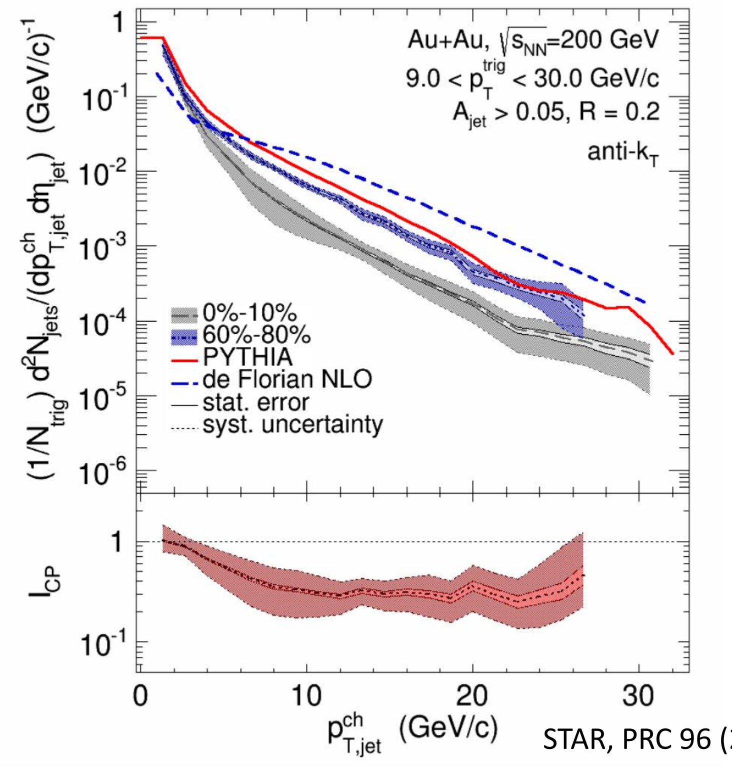
collisional energy loss   radiative energy loss



- Depends on traversing parton's initial energy and mass/virtuality, medium temperature and density, strong interaction coupling strength α_s, and path length, etc.

