Jet quenching studies with new jet substructure and suppression measurements in ATLAS

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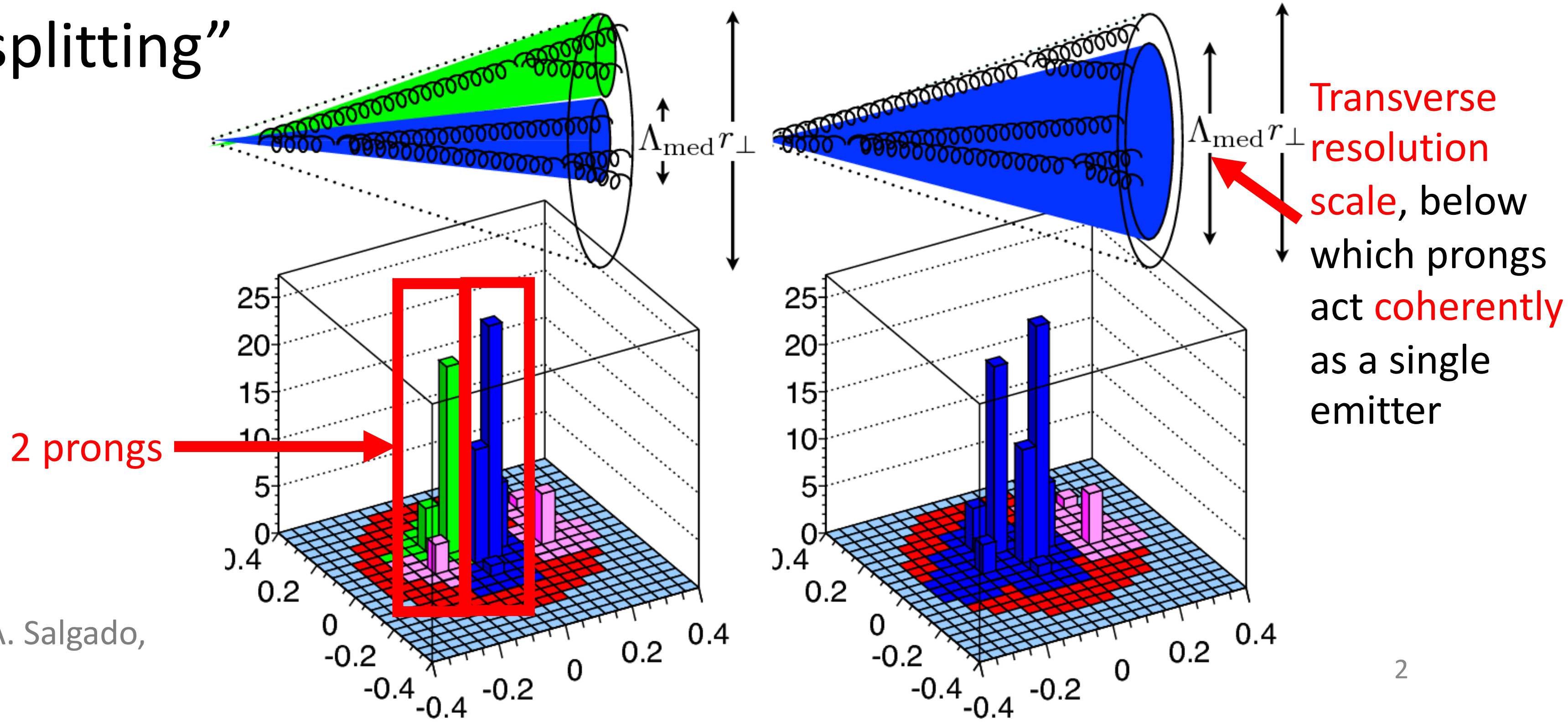
Motivation

- Jets lose energy in the quark-gluon plasma (QGP) and this probes the properties of the QGP.
- Does this energy loss depend on the jet substructure?
  - Can we see the color coherence/de-coherence effects?

