

Investigation of initial state effects in $p+Pb$ collisions at ATLAS via measurement of the centrality dependence of the dijet yield



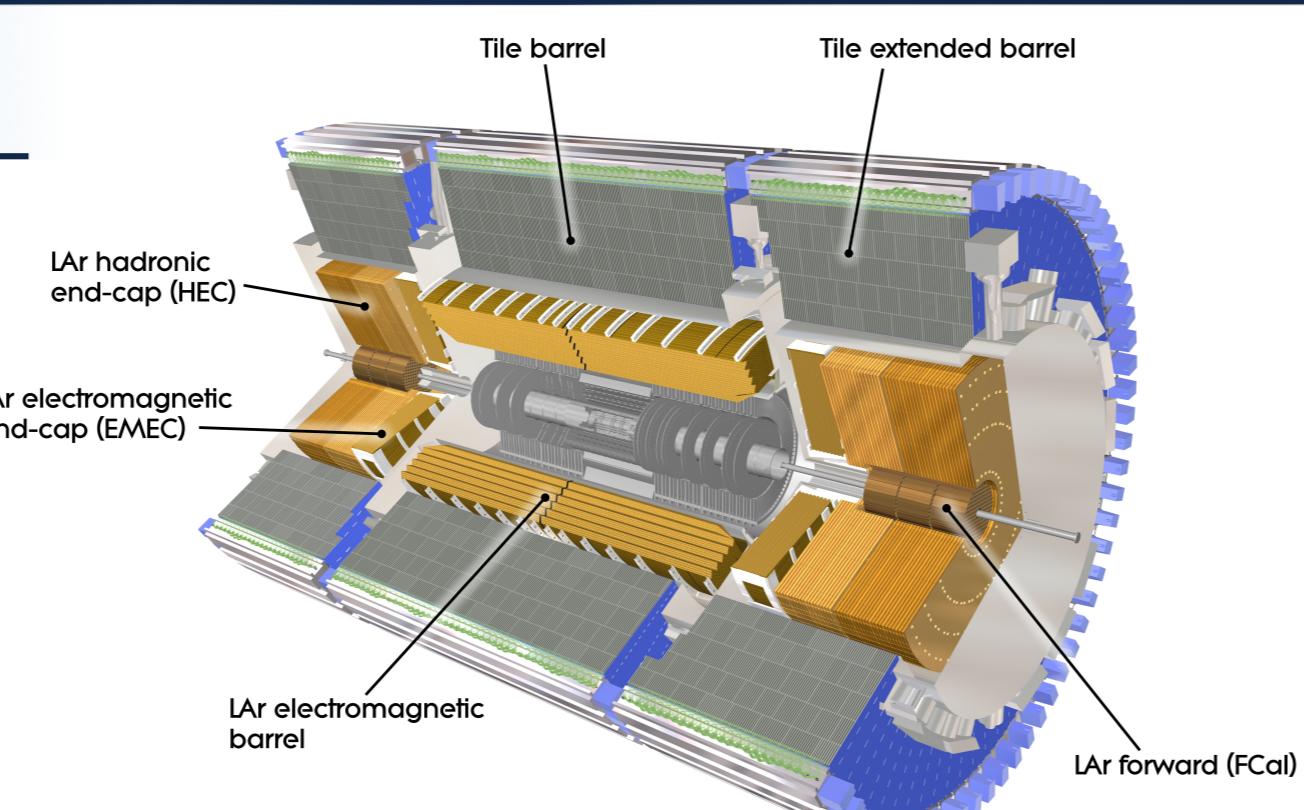
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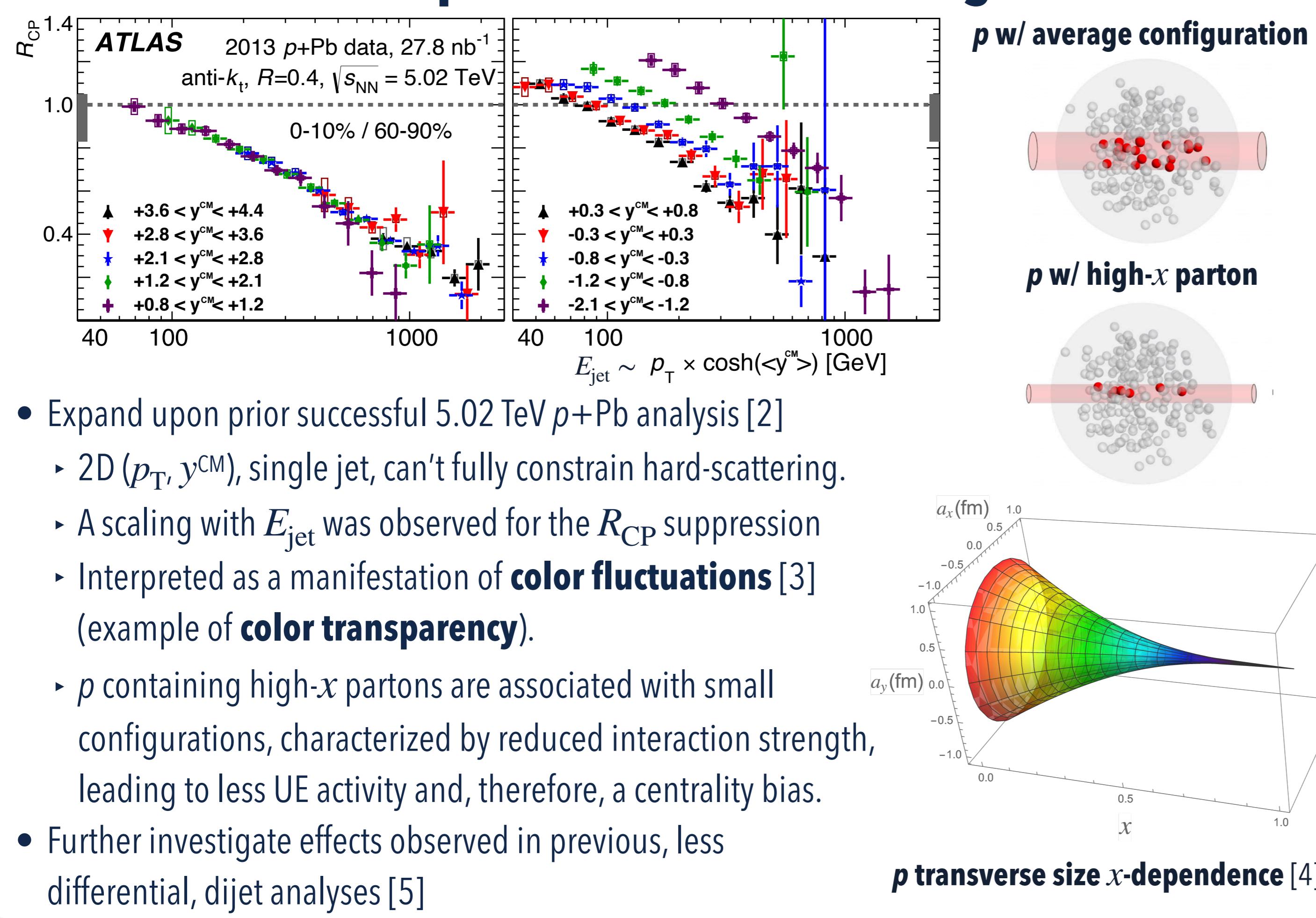


