Jet radius dependence of dijet momentum balance and suppression in Pb+Pb collisions at 5.02 TeV with the ATLAS detector

Anabel Romero, for the ATLAS Collaboration

Department of Physics, College of Engineering, University of Illinois at Urbana-Champaign

arXiv:2407.18796

MOTIVATION

Relativistic heavy ion collisions produce a high density and high temperature state of matter known as the quark gluon plasma (QGP).

Hard scattered partons create collimated sprays of particles, called jets, that can be measured in particle collisions.

Pairs of back-to-back jets are produced within the QGP and lose energy while traversing it.

Jet energy loss can be studied by measuring the ratio of the subleading (second most energetic) to leading (most energetic) jet transverse momentum (p_T):

$$x_J \equiv p_{T,2}/p_{T,1}$$

The absolutely normalized x_J distributions can be measured in Pb+Pb and pp collisions as:

$$\frac{1}{\langle T_{AA}\rangle N_{evt}^{AA}}\frac{dN_{pair}^{AA}}{dx_J} \qquad \frac{1}{L_{pp}}\frac{dN_{pair}^{pp}}{dx_J}$$

To quantify the differences between Pb+Pb and pp, J_{AA} is defined as:

$$J_{AA} \equiv \frac{\frac{1}{\langle T_{AA}\rangle N_{evt}^{AA}}\frac{dN_{pair}^{AA}}{dx_J}}{\frac{1}{L_{pp}}\frac{dN_{pair}^{pp}}{dx_J}}$$

A jet radius dependent dijet measurement allows for a study of jet energy loss in the QGP.

The pair nuclear modification factors R_{AA}^{pair} are defined for leading and subleading jets as:

$$R_{AA}^{pair}(p_{T,1}) = \frac{\frac{1}{\langle T_{AA}\rangle N_{evt}^{AA}}\int_{0.32\times p_{T,1}}^{p_{T,1}}\frac{d^2N_{pair}^{AA}}{dp_{T,1}dp_{T,2}}dp_{T,2}}{\frac{1}{L_{pp}}\int_{0.32\times p_{T,1}}^{p_{T,1}}\frac{d^2N_{pair}^{pp}}{dp_{T,1}dp_{T,2}}dp_{T,2}}$$

$$R_{AA}^{pair}(p_{T,2}) = \frac{\frac{1}{\langle T_{AA}\rangle N_{evt}^{AA}}\int_{p_{T,2}}^{p_{T,2}/0.32}\frac{d^2N_{pair}^{AA}}{dp_{T,1}dp_{T,2}}dp_{T,1}}{\frac{1}{L_{pp}}\int_{p_{T,2}}^{p_{T,2}/0.32}\frac{d^2N_{pair}^{pp}}{dp_{T,1}dp_{T,2}}dp_{T,1}}$$

ANALYSIS

Data:
$1.72\ nb^{-1}$ of Pb+Pb data and $255\ pb^{-1}$ of pp data, both at $\sqrt{s_{NN}} = 5.02$ TeV.

Event selection:

- Dijets of jet radius R = 0.2, 0.3, 0.4, 0.5, 0.6 with $\Delta\Phi > 7\pi/8$ and $|y| < 2.1$.
- For R = 0.2, 0.3, 0.4, $p_{T1} > 100$ GeV and $p_{T2} > 32$ GeV.
- For R = 0.5, $p_{T1} > 158$ GeV and $p_{T2} > 41$ GeV.
- For R = 0.6, $p_{T1} > 158$ GeV and $p_{T2} > 51$ GeV.

Procedure:

- Measured p_{T1}-p_{T2} distributions of leading and subleading jets.
- Applied combinatoric dijet subtraction and efficiency correction.
- Unfolded on leading and subleading jet p_T.
- Projected unfolded p_{T1}-p_{T2} distributions into x_J distributions.

SYSTEMATIC UNCERTAINTIES

Jet related:

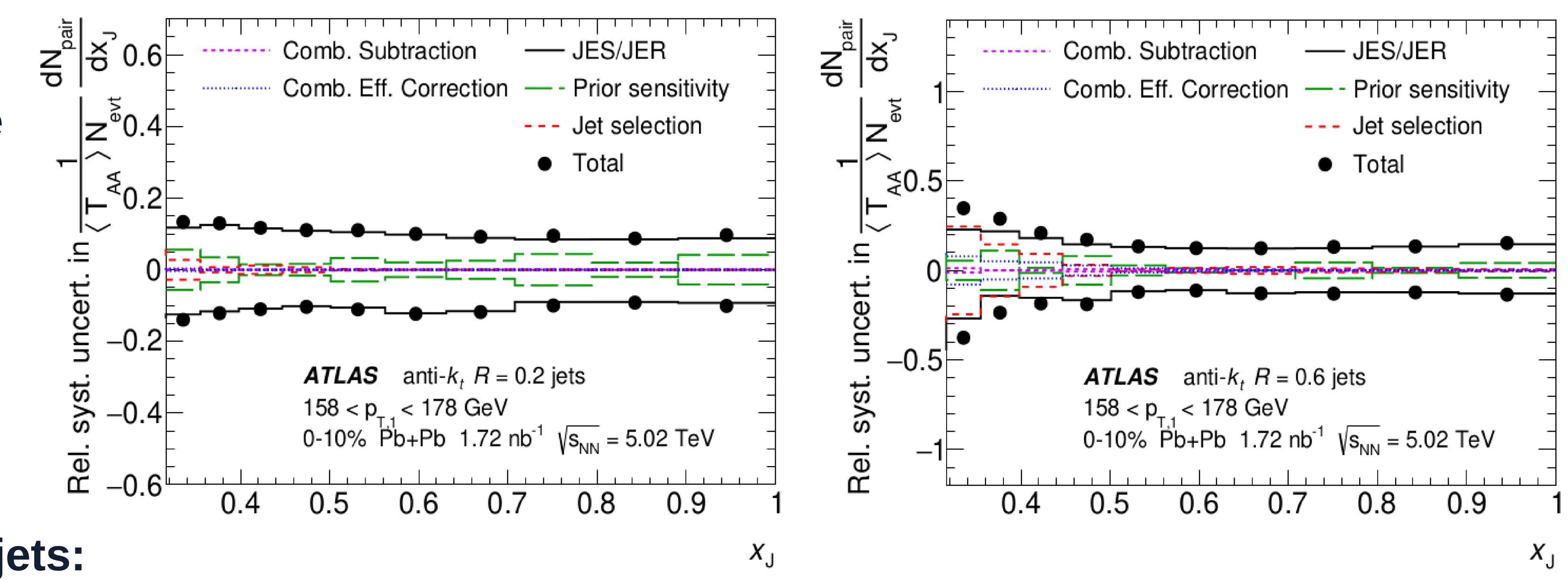
- Jet energy scale and jet energy resolution.

Unfolding:

- Prior sensitivity.
- Jet selection.

Combinatoric dijets:

- Subtraction.
- Efficiency correction.

