DNP2020

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APS physics

Measuring the Groomed Shared Momentum Fraction z_g in Au+Au Collisions at $\sqrt{s_{NN}}$ = 200 GeV Using a Semi-inclusive Approach

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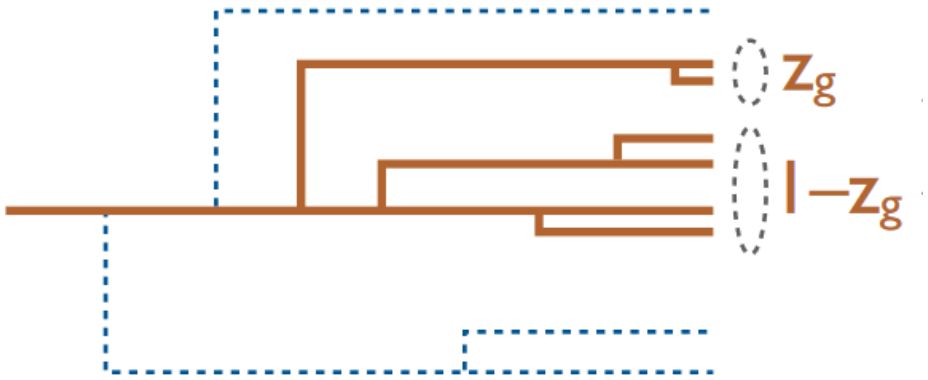
Groomed Shared Momentum Fraction z_g

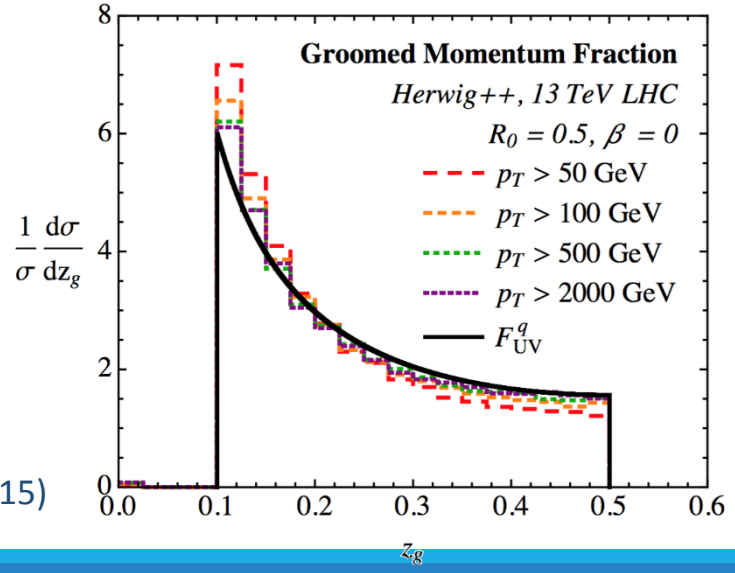
- z_g is a substructure observable which probes the physics of the first hard splitting of a hard-scattered parton
- Defined as the momentum fraction of the subleading subjet groomed using SoftDrop [1] (here with chosen parameters $z_{\text{cut}} = 0.1, \beta = 0$)