→Measure R_{AA} vs "splitting"



J. Casalderrey-Solana, Y. Mehtar-Tani, C. A. Salgado, K. Tywoniuk, Phys. Lett. B725 (2013) 357

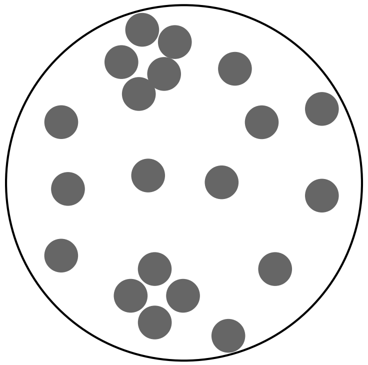
Analysis technique (1)

- Reconstruct large-radius jets by re-clustering underlying-event subtracted $R = 0.2$ jets.

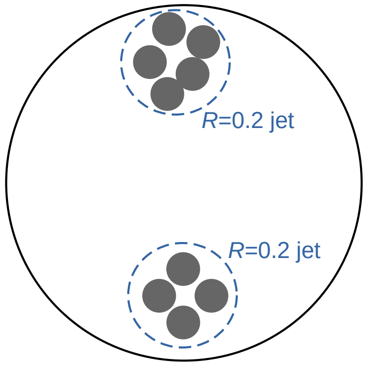
Anti-k_t $R = 0.2$ jets
$p_T > 35$ GeV

→ Anti-k_t $R = 1.0$ — Cluster →

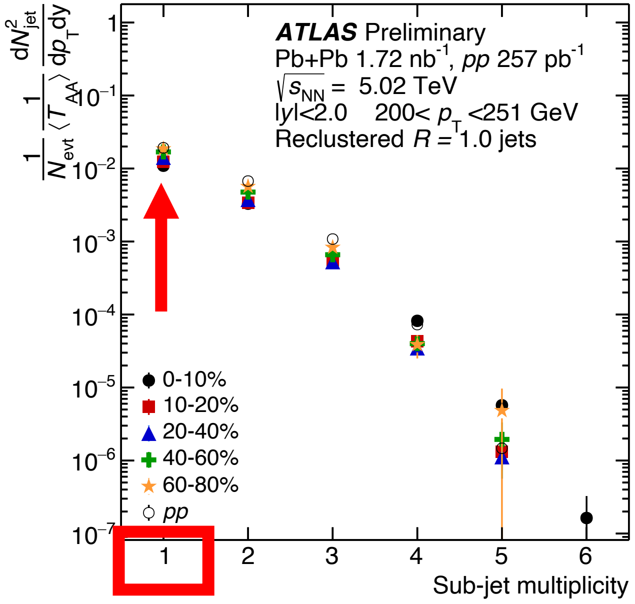
$R = 1.0$ large-radius jets
(with $R = 0.2$ sub-jets)



"Conventional"
R=1.0 jet



Re-clustered
R=1.0 jet



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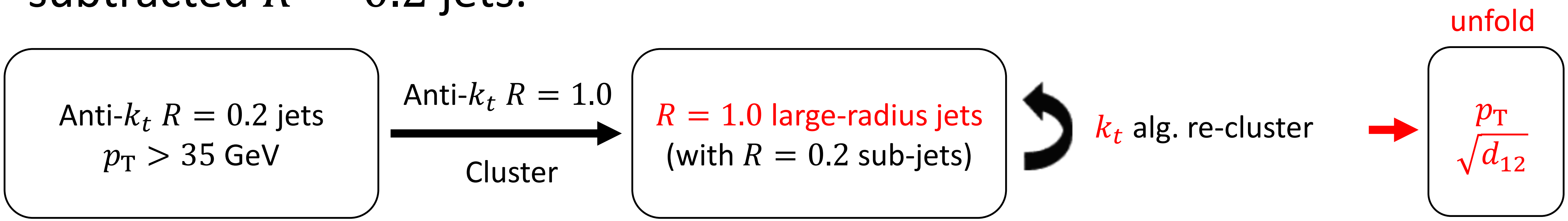
Analysis technique (1)

- Reconstruct large-radius jets by re-clustering underlying-event subtracted $R = 0.2$ jets.



- At the last k_t clustering step (2->1)(hardest splitting in the jet), define the splitting scale:

$$\sqrt{d_{12}} \equiv \min(p_{T1}, p_{T2}) \cdot \Delta R_{12}, \; \Delta R_{12} = \sqrt{\Delta\phi_{12}^2 + \Delta y_{12}^2}$$

- 2D (1D) Bayesian unfolding in jet p_T and $\sqrt{d_{12}}$ (in jet p_T only).