The ATLAS Calorimeter System

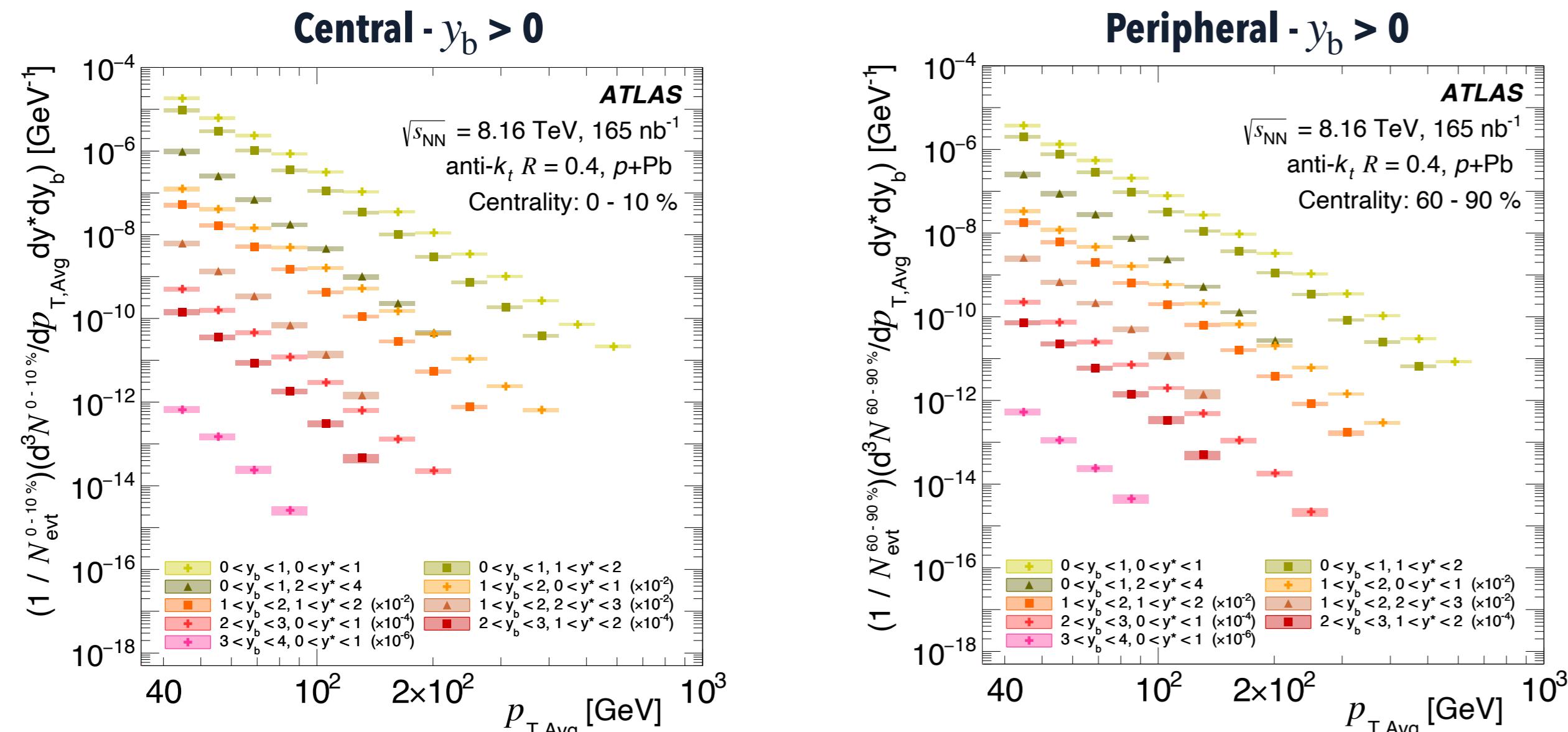
The ATLAS [1] calorimeter system consists of a liquid-argon (LAr) electromagnetic calorimeter, a steel sampling hadronic calorimeter, a LAr hadronic end-cap calorimeter, and two LAr forward calorimeters. The entire system has coverage out to $|\eta| < 4.9$.



Motivation: is the proton's size fluctuating?



