Measurement of suppression of large-radius jets and its dependence on substructure in Pb+Pb at 5.02 TeV with ATLAS

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Introduction

- Measurements of the suppression of the jet yield in Pb+Pb compared to *pp* provide insight on 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 its dependence on $\sqrt{d_{12}}$.

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

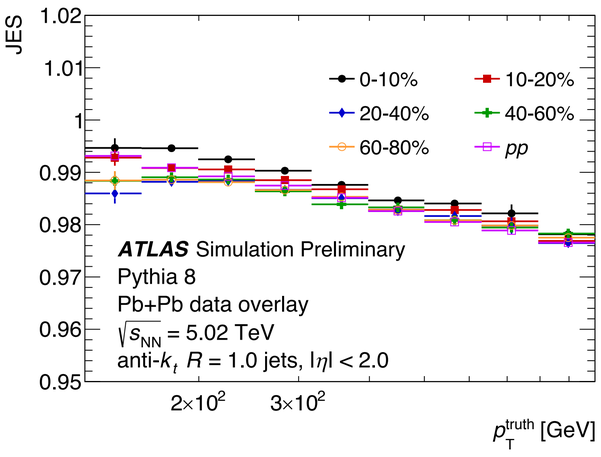
- $\sqrt{d_{12}}$ is evaluated from the last clustering step in the k_t jet finding algorithm, corresponding to the hardest splitting in the jet. It characterizes the jet substructure scale.

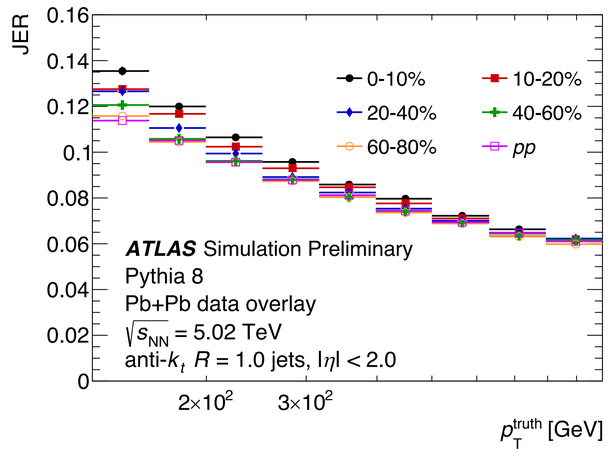
$$\sqrt{d_{12}} = \min(p_{\mathrm{T1}}, p_{\mathrm{T2}}) \cdot \Delta R_{12},\ \Delta R_{12} = \sqrt{\Delta\phi_{12}^2 + \Delta y_{12}^2}$$

- This measurement [2] is carried out with 2018 Pb+Pb (1.72 nb^{-1}) and 2017 *pp* (257 pb^{-1}) data, both recorded at the center-of-mass energy of 5.02 TeV.

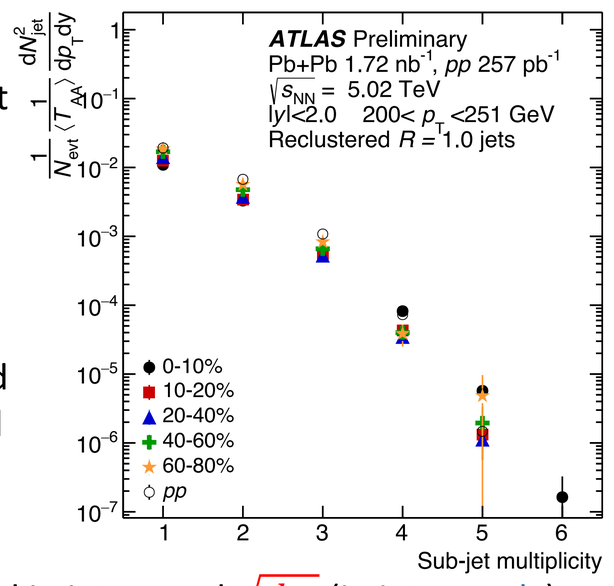
Jet reconstruction and analysis procedure

- The large-radius jets are reconstructed with anti-k_t $R = 1.0$ within $|y| < 2.0$, by re-clustering anti- k_t $R = 0.2$ jets [3] with $p_{\mathrm{T}} > 35$ GeV.





- This method suppresses the underlying events 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 sub-jet JER and combinatorial contributions from jets produced in other independent hard scatterings.