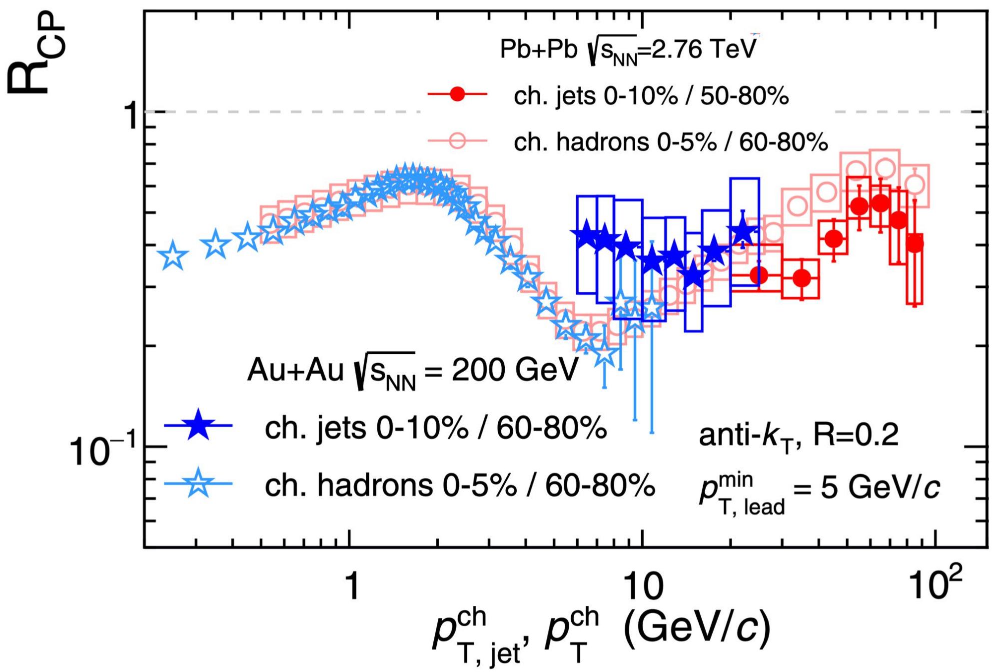
Jet measurements in Au+Au@200 GeV

Semi-inclusive hadron+jet



STAR, PRC 96 (2017) 024905

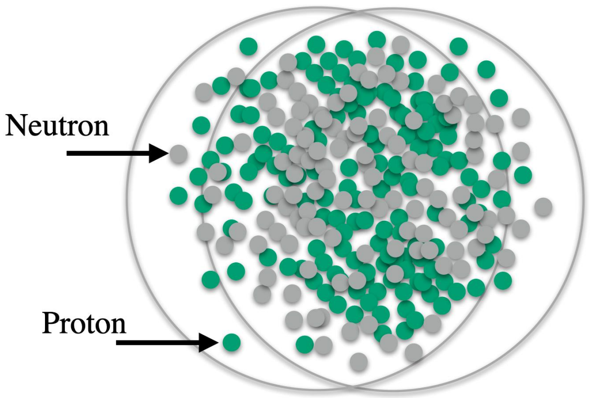
Inclusive jet



STAR, PRC 102 (2020) 054913

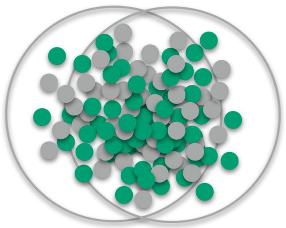
- High p_T hadron triggered recoil jets and inclusive jets are measured by STAR experiment
- Strong suppression is observed in central Au+Au collisions, with a similar magnitude as at the LHC

System size dependence of jet suppression?



$${}^{197}_{79}Au + {}^{197}_{79}Au$$

This Talk!



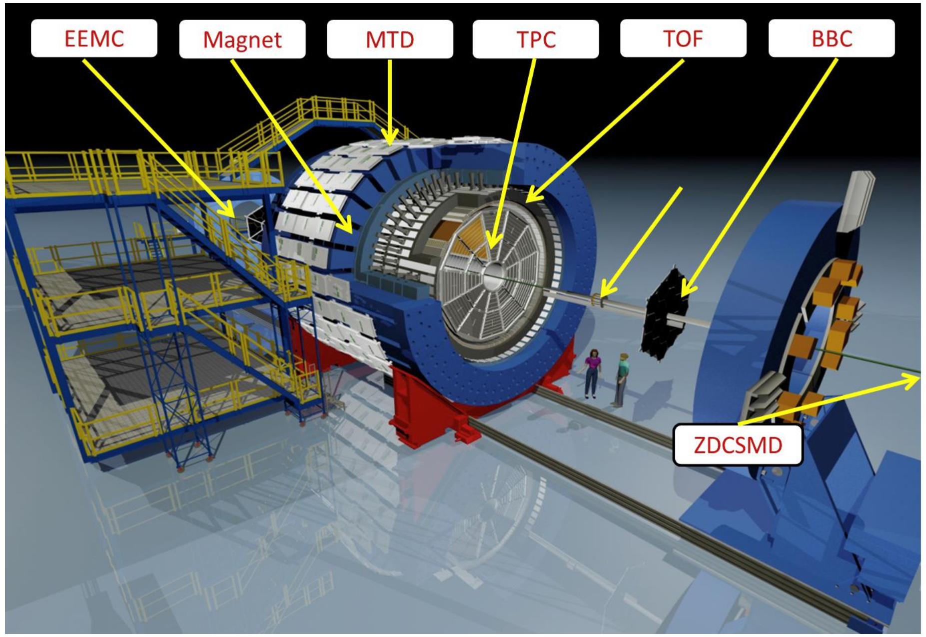
$${}^{96}_{40}Zr + {}^{96}_{40}Zr \,/\, {}^{96}_{44}Ru + {}^{96}_{44}Ru$$

Study jet quenching in a smaller collision system (Zr+Zr and Ru+Ru) than Au+Au collisions using semi-inclusive h+jet measurement

Provide information of parton energy loss for different initial energy density, temperature of the medium, and smaller path length compared to Au+Au collisions

STAR detector

Time Projection Chamber (TPC):
Provides tracking for charged particles within ±1 unit of pseudo-rapidity and covers 2π in azimuth