Triple Differential Per-Event Dijet Yield

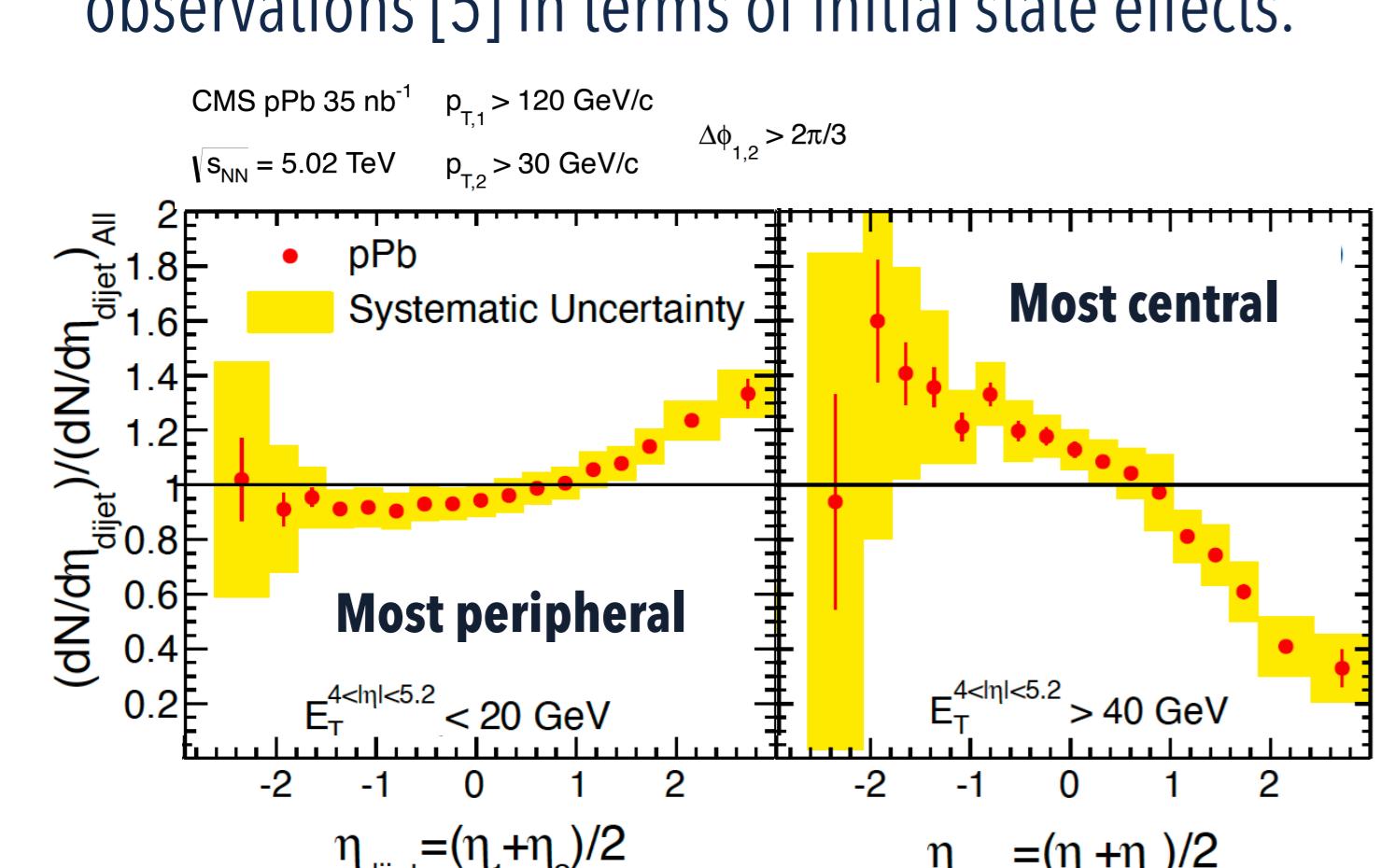


Central-to-Peripheral Ratio, R_{CP}

The central-to-peripheral ratio of the per-event dijet yield is constructed to study the centrality dependence of dijet production in $p+Pb$ collisions.