Analysis technique (2)

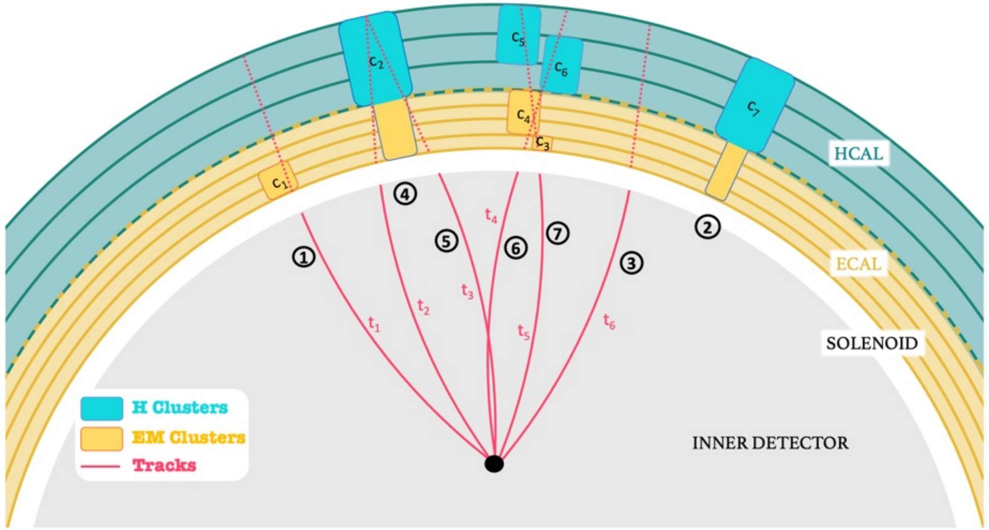
- Reconstruct $R = 0.4$ jets by re-clustering underlying-event subtracted track-calo-clusters (TCCs).

TCCs for "particles"
$p_{\mathrm{T}} > 4$ GeV

Anti-k_t $R = 0.4$
Cluster

$R = 0.4$ jets
(with TCC constituents)

Calorimeter: energy
Track: angular information



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Analysis technique (2)

- Reconstruct $R = 0.4$ jets by re-clustering underlying-event subtracted track-calo-clusters (TCCs).

TCCs for "particles"
$p_{\mathrm{T}} > 4$ GeV

→ Anti-k_t $R = 0.4$ Cluster →

$R = 0.4$ jets
(with TCC constituents)

C/A alg. re-cluster + Soft-drop grooming ($z_{\mathrm{cut}} = 0.2$, $\beta = 0$) →

unfold

p_{T}
r_g

$$\frac{\min(p_{\mathrm{T},j_1}, p_{\mathrm{T},j_2})}{p_{\mathrm{T},j_1} + p_{\mathrm{T},j_2}} > z_{\mathrm{cut}} \left(\frac{\Delta R_{12}}{R}\right)^{\beta}$$

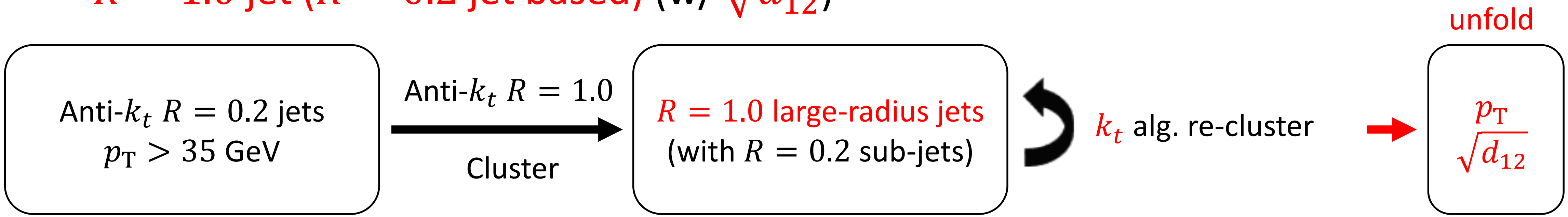
- Soft-drop (with C/A) identifies the hardest splitting and its opening angle:

$$\text{(groomed) } r_g = \Delta R_{12} = \sqrt{\Delta\phi_{12}^2 + \Delta y_{12}^2}$$