Year 2018 data taking for Ru+Ru and Zr+Zr at $\sqrt{s_{NN}}$ = 200 GeV
full production is ready and being actively worked on
13% statistics are shown in this talk
Charged particles:

$|\eta| < 1$, $0.2 < p_T < 30$ GeV/c

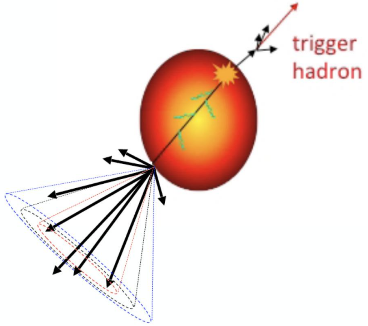
Jet reconstruction:

anti-k_T algorithm, R_{jet} = 0.2 and 0.4, $|\eta_{jet}| < 1 - R_{jet}$

	0-10% centrality	60-80% centrality
Current statistics for this presentation (~13%)	~124k (trigger events $7 < p_T^{trig} < 30$ GeV/c)	~14k (trigger events $7 < p_T^{trig} < 30$ GeV/c)
Full statistics (ongoing)	~0.94M	~0.10M

Semi-inclusive hadron+jet to study jet quenching

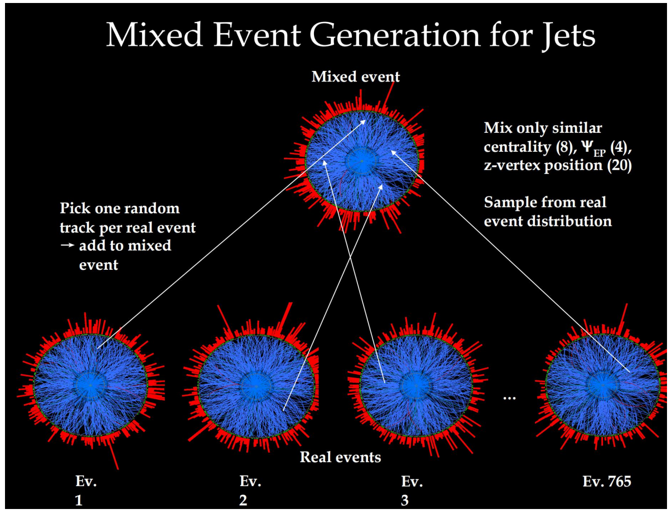
- Trigger-normalized yield of jets recoiling from a high p_T trigger hadron



$$\frac{1}{N_{\mathrm{trig}}^{\mathrm{AA}}} \cdot \frac{d^3 N_{\mathrm{jet}}^{\mathrm{AA}}}{dp_{\mathrm{T,jet}}^{\mathrm{ch}} d\Delta\phi d\eta_{\mathrm{jet}}}\Bigg|_{p_{\mathrm{T,trig}}} = \left(\frac{1}{\sigma^{\mathrm{AA}\to\mathrm{h+X}}} \cdot \frac{d^3 \sigma^{\mathrm{AA}\to\mathrm{h+jet+X}}}{dp_{\mathrm{T,jet}}^{\mathrm{ch}} d\Delta\phi d\eta_{\mathrm{jet}}}\right)\Bigg|_{p_{\mathrm{T,trig}}}$$

- Jet yield is integrated over a recoil region in azimuth relative to the trigger hadron direction

$$Y\left(p_{\mathrm{T,jet}}^{\mathrm{ch}}\right) = \int_{3\pi/4}^{5\pi/4} d\Delta\phi \left[\frac{1}{N_{\mathrm{trig}}^{\mathrm{AA}}} \cdot \frac{d^3 N_{\mathrm{jet}}^{\mathrm{AA}}}{dp_{\mathrm{T,jet}}^{\mathrm{ch}} d\Delta\phi d\eta_{\mathrm{jet}}}\Bigg|_{p_{\mathrm{T,trig}} > p_{\mathrm{T,thresh}}}\right]$$



- Jet quenching observable:

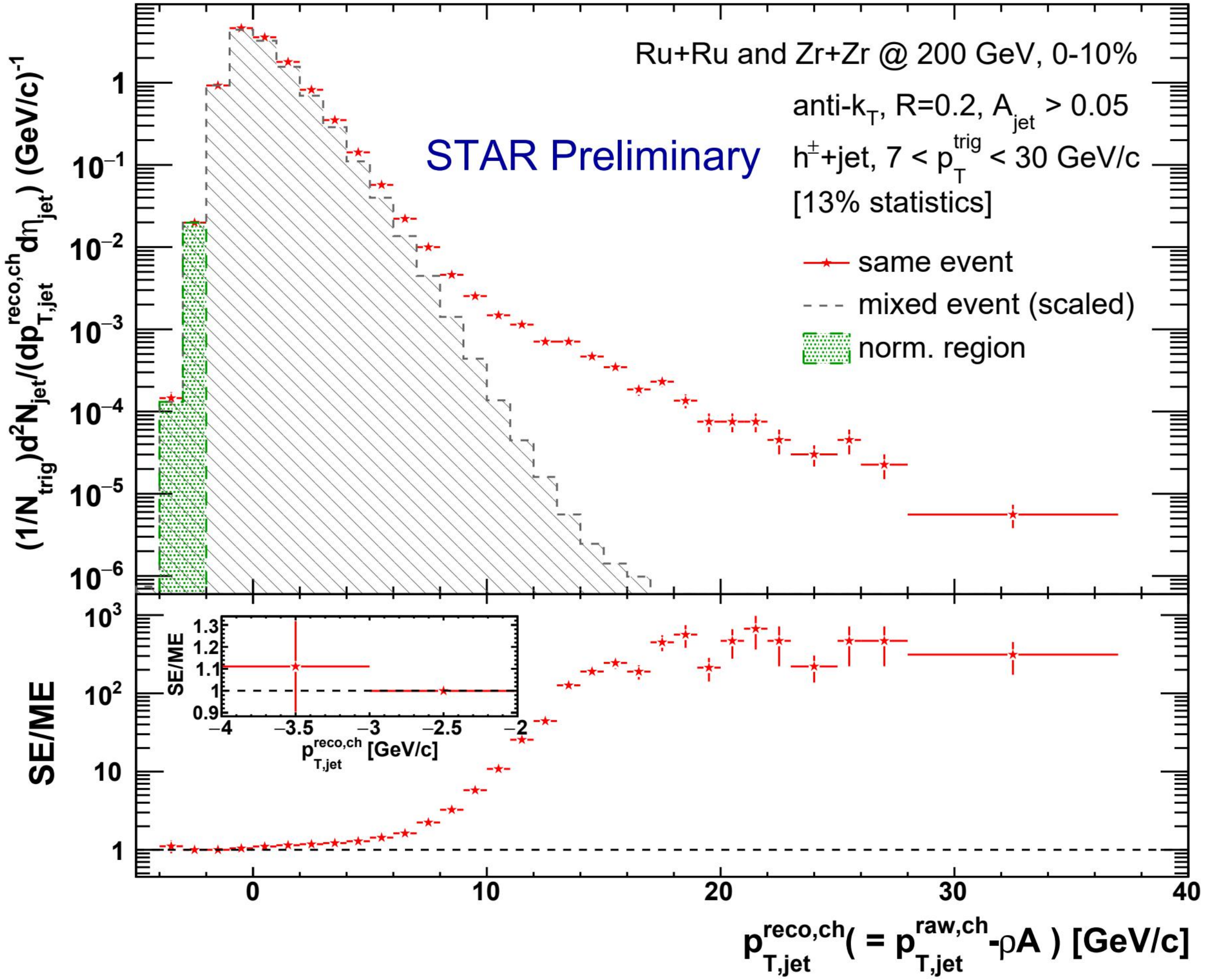
$$I_{\mathrm{CP}} = \frac{Y(p_{\mathrm{T,jet}}^{\mathrm{ch}})\big|_{0-10\%}}{Y(p_{\mathrm{T,jet}}^{\mathrm{ch}})\big|_{60-80\%}}$$