$$z_g = \frac{\text{Min}(p_{T,1}, p_{T,2})}{p_{T,1} + p_{T,2}} > 0.1$$

- Higher z_g → more symmetric splitting
- Lower z_g → more asymmetric splitting

J. Thaler, Alice Workshop 2015 (figure)





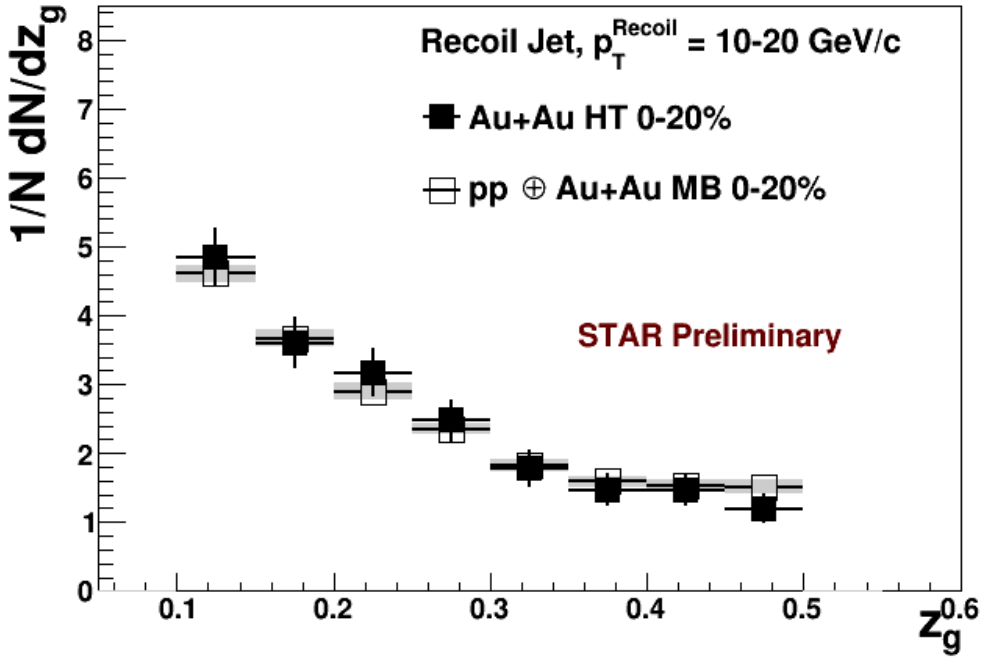
Larkoski et al.,
PRD 91, 111501 (2015)

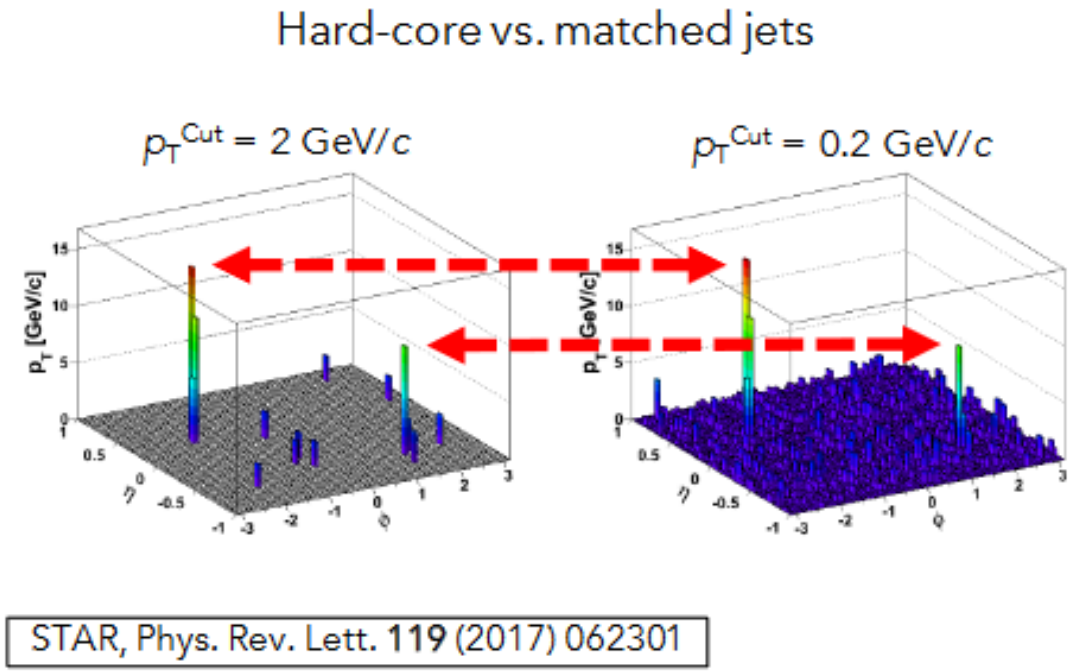
Jets In a Heavy Ion Environment

- Background uncorrelated to hard scatterings present in heavy-ion collisions
- Pedestal-like background subtraction: $p_{\mathrm{T,jet}}^{\mathrm{reco}} = p_{\mathrm{T,jet}}^{\mathrm{raw}} - \rho A_{\mathrm{jet}}$
- With the pedestal-like subtraction still present are fluctuations in the background, which are purely combinatorial and are reconstructed as jet-like objects
- Leading track or hard-core requirement are usual methods to remove purely combinatorial jets from jet candidate sample, however at the cost of imposing surface and/or fragmentation bias