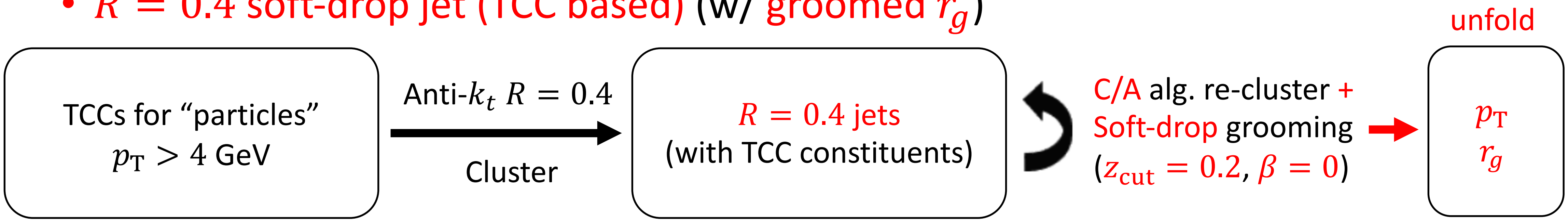
- 2D (1D) Bayesian unfolding in jet p_{T} and r_g (in jet p_{T} only).

Analysis technique (summary)

- Technique 1:
  - $R = 1.0$ jet ($R = 0.2$ jet based) (w/ $\sqrt{d_{12}}$)



- Technique 2:
  - $R = 0.4$ soft-drop jet (TCC based) (w/ groomed r_g)