I_{cp} <1 quantifies the magnitude of the jet quenching

- Advantage: Combinatorial jets removed statistically by a mixed-event approach

h+jet p_T spectrum for jets with $R = 0.2$

0-10% centrality in Ru+Ru and Zr+Zr collisions

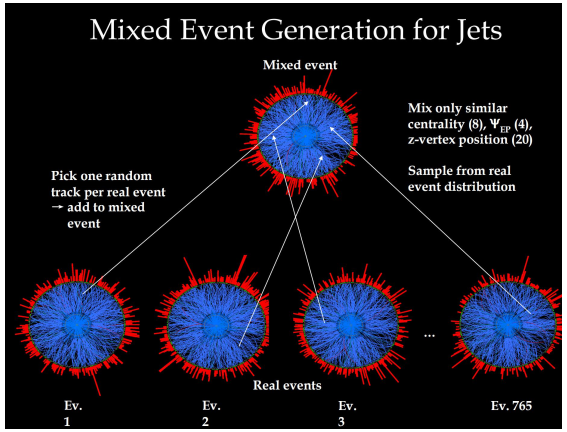


$$7 < p_T^{\mathrm{trig}} < 30\ \mathrm{GeV}/c$$

$p_{\mathrm{T,jet}}^{\mathrm{reco}} < 0$: Almost identical between the same-event (SE) and mixed-event (ME) jet p_T spectra

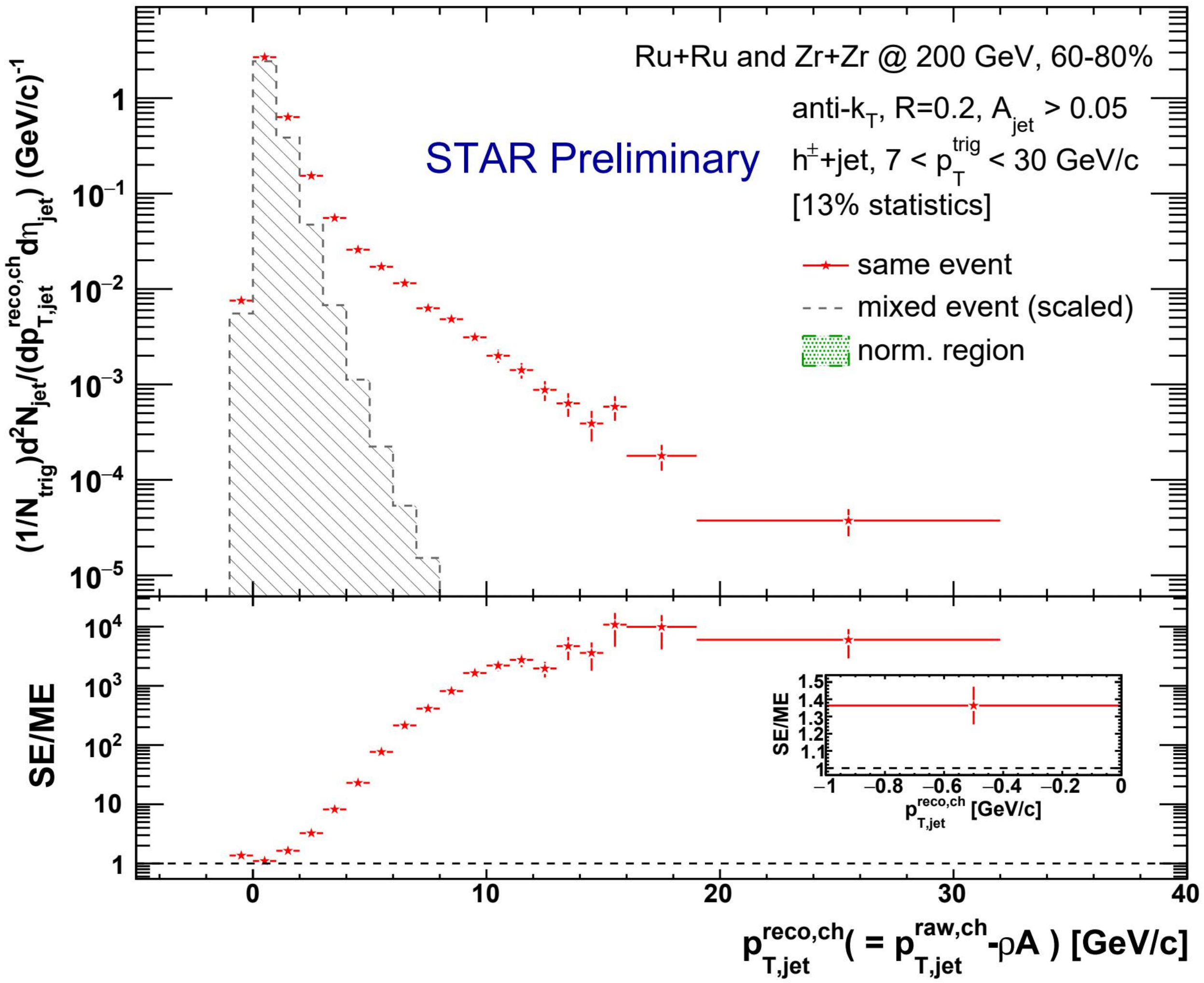
$p_{\mathrm{T,jet}}^{\mathrm{reco}} > 0$: Correlated (w.r.t. trigger particles) jet contribution dominates over combinatorial jet contribution at high $p_{\mathrm{T,jet}}^{\mathrm{reco}}$