Previous STAR Measurement of z_g

- z_g for di-jet sample, $p_{T,jet}^{Trig}$ > 20 GeV/c and , $p_{T,jet}^{Recoil}$ > 10 GeV/c (full jets)
- Hard-core matched jets to eliminate combinatorial jets
- Found no significant modification in central Au+Au compared to embedded *pp*

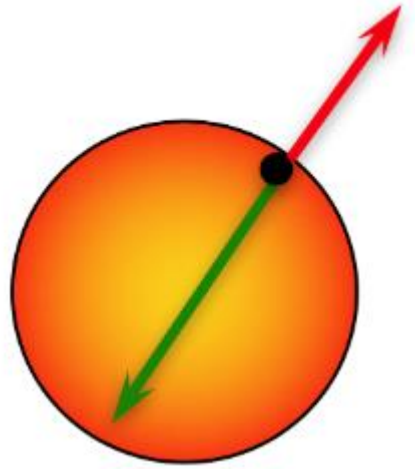




STAR, Phys. Rev. Lett. **119** (2017) 062301

Semi-inclusive Approach and its Benefits

- Select triggered events with a high p_{T} particle, selecting events with a preferentially surface-biased high Q^2 process

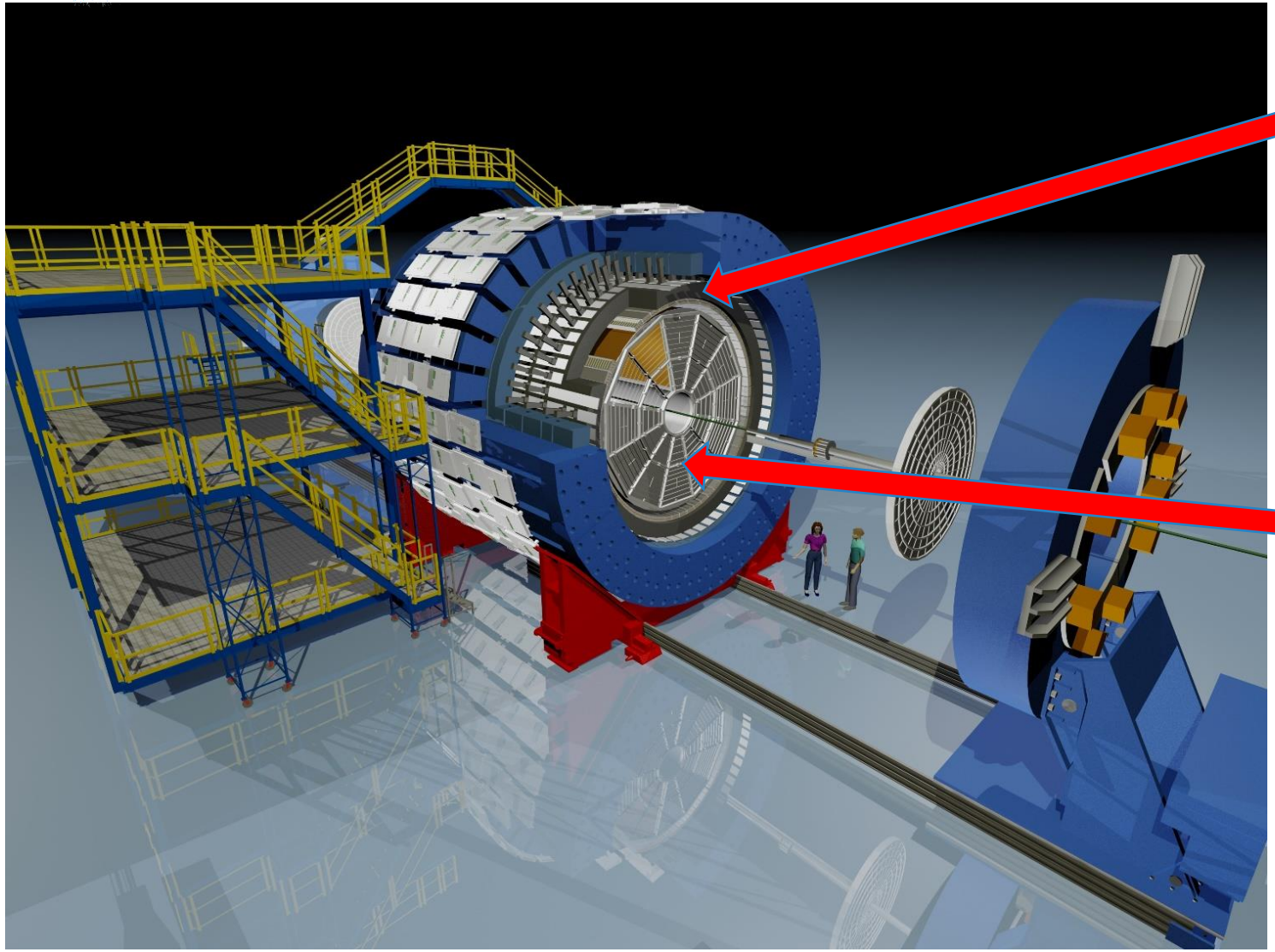