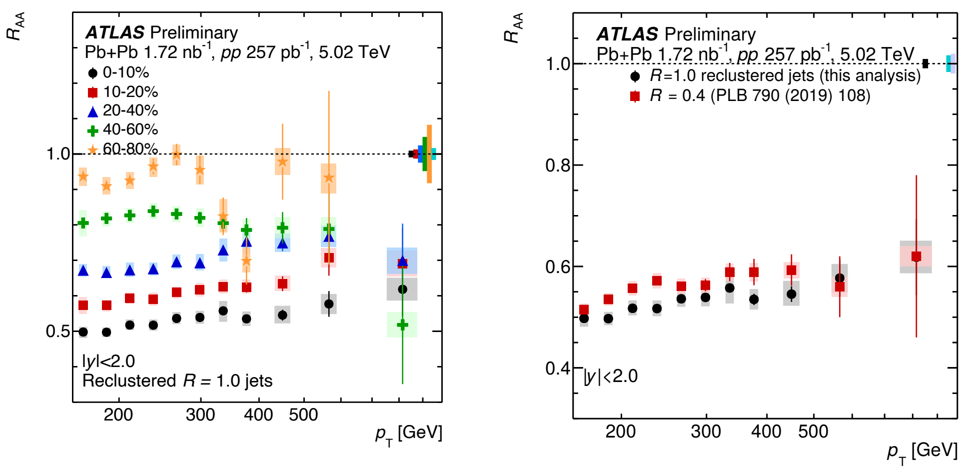


- Data: 2018 Pb+Pb (1.72 nb^{-1}) + 2017 *pp* (257 pb^{-1}), both at 5.02 TeV

Result: inclusive R_{AA}

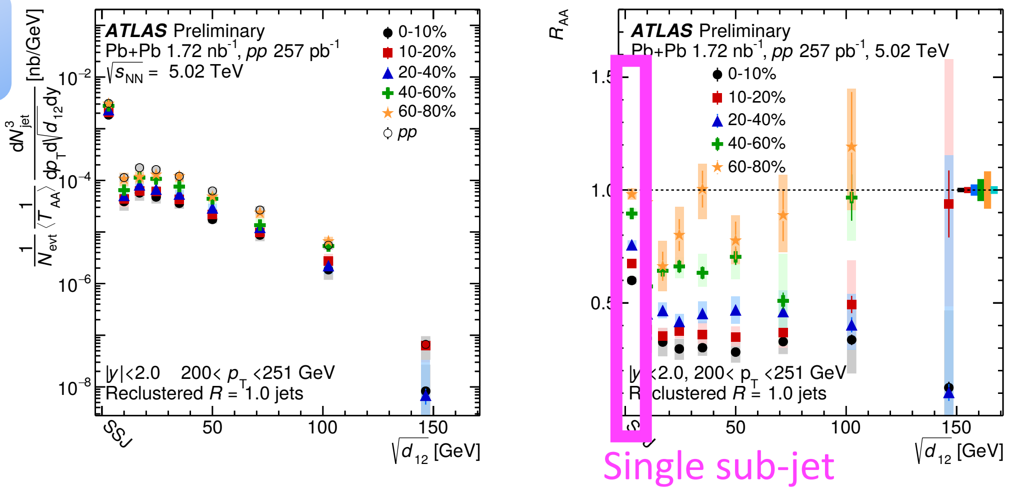
$R = 0.2$ jet based
$R = 1.0$ jet

Technique 1



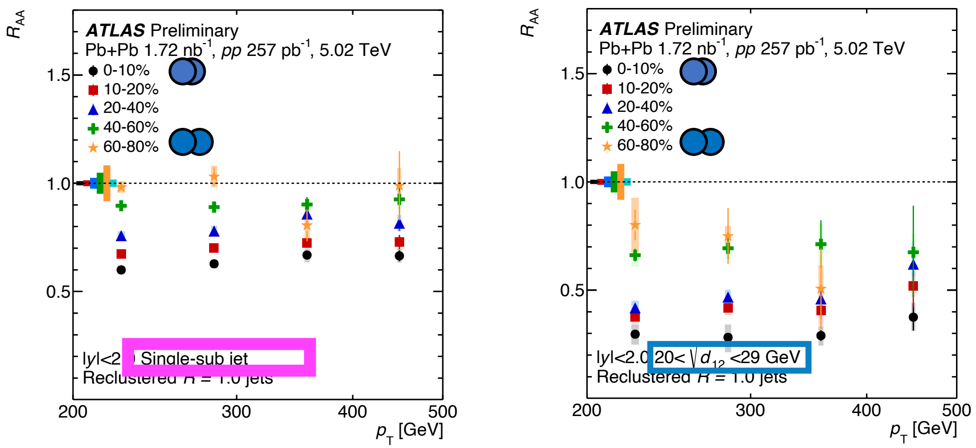
- Measured R_{AA} (0-10%) is qualitatively consistent with $R = 0.4$ anti-k_t jets, even though $R = 1.0$ jets are defined in a very different way.

Yields and R_{AA} vs $\sqrt{d_{12}}$



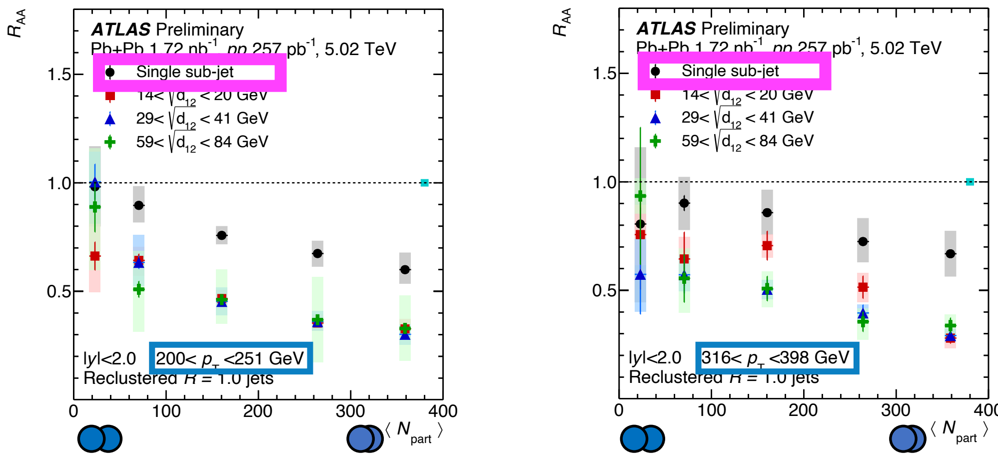
- R_{AA} drops significantly from single sub-jet (SSJ) to non-zero $\sqrt{d_{12}}$ (more complex substructure).

R_{AA} vs jet p_{T}



- Again jets with a single sub-jet are less suppressed.
- Jets with a single sub-jet show similar trends as inclusive measurement but smaller suppression.

