Measurement of dependence of jet suppression on substructure in Pb+Pb with ATLAS

COLUMBIA UNIVERSITY IN THE CITY OF NEW YORK

ATLAS EXPERIMENT

Wenkai Zou for the ATLAS Collaboration

Introduction

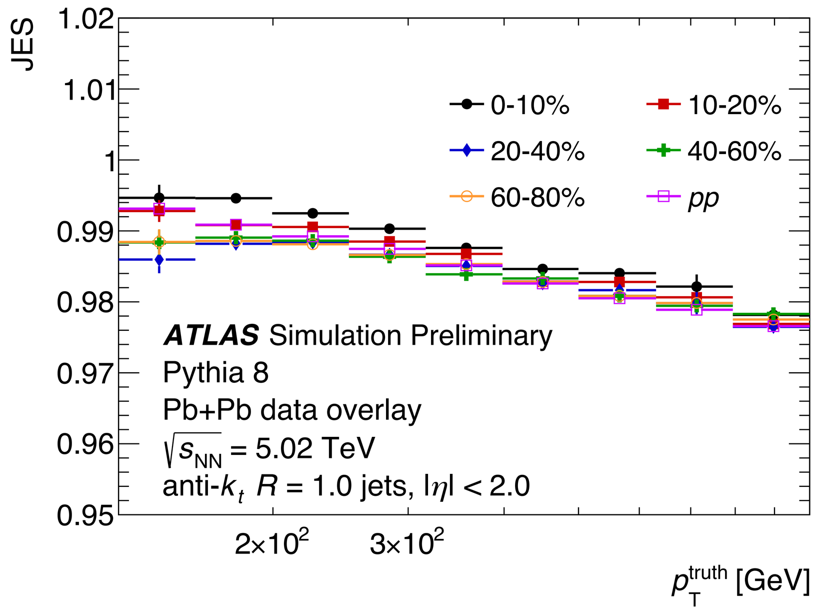
- Measurements of the suppression of the jet yield in Pb+Pb compared to *pp* provide insight into the energy-loss process and the properties of the quark-gluon plasma (QGP).
- In some models [1] which describe the jet energy loss in the QGP, the medium can only resolve partonic fragments at certain transverse resolution scale, below which they act coherently as a single emitter.
- To study this, nuclear modification factor, R_{AA} is measured with large-radius jets and dependence on splitting scale $\sqrt{d_{12}}$.
- This measurement [2] is carried out with 2018 Pb+Pb (1.72 nb^{-1}) and 2017 *pp* (257 pb^{-1}) data, both recorded at 5.02 TeV.

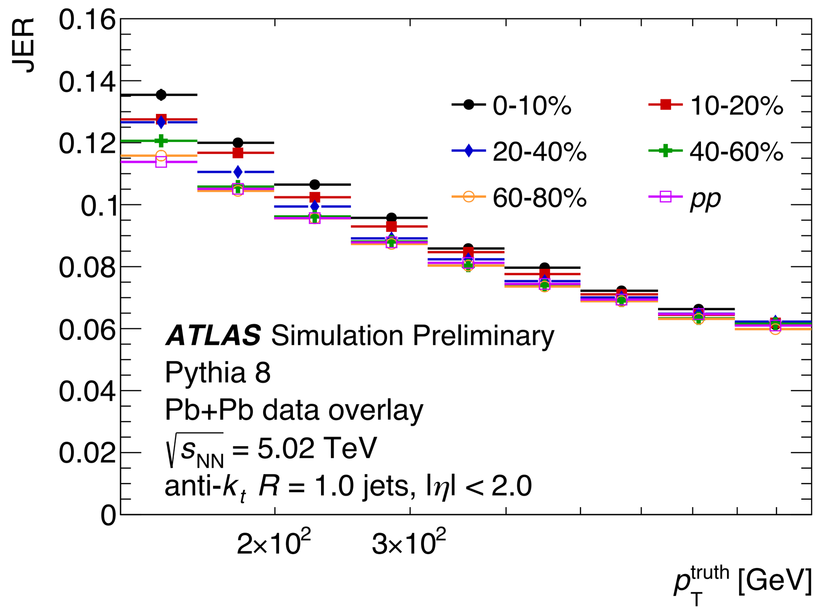
$$R_{AA} = \frac{\left.\frac{1}{N_{\mathrm{evt}}^{\mathrm{tot}}} \frac{\mathrm{d}^3 N_{\mathrm{jet}}}{\mathrm{d}p_{\mathrm{T}}\mathrm{d}\sqrt{d_{12}}\mathrm{d}y}\right|_{\mathrm{cent}}}{\left.\langle T_{AA}\rangle \frac{\mathrm{d}^3 \sigma_{\mathrm{jet}}}{\mathrm{d}p_{\mathrm{T}}\mathrm{d}\sqrt{d_{12}}\mathrm{d}y}\right|_{pp}}$$