- Reconstruct jets in recoil range of the trigger object, a sample of jets which are potentially biased towards having a longer path length in the medium

- Minimal discrimination of jets on a jet-by-jet basis, avoiding imposing a fragmentation or surface bias on the measured jets

- Uncorrelated jets which mostly arise due to background fluctuations are subtracted off using a mixed event technique

STAR Detector



BEMC

Barrel Electromagnetic Calorimeter

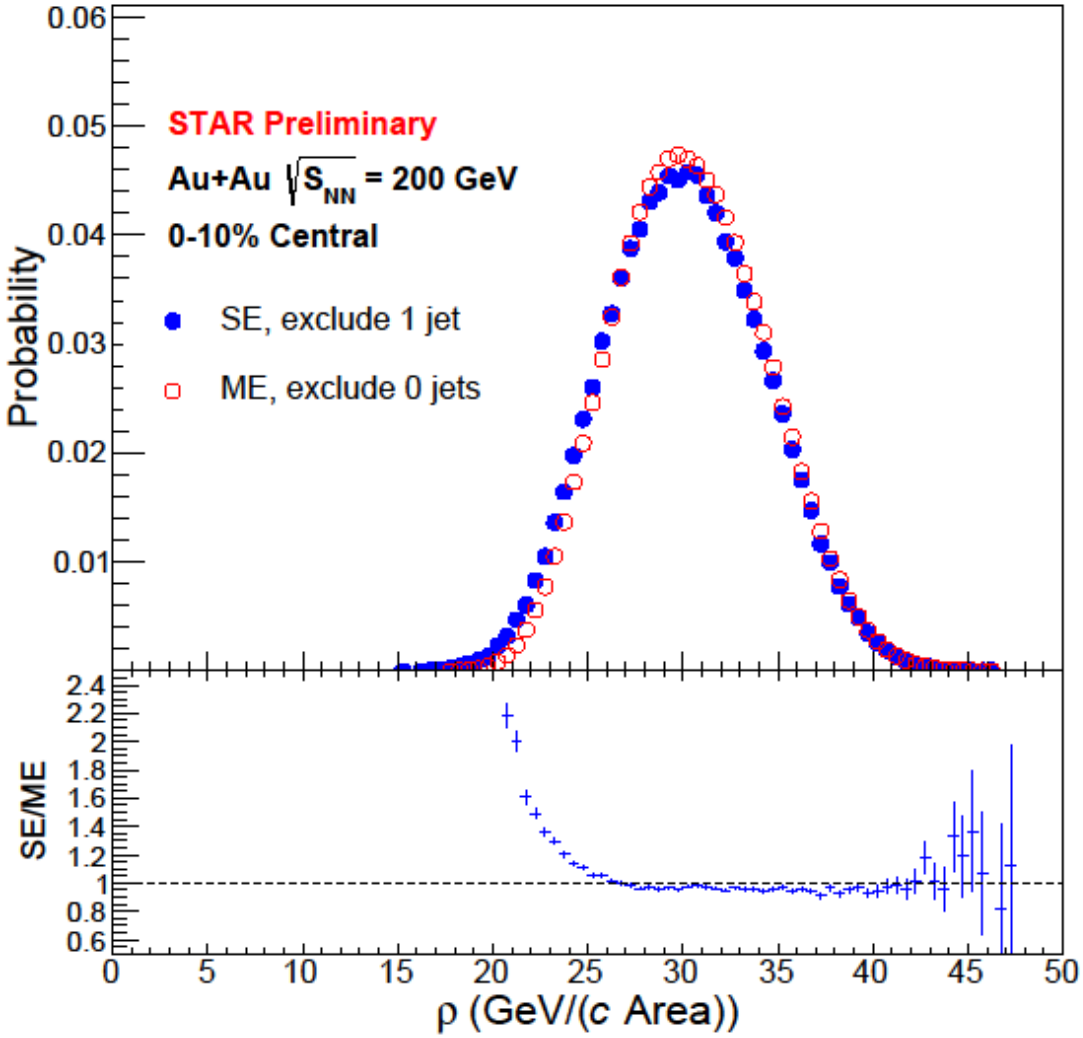
- $|\eta| < 1$
- $0 < \varphi < 2\pi$
- Used for triggering