R_{AA} vs $\langle N_{\mathrm{part}} \rangle$



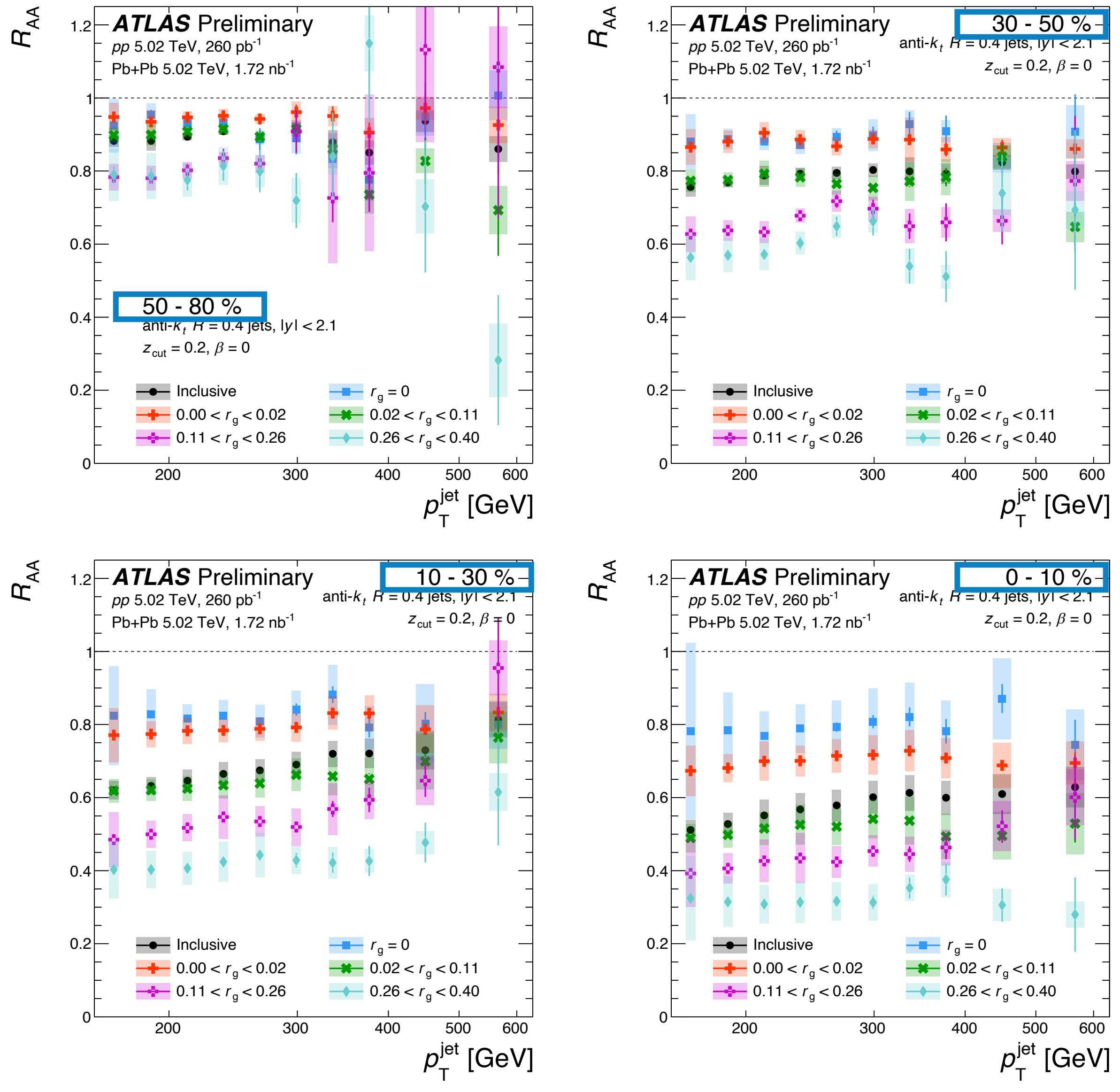
- Again jets with a single sub-jet are less suppressed.
- R_{AA} decreases as $\langle N_{\mathrm{part}} \rangle$ increases (more central collisions).