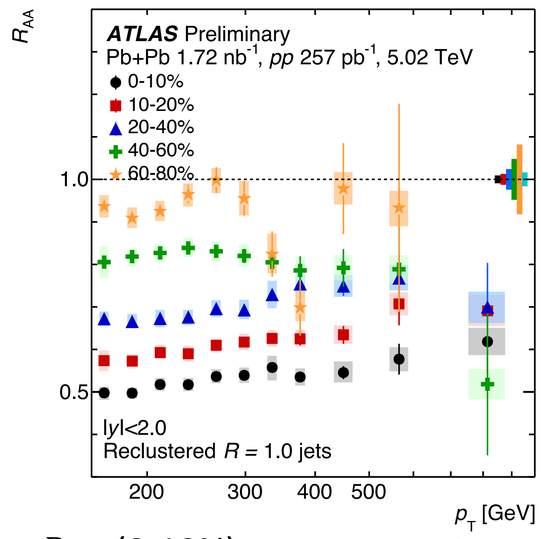


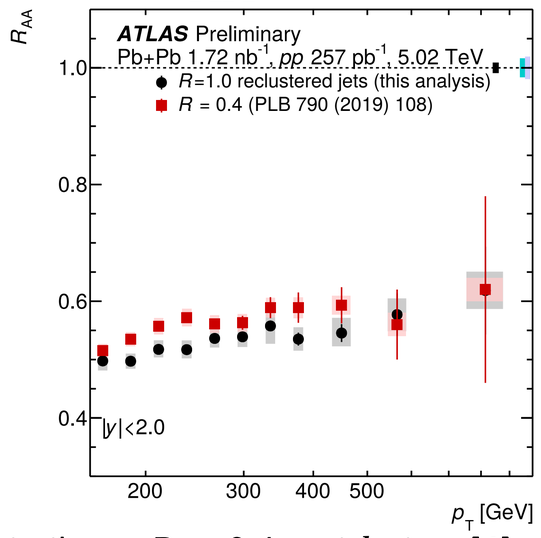
- 2D (1D) Bayesian unfolding is applied in jet p_{T} and $\sqrt{d_{12}}$ (in jet p_{T} only).
- The unfolding removes the effects of the jet energy resolution, residual jet energy scale non-closure, and the combinatorial contribution.

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 the R_{AA} ratio.
- Dominated by the jet energy scale term.

Result: inclusive R_{AA}

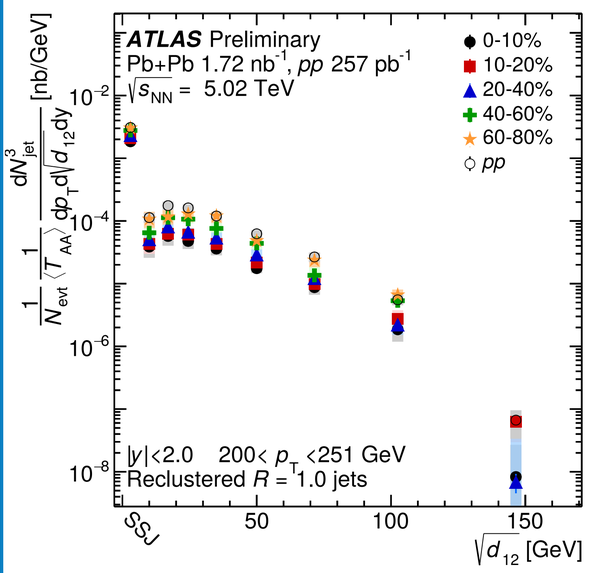


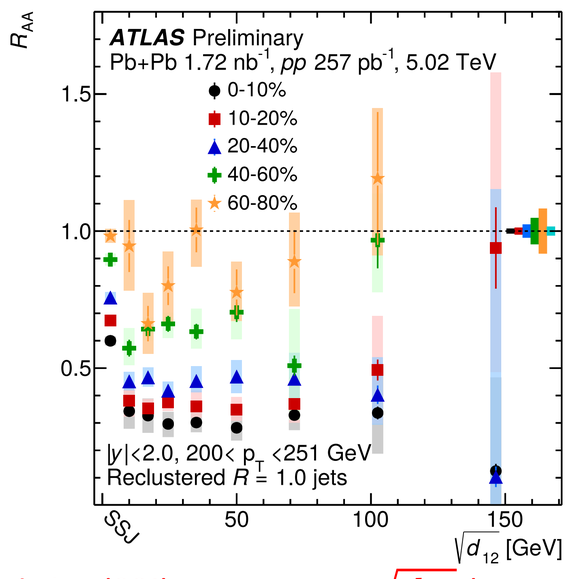


- R_{AA} (0-10%) measurement result is similar to $R = 0.4$ anti-k_t jets [4].
- Energy between $R = 0.2$ sub-jets is not recovered and this reduces R_{AA}.