$$R_{\text{CP}}(p_{T,\text{Avg}}, y_b, y^*) = \frac{\frac{1}{(T_{\text{AB}})} \frac{1}{N_{\text{evt}}} \frac{d^3N_{0-10\%}^{0-10\%}}{dp_{T,\text{Avg}} dy_b dy^*}}{\frac{1}{(T_{\text{AB}})} \frac{1}{N_{\text{evt}}} \frac{d^3N_{60-90\%}^{60-90\%}}{dp_{T,\text{Avg}} dy_b dy^*}}$$

- Increased suppression for dijets characterized by larger forward boost and by scatterings at higher hard-scale $p_{T,\text{Avg}}$.
- Allows for recasting previous CMS observations [5] in terms of initial state effects.



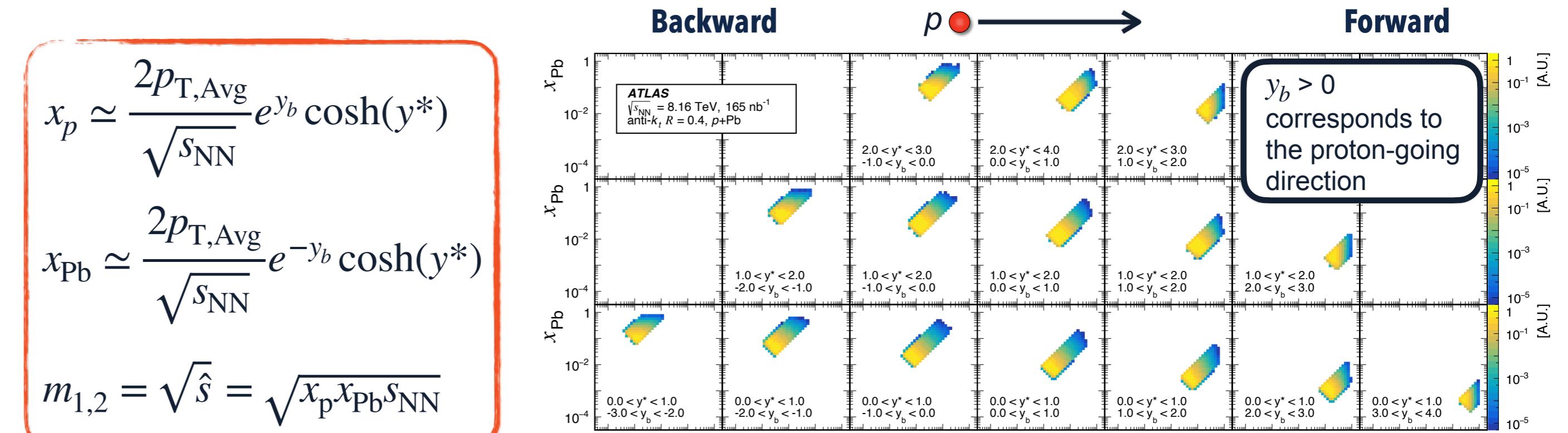
Details of the Measurement

- Measurement uses anti- k_t $R = 0.4$ jets at $\sqrt{s_{\text{NN}}} = 8.16 \text{ TeV}$ in $p+Pb$ collisions with 165 nb^{-1} of $p+Pb$ data collected in 2016.

$$p_{T,1} > 40 \text{ GeV}, \quad p_{T,2} > 30 \text{ GeV}, \quad \text{and} \quad -2.8 < \eta < 4.5$$