ME works very well for this analysis



h+jet p_T spectrum for jets with $R = 0.2$

60-80% centrality in Ru+Ru and Zr+Zr collisions



$$7 < p_T^{trig} < 30 \text{ GeV}/c$$

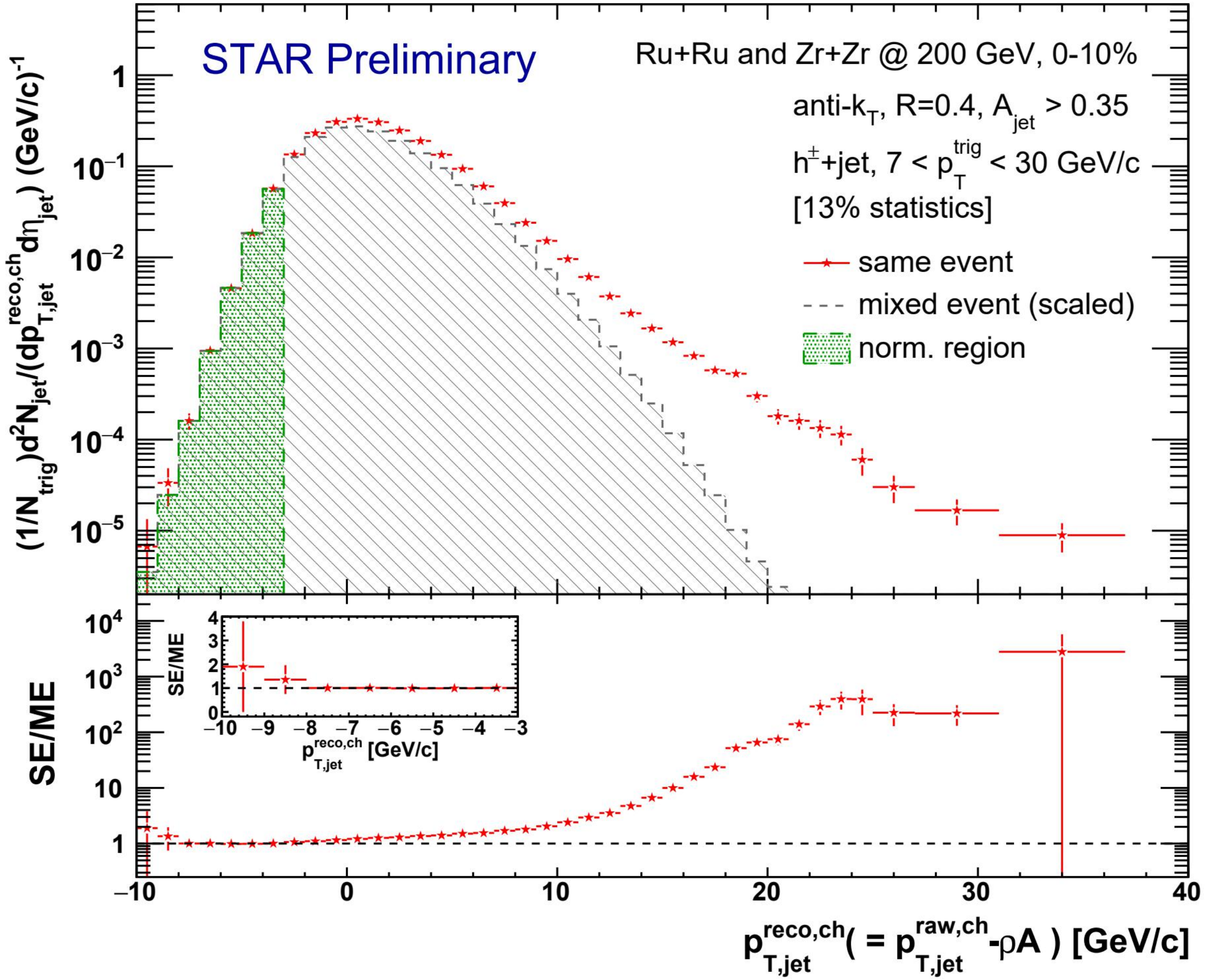
$p_{T,jet}^{reco} < 0$: Almost identical between SE and ME jet p_T spectra