TPC

Time Projection Chamber

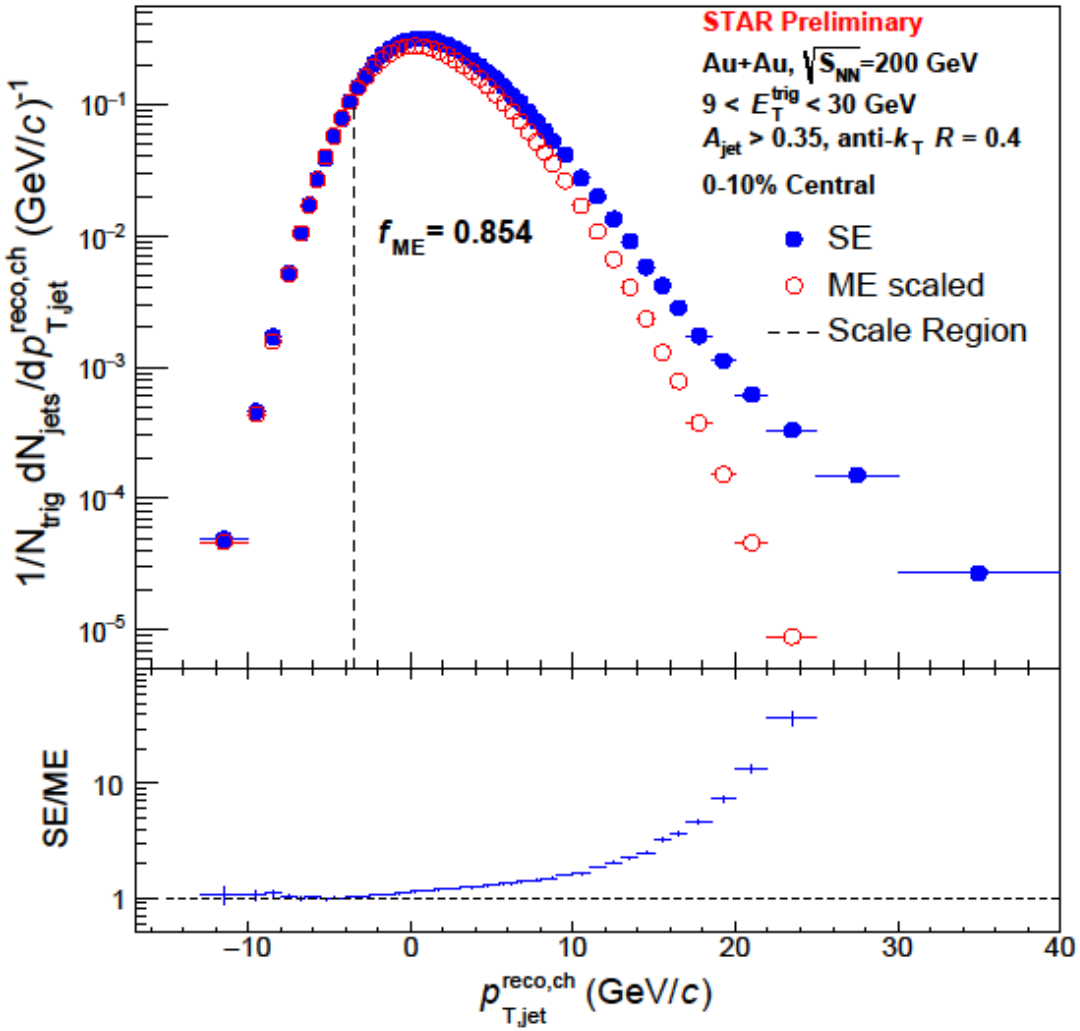
- $|\eta| < 1$
- $0 < \varphi < 2\pi$
- Charged particles for jet analysis