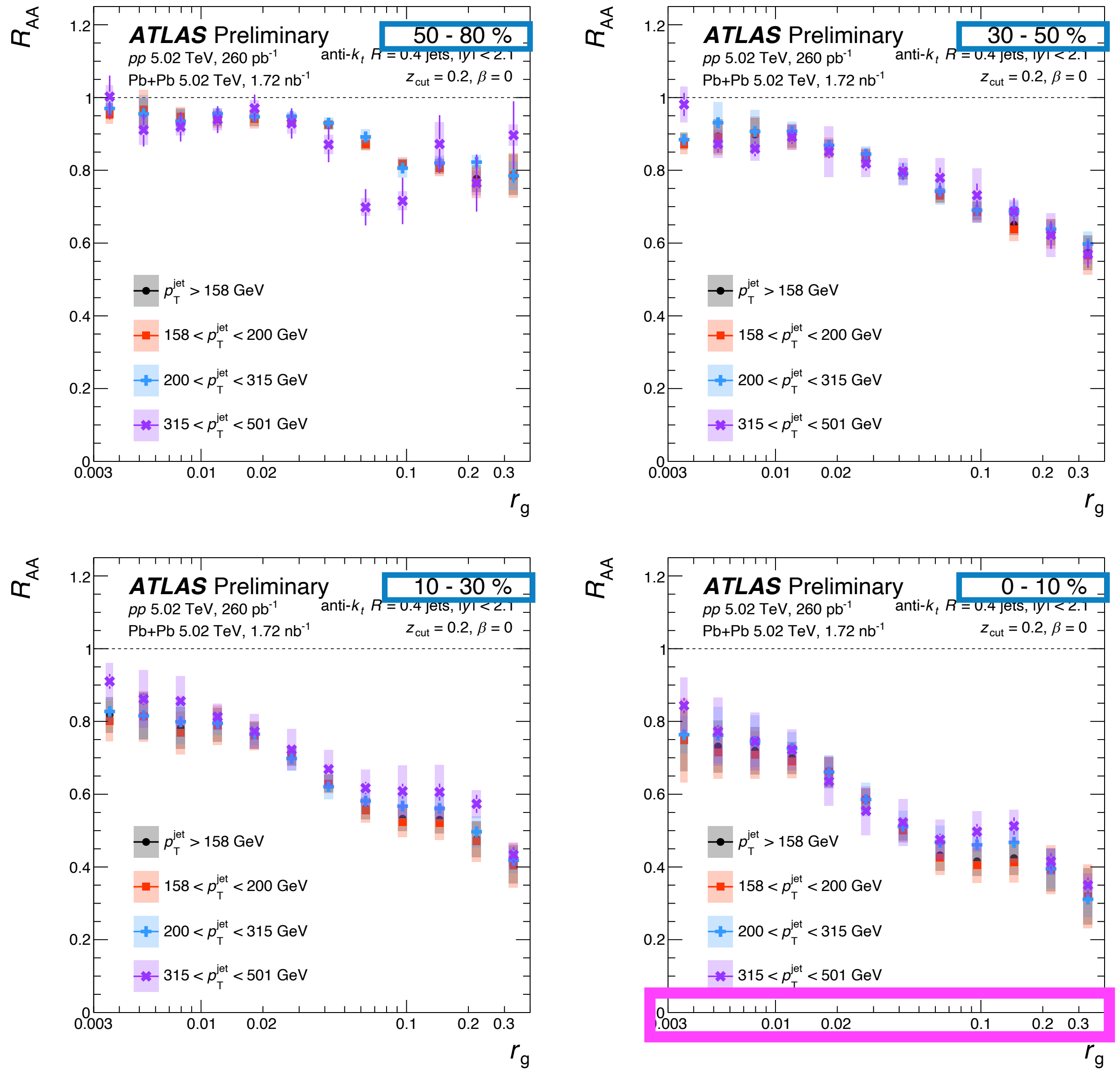
R_{AA} vs jet p_{T}

TCC based $R = 0.4$ soft-drop jet

Technique 2

R_{AA} vs r_g





- $r_g = 0$: single TCC (or groomed down to single TCC).
- R_{AA} does not depend strongly on p_{T} for a given r_g.
- Stronger suppression in more central collisions.

- R_{AA} decreases monotonically and significantly with increasing r_g.
- Higher decrease rate at low r_g.

Summary

- These two analyses directly probe the ability of the medium to resolve the partonic fragments in the jet.