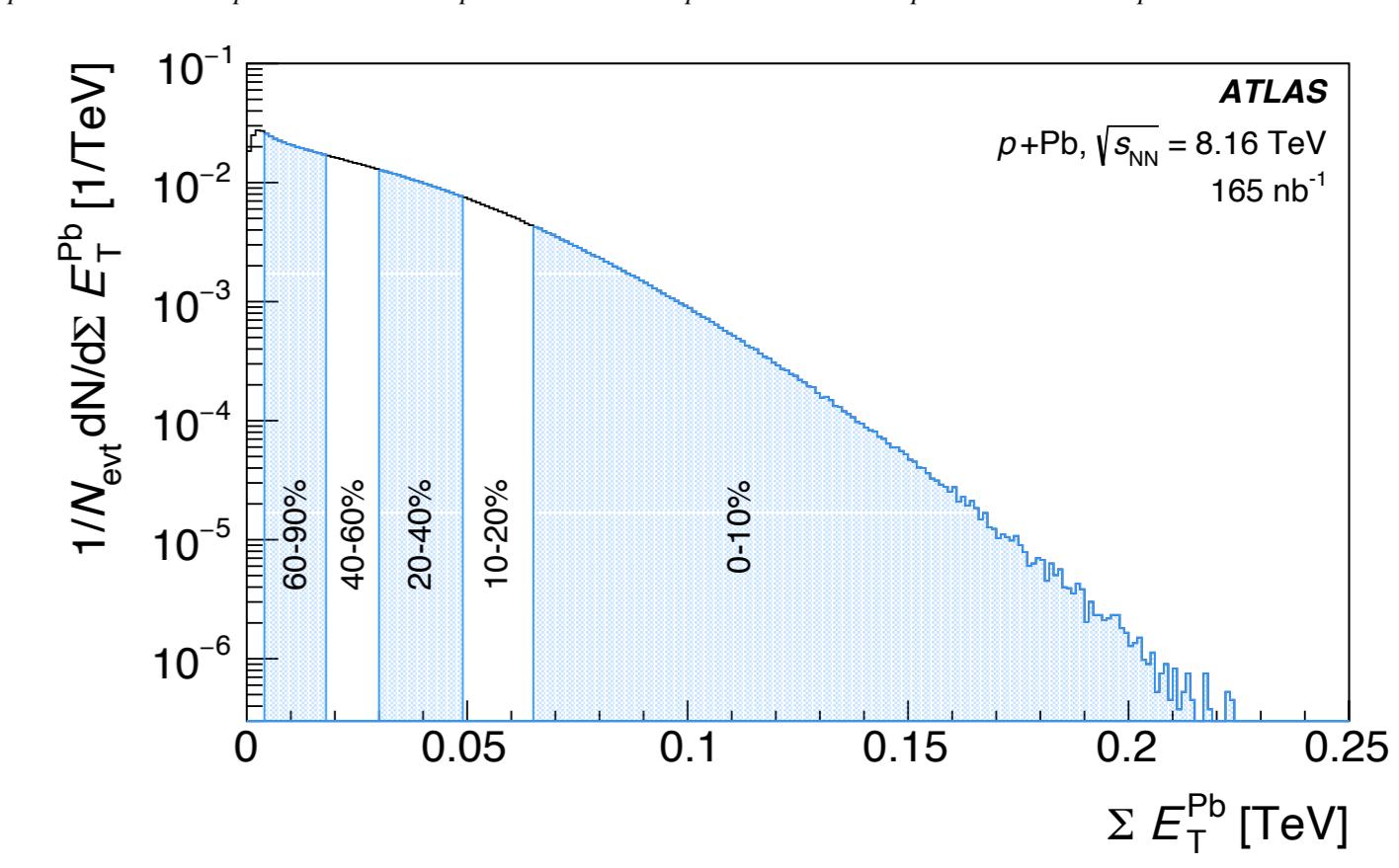
- Chosen kinematic variables allow for full characterization of the partonic scattering system:

$$p_{T,\text{Avg}} = \frac{p_{T,1} + p_{T,2}}{2}, \quad y_b = \frac{y_1^{\text{CM}} + y_2^{\text{CM}}}{2}, \quad \text{and} \quad y^* = \frac{|y_1^{\text{CM}} - y_2^{\text{CM}}|}{2}$$