Jet reconstruction and analysis procedure

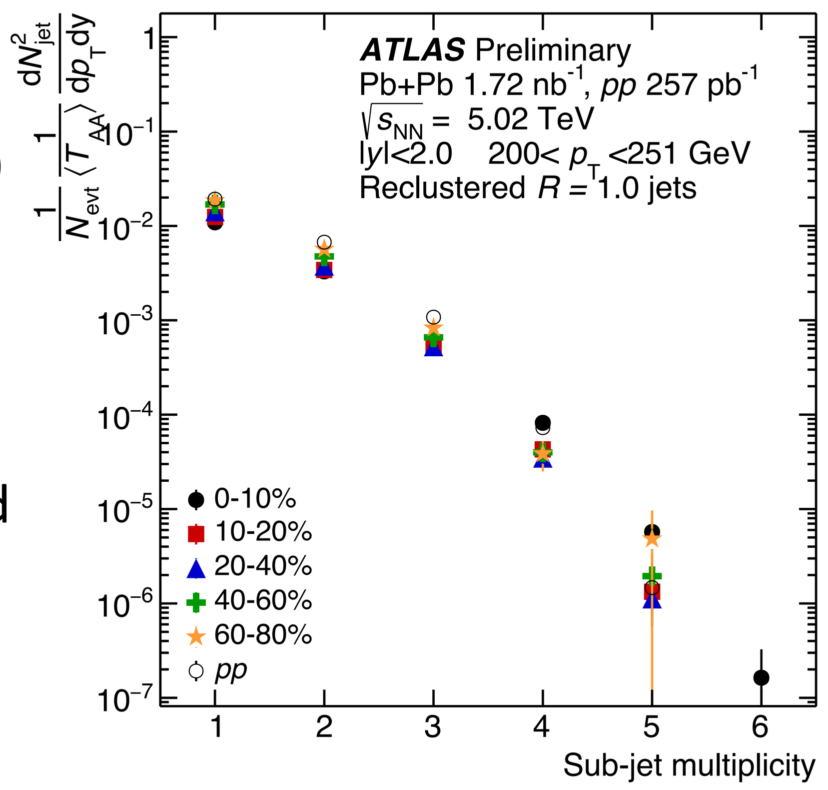
- $R = 1.0$ large-radius jets: select anti-k_t $R = 0.2$ jets [3] with $p_{\mathrm{T}} > 35$ GeV, and cluster them with anti-k_t $R = 1.0$ algorithm within $|y| < 2.0$.
- Splitting scale $\sqrt{d_{12}}$ characterizes the jet substructure. Run k_t alg. to re-cluster the $R = 0.2$ sub-jets in the $R = 1.0$ jet, and at the last clustering step (2->1), which corresponds to the hardest splitting in the jet, define:

$$\sqrt{d_{12}} \equiv \min(p_{\mathrm{T}1}, p_{\mathrm{T}2}) \cdot \Delta R_{12},\ \Delta R_{12} = \sqrt{\Delta\phi_{12}^2 + \Delta y_{12}^2}$$





- This reconstruction method suppresses the underlying event and gives good jet energy scale (JES) and jet energy resolution (JER).
- Most $R = 1.0$ jets have only one $R = 0.2$ sub-jet.
- The centrality dependence of the sub-jet multiplicity can be attributed to the resolution and combinatorial contributions from jets produced in other independent hard scatterings.