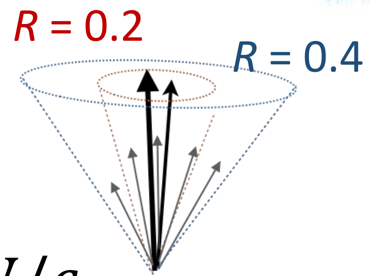
Combinatorial jet contribution is less in 60-80% centrality compared to 0-10% centrality

$p_{T,jet}^{reco} > 0$: Correlated (w.r.t. trigger particles) jet contribution dominates over combinatorial jet contribution at high $p_{T,jet}^{reco}$

h+jet p_T spectrum for jets with $R = 0.4$

0-10% centrality in Ru+Ru and Zr+Zr collisions





$$7 < p_T^{\mathrm{trig}} < 30\ \mathrm{GeV}/c$$

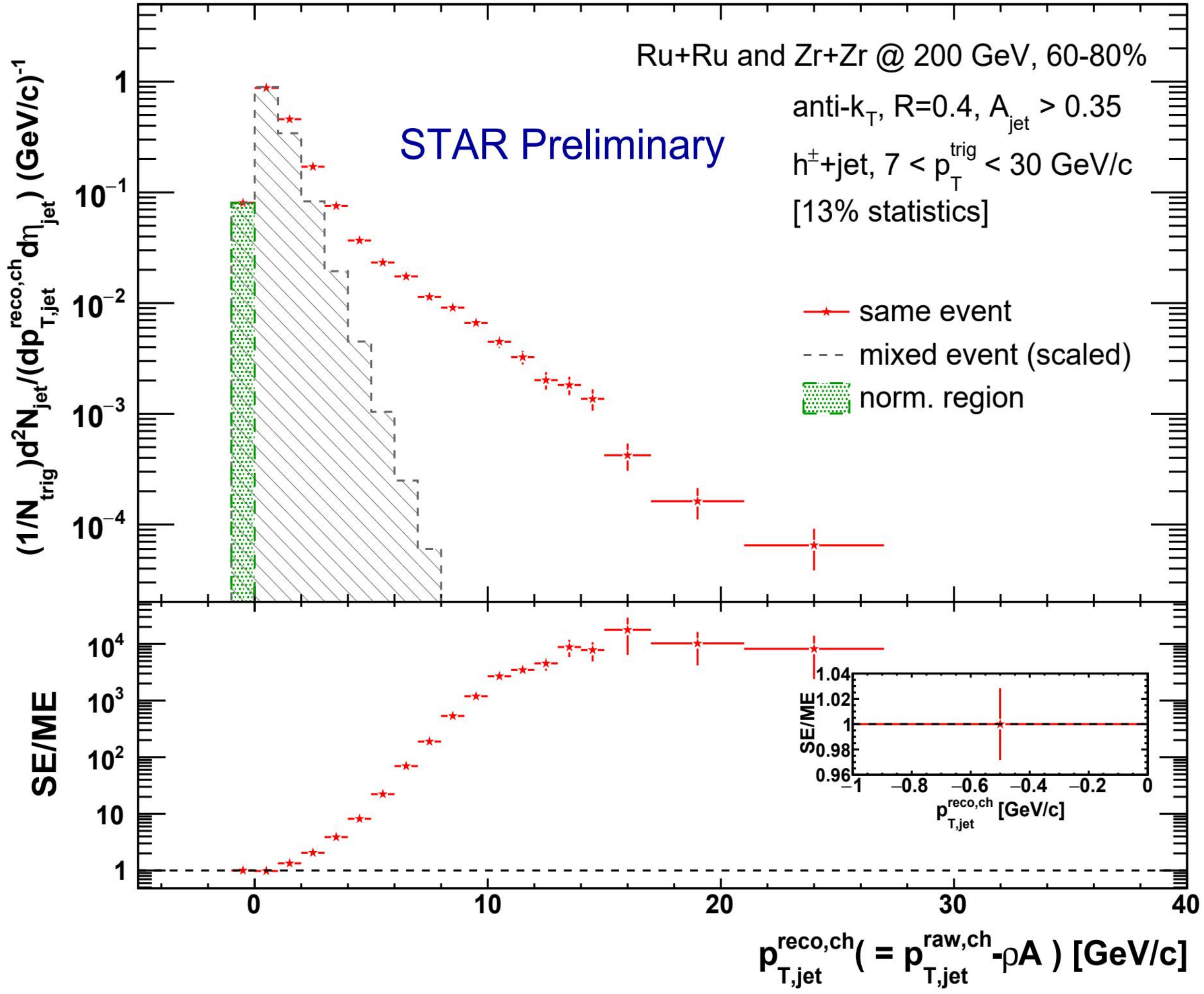
$p_{\mathrm{T,jet}}^{\mathrm{reco}} < 0$: Almost identical between between SE and ME jet p_T spectra