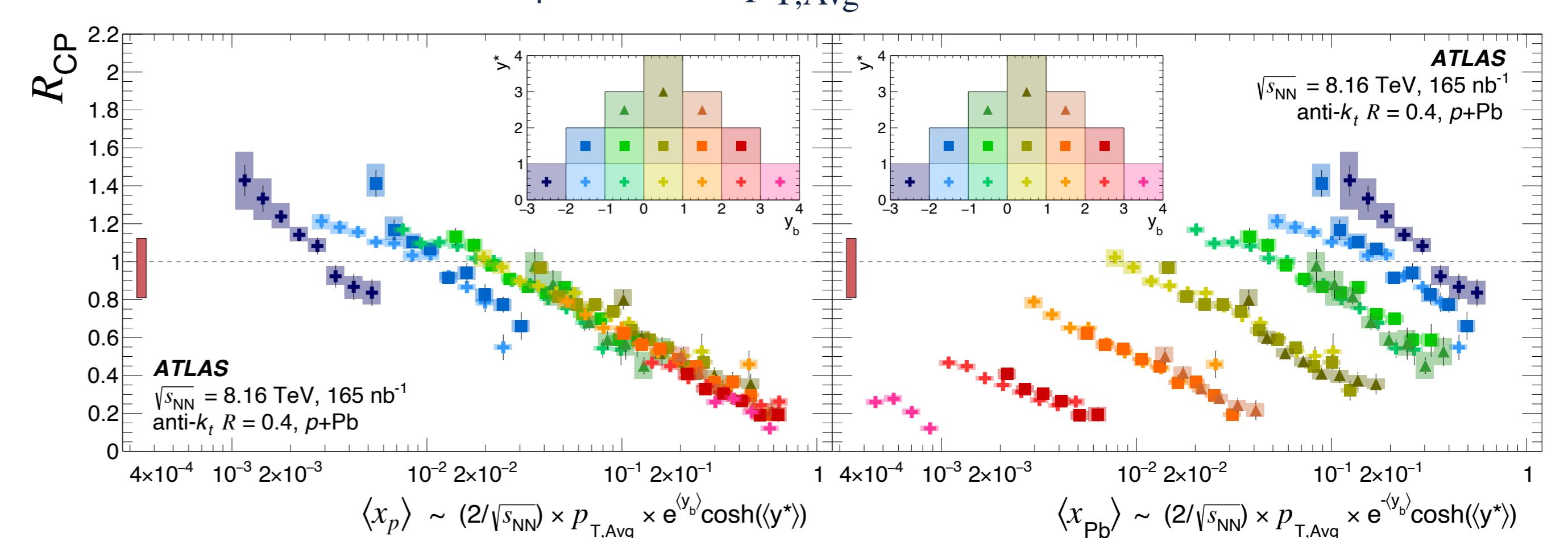
- 1D bayesian unfolding in $p_{T,\text{Avg}}$ + efficiency correction for any residual y_b or y^* migration.
- Centrality intervals are defined by the total transverse energy in the Pb-going FCal, ΣE_T^{Pb} .

$$\text{Centrality-Binned Triple Differential Per-Event Dijet Yield} = \frac{1}{N_{\text{evt}}} \frac{d^3N_{\text{dijet}}}{dp_{T,\text{Avg}} dy_b dy^*}$$



R_{CP} vs Hard Scattering Kinematics

The parton-level kinematics can be approximated by using the average value of y_b and y^* in each kinematic bin, and the midpoint of each $p_{T,\text{Avg}}$ bin.



- Strong **log-linear x_p -scaling** observed when moving toward the **proton's valence dominance region**. This trend breaks down when approaching low- x_p (\leftrightarrow high x_{Pb}).
- No monotonic scaling observed as a function of decreasing x_{Pb} , suggesting gluon saturation is not the dominant source of the effect.