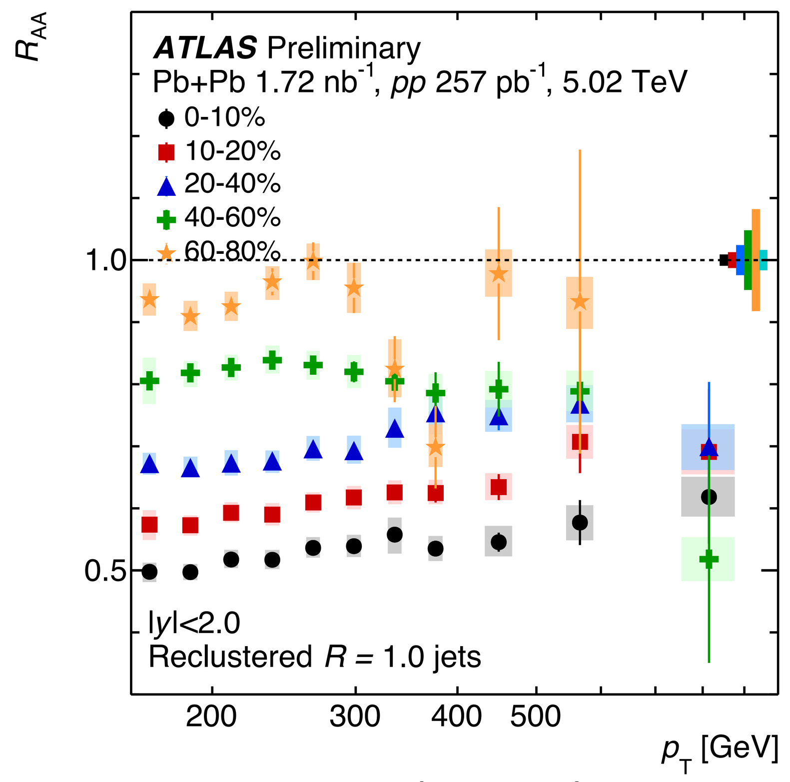


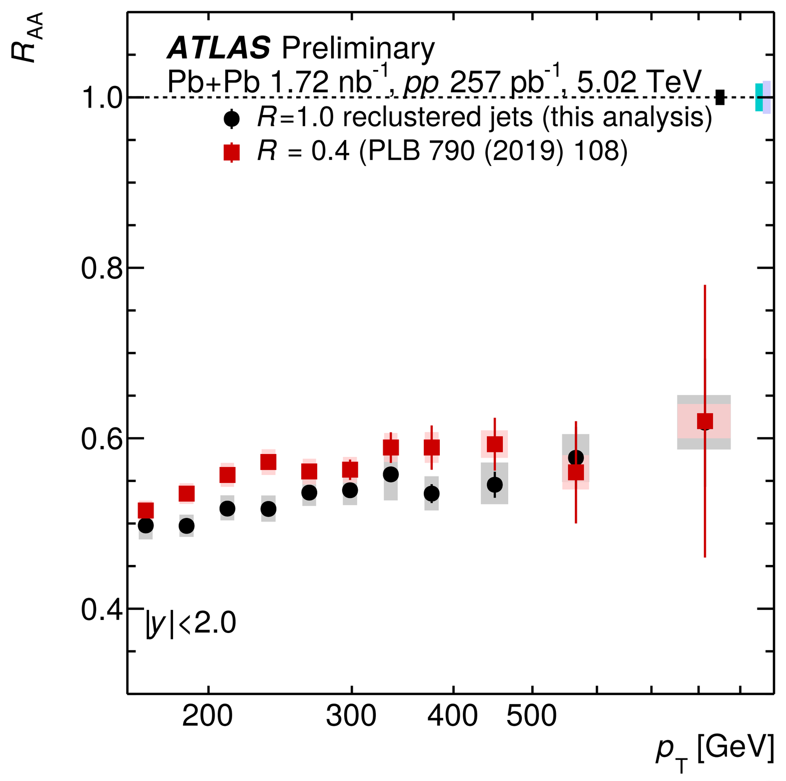
- 2D (1D) Bayesian unfolding is applied in jet p_{T} and $\sqrt{d_{12}}$ (in jet p_{T} only).
- The unfolding removes the effects of the jet energy resolution, residual jet energy scale non-closure, and the combinatorial contribution.