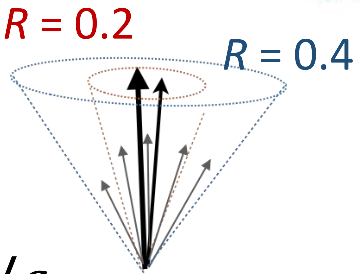
Larger background fluctuation for R = 0.4 than R = 0.2

$p_{\mathrm{T,jet}}^{\mathrm{reco}} > 0$: Correlated (w.r.t. trigger particles) jet contribution dominates over combinatorial jet contribution at high $p_{\mathrm{T,jet}}^{\mathrm{reco}}$

h+jet p_T spectrum for jets with R = 0.4

60-80% centrality in Ru+Ru and Zr+Zr collisions





$$7 < p_T^{\mathrm{trig}} < 30\ \mathrm{GeV}/c$$

$p_{\mathrm{T,jet}}^{\mathrm{reco}} < 0$: Almost identical between between SE and ME jet p_T spectra

Combinatorial jet contribution is less in 60-80% centrality compared to 0-10% centrality

$p_{\mathrm{T,jet}}^{\mathrm{reco}} > 0$: Correlated (w.r.t. trigger particles) jet contribution dominates over combinatorial jet contribution at high $p_{\mathrm{T,jet}}^{\mathrm{reco}}$

Stay tuned

We are working on full statistics for Ru+Ru and Zr+Zr collisions

- 13% statistics for this presentation
- Full statistics have a large impact for this measurement
- We expect to have a higher jet p_T reach
- Smaller systematic uncertainties in these data than Au+Au collisions for the 0-10% centrality

	0-10% centrality	60-80% centrality
Current statistics for this presentation (~13%)	~124k (trigger events $7 < p_T^{trig} < 30$ GeV/c)	~14k (trigger events $7 < p_T^{trig} < 30$ GeV/c)
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Ongoing work: fully corrected recoil charged jet p_T spectrum and calculation of nuclear modification factor (I_{CP})

Summary

- STAR has observed strong jet suppression in central Au+Au collisions
- Ru+Ru and Zr+Zr collisions can help to study system size dependence of the parton energy loss
  - In this talk, we presented preliminary results with 13% statistics
  - ME approach for precise background removal works well
  - Work on full statistics and corrections for detector response and background fluctuation

Thank You!