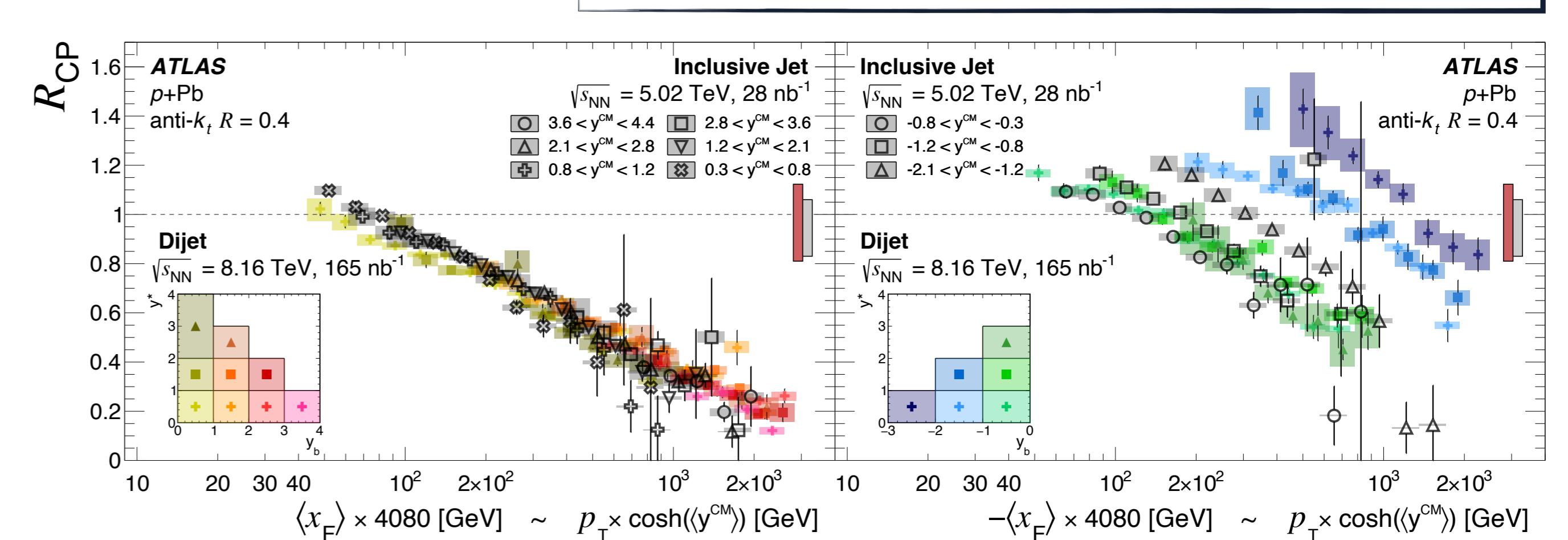
Direct link to 5.02 TeV inclusive jet results [2] achievable thanks to Feynman- x (x_F) variable

$$x_p - x_{\text{Pb}} = x_F = \frac{2p_z}{\sqrt{s_{\text{NN}}}}$$

Initial state definition Final state definition

$$\sim \pm \frac{2p_T \times \cosh y^{\text{CM}}}{\sqrt{s_{\text{NN}}}} \rightarrow \pm \frac{\sqrt{s_{\text{NN}}}}{2} \times x_F \sim p_T \times \cosh y^{\text{CM}}$$

Assuming $m_T = \sqrt{m^2 + p_T^2} \sim p_T$ $\sinh y^{\text{CM}} \sim \pm \cosh y^{\text{CM}}$ if $|y^{\text{CM}}| \gg 0$



- **Striking agreement between dijet and inclusive jet results** for positive y_b and y^{CM} .
- Demonstration that the physics mechanism responsible for the R_{CP} suppression in this kinematic region is the same in the two analyses, and the **scaling behavior** observed at 5.02 TeV with the jet energy is **effectively governed by the proton configuration in the initial state**.
- Agreement progressively worsens at negative y_b and y^{CM} , corresponding to average proton configurations and to the high- x region for the parton originating from the Pb nucleus.
- New fundamental input to **parameterize color fluctuation effects in p+A collisions**.