Systematic uncertainties

- The following systematic uncertainties are considered for this analysis:
  1. Uncertainty of the jet energy scale
  2. Uncertainty of the jet energy resolution
  3. Sensitivity of the unfolding to the prior
  4. Uncertainty from the limited number of MC events
  5. Uncertainty of the mean nuclear thickness function (T_{AA}) values
  6. Uncertainty of the *pp* luminosity
- Many cancel out between Pb+Pb and *pp* when calculating R_{AA} ratio.
- Dominated by the jet energy scale term.

Result: inclusive R_{AA}

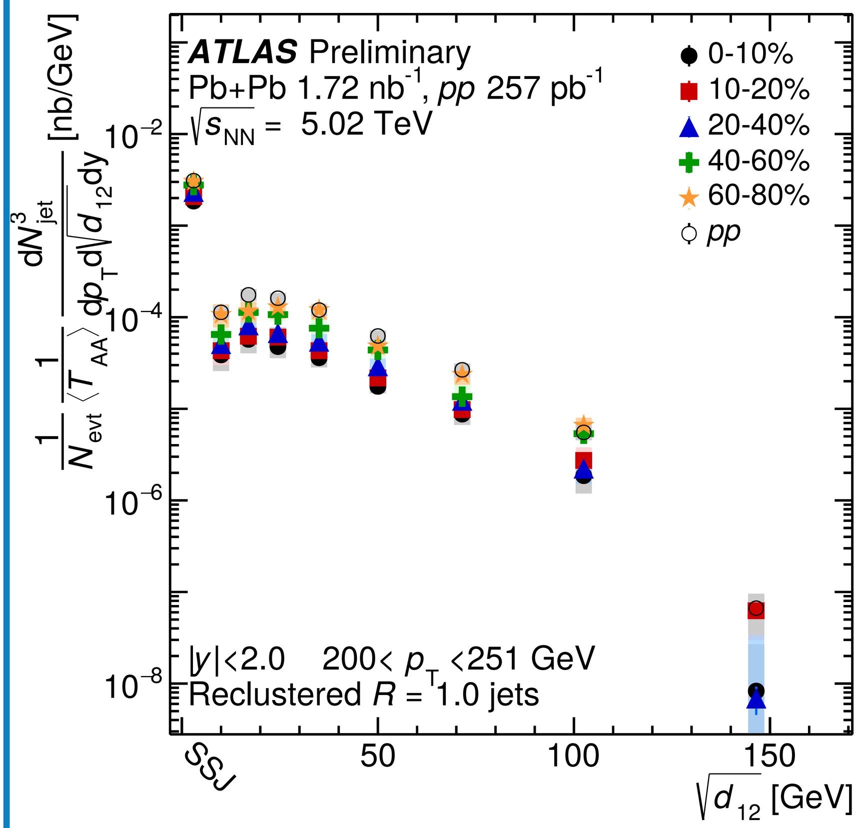


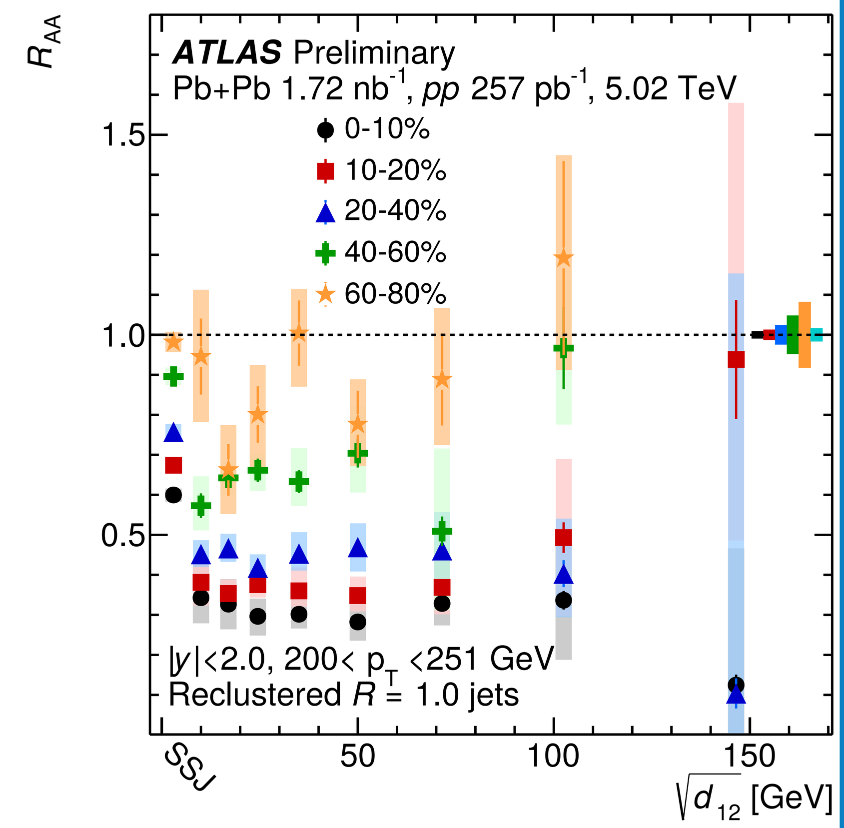


- Measured R_{AA} (0-10%) is qualitatively consistent with $R = 0.4$ anti-k_t jets [4], even though $R = 1.0$ jets are defined in a very different way.