$R = 0.2$ jet based
$R = 1.0$ jet
(Technique 1)

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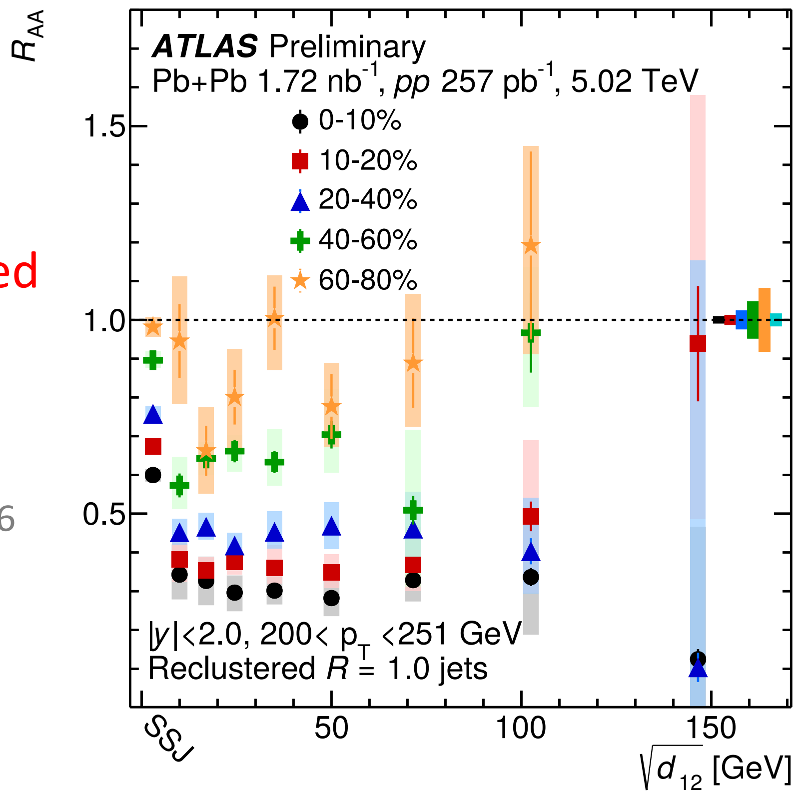

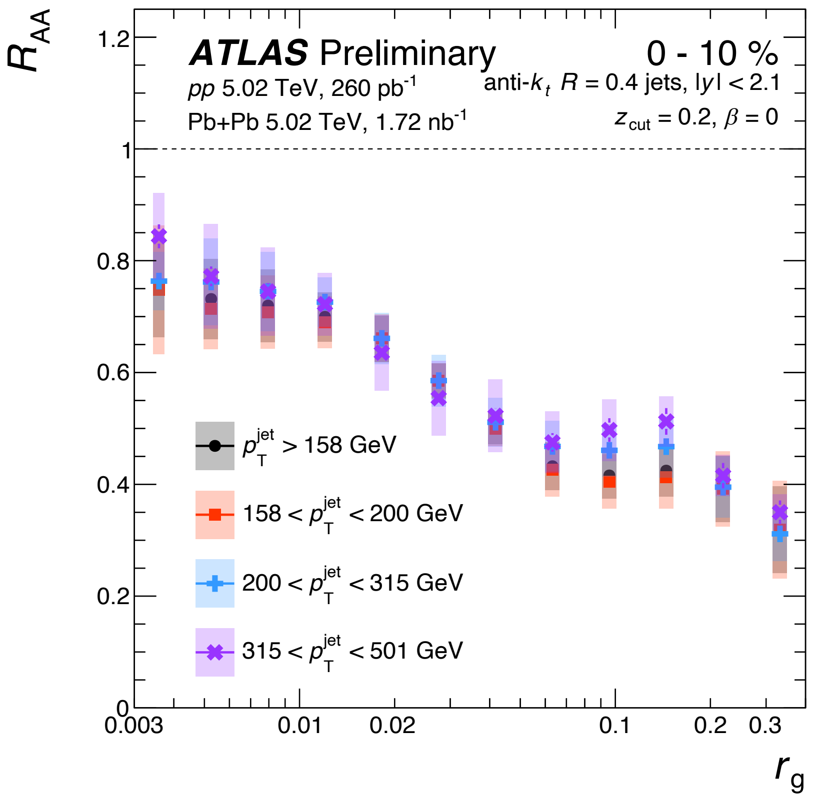

TCC based
$R = 0.4$ soft-drop jet
(Technique 2)

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- Jets with one single sub-jet (narrower opening angle) are significantly less suppressed compared to jets with multiple sub-jets (wider opening angle).