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

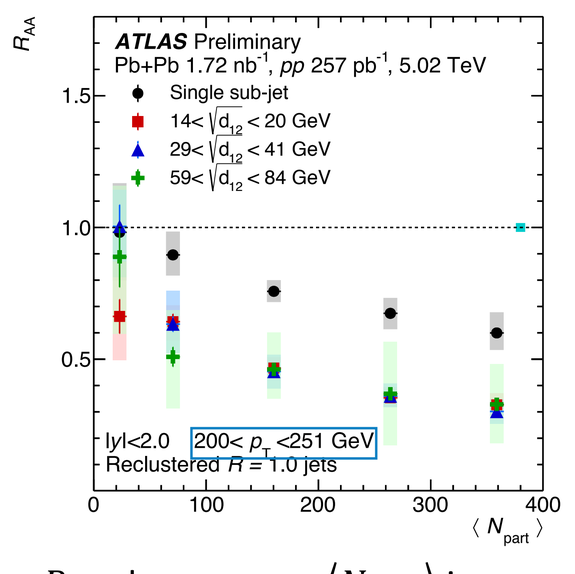
Yields and R_{AA} vs $\sqrt{d_{12}}$

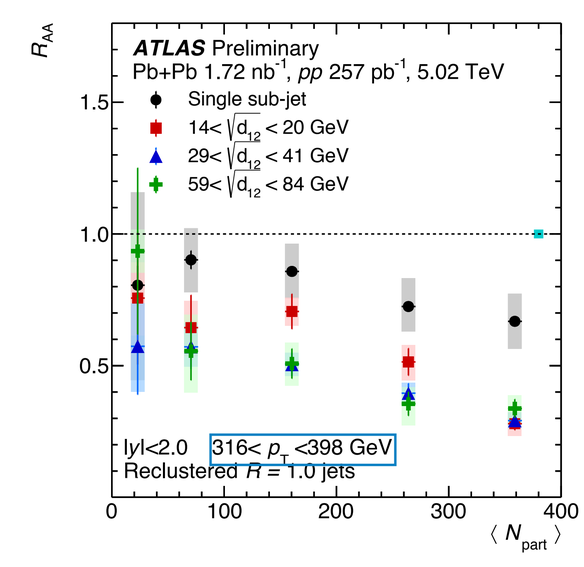




- R_{AA} drops significantly from single sub-jet (SSJ) to non-zero $\sqrt{d_{12}}$ (more complex substructure).

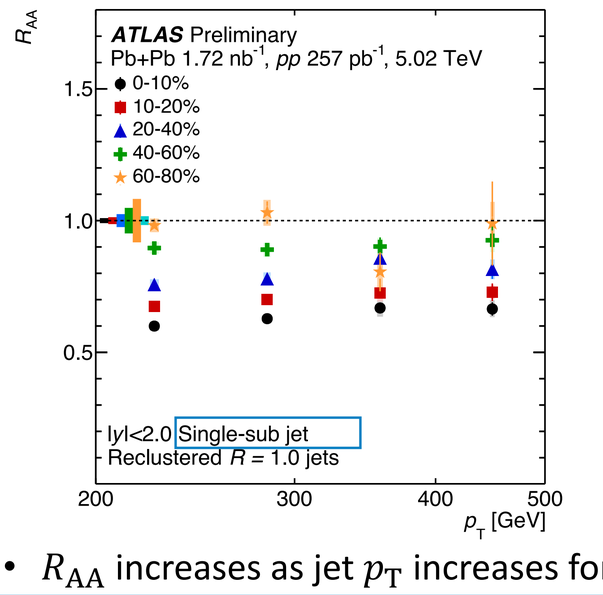
R_{AA} vs $\langle N_{\mathrm{part}} \rangle$

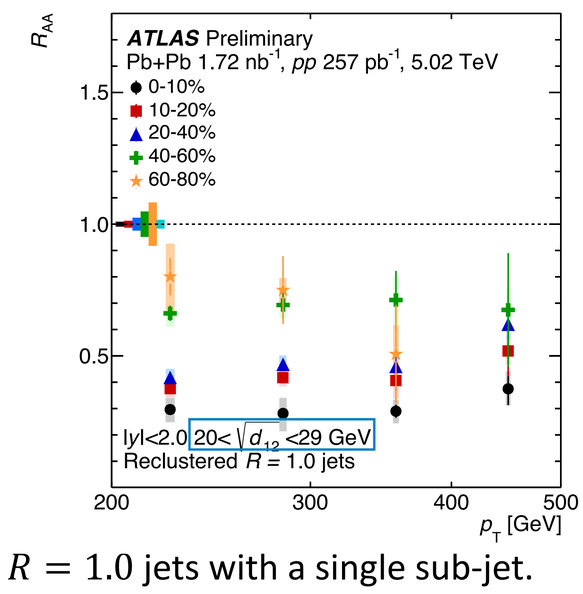




- R_{AA} decreases as $\langle N_{\mathrm{part}} \rangle$ increases (more central collisions).

R_{AA} vs jet p_{T}





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

Reference

[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.

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