Result: R_{AA} with $\sqrt{d_{12}}$ dependence

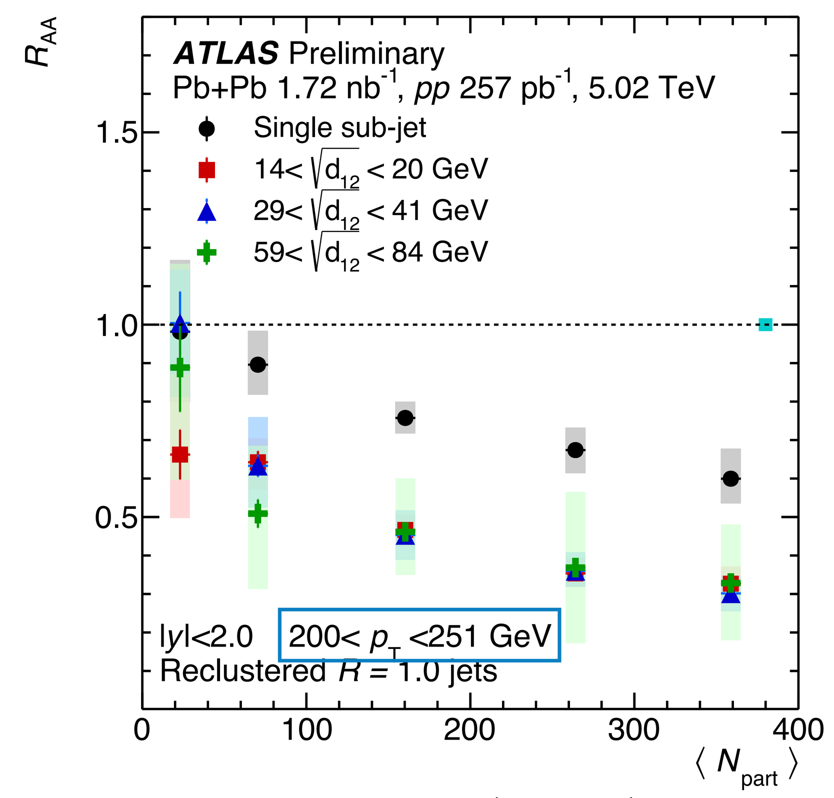
Yields and R_{AA} vs $\sqrt{d_{12}}$

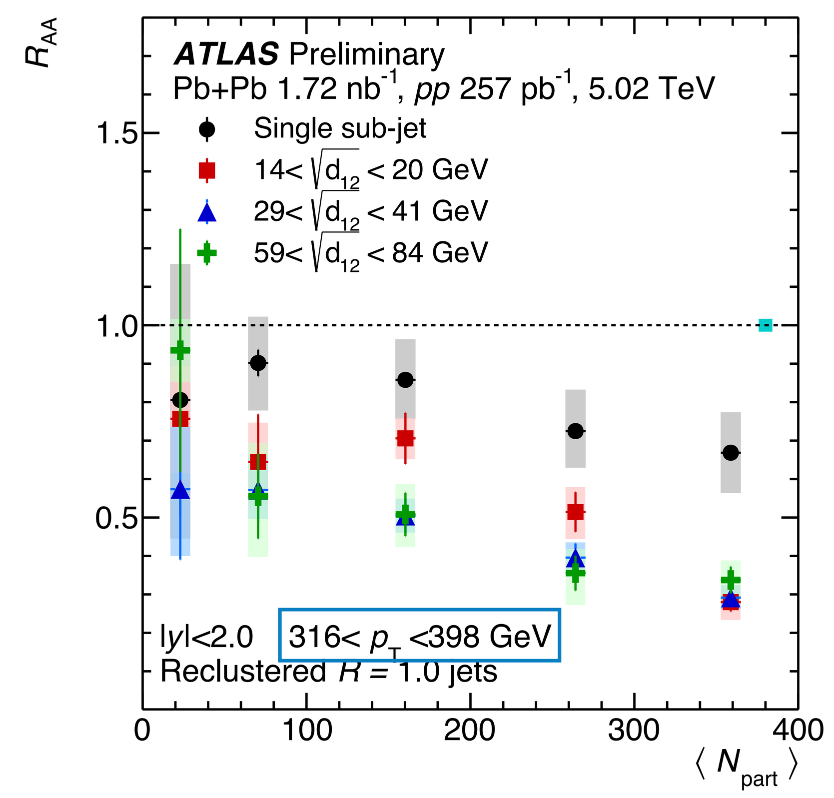