Mixed Events and Transverse Energy Density ρ



- Same Event (SE): HT triggered event, containing a BEMC tower with $E_{\mathrm{T}} > 9\ \mathrm{GeV}$
- Mixed Event (ME): Minimum-bias events, mixed in bins of vertex position z_{vtx}, event-plane angle ψ_{EP}, luminosity, and centrality
- Absolute definition of ρ is not important, goal is to maximize relative agreement between SE and ME
- Variation in relative definition of ρ is taken as systematics

Extracting Uncorrelated Jet Yields



- Jets reconstructed (anti-k_T R=0.4) in SE and ME in the recoil range of the trigger object of the SE

$$\left|\varphi_{\mathrm{jet}} - \varphi_{\mathrm{trig}}\right| > \pi - \pi/4$$

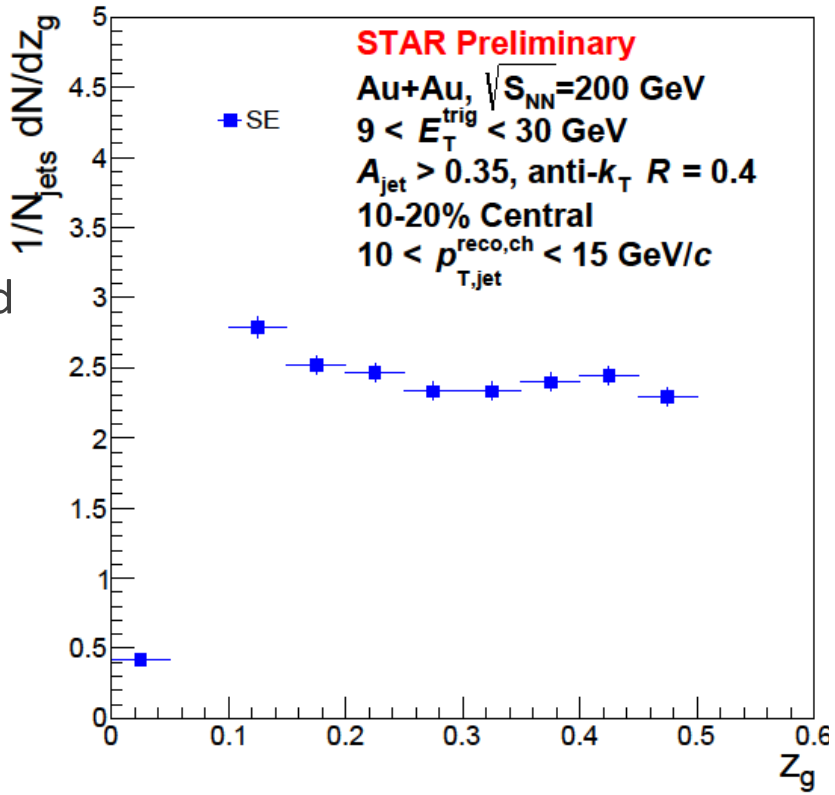
- Jets' p_T are shifted using area-based subtraction:

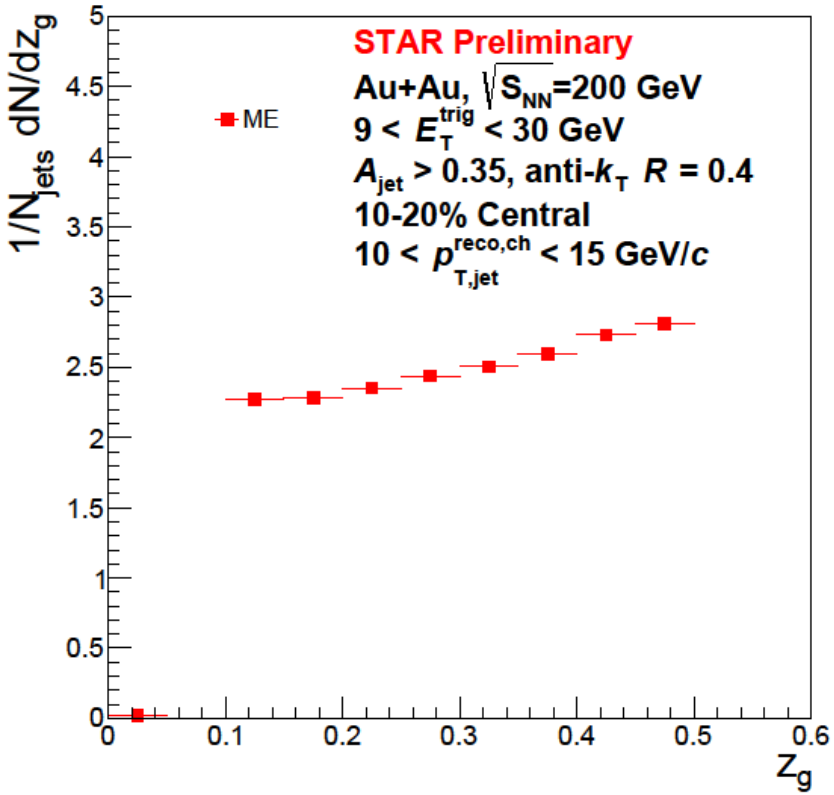
$$p_{\mathrm{T,jet}}^{\mathrm{reco,ch}} = p_{\mathrm{T,jet}}^{\mathrm{raw,ch}} - \rho A_{\mathrm{jet}}$$

- Total per-trigger yield of jets within the recoil range is approximately the same for both ME and SE
- Most negative $p_{T,jet}$ region expected to have same per-trigger yields, ME scaled down by factor f_{ME} to compensate
- Can extract the yields of uncorrelated jets within a given jet p_T bin

SE and ME z_g Distributions

- SE has both signal and uncorrelated background jets
- ME consists of purely uncorrelated background jets
- Both classes of jets are subtracted using Constituent Subtraction

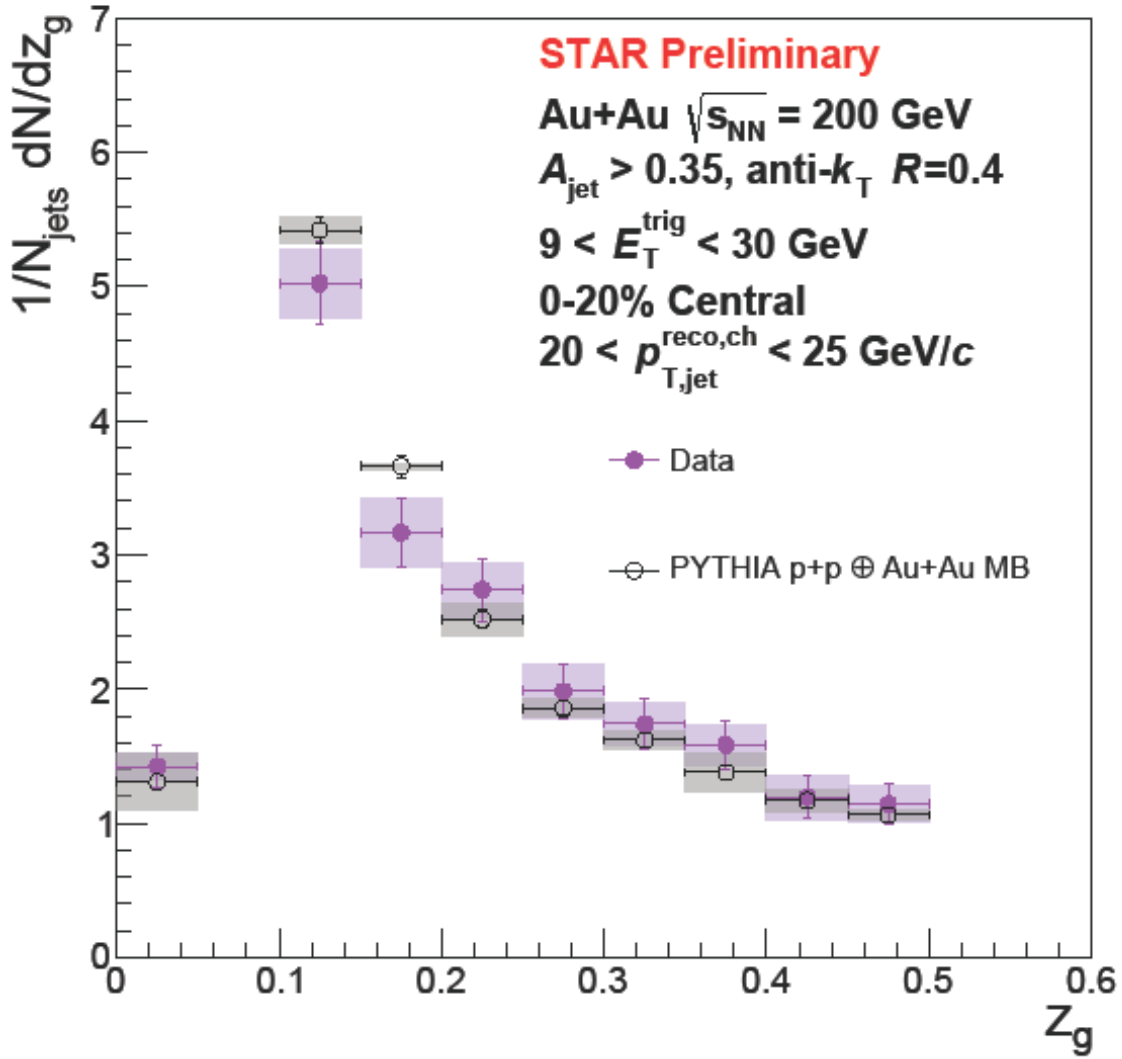




- Shape of ME z_g distribution is significantly different than the usual 1/z shape
- Zeroth bin populated by jets which do not pass SoftDrop criterion, which notably is rare for combinatorial jets
- Combinatorial jet subtracted z_g is obtained by scaling ME distribution and subtracting from the SE distribution

Detector Level Comparison

- Combined **0-20%** centrality detector level jets with $20 < p_{\mathrm{T,jet}}^{\mathrm{reco,ch}} < 25$ GeV/c
- Jet p_{T} range shown is insensitive to details of the combinatorial jet subtraction (less than 5% contribution)
- Comparison to smeared PYTHIA-6 embedded into MB 0-20% Au+Au events
- No significant modification found in this $p_{\mathrm{T,jet}}$ range compared to PYTHIA-6



Summary and Outlook

- Measured z_{g} for 0-20% central events within $20 < p_{\mathrm{T,jet}}^{\mathrm{reco,ch}} < 25$ GeV/c where the combinatorial jet contribution is less than 5%

- No significant modification for this semi-inclusively selected sample of jets compared to detector level PYTHIA-6 embedded into MB Au+Au collisions

- Plan to utilize this semi-inclusive approach to measure z_{g} down to lower jet p_{T} without inducing a fragmentation or surface bias on the measured jets