- R_{AA} drops significantly from single sub-jet (SSJ) to non-zero $\sqrt{d_{12}}$ (more complex substructure).

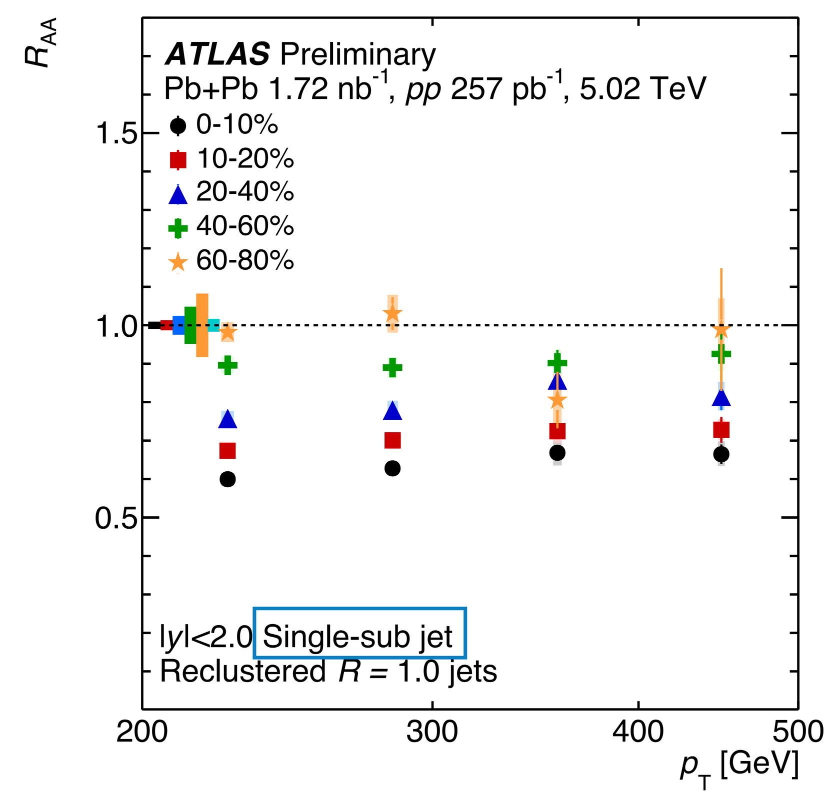
R_{AA} vs $\langle N_{\mathrm{part}}\rangle$

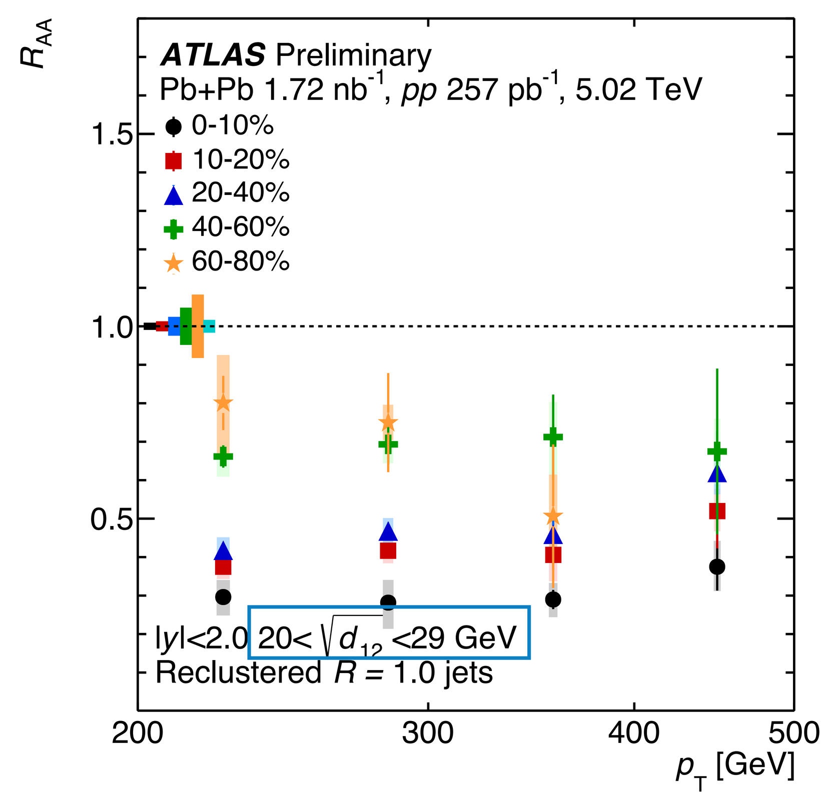




- R_{AA} decreases as $\langle N_{\mathrm{part}}\rangle$ increases (more central collisions).

R_{AA} vs jet p_{T}





- R_{AA} increases as jet p_{T} increases for $R = 1.0$ jets with a single sub-jet.

References and acknowledgements

[1] Y. Mehtar-Tani and K. Tywoniuk, Phys. Lett. B 744 (2015) 284.
[2] ATLAS Collaboration, ATLAS-CONF-2019-09 (2019).
[3] M. Cacciari, G. P. Salam and G. Soyez, Eur. Phys. J. C 72 (2012) 1896.
[4] ATLAS Collaboration, Phys. Lett. B 790 (2019) 108.

- This work was supported by the United States Department of Energy Grant DOE-FG02-86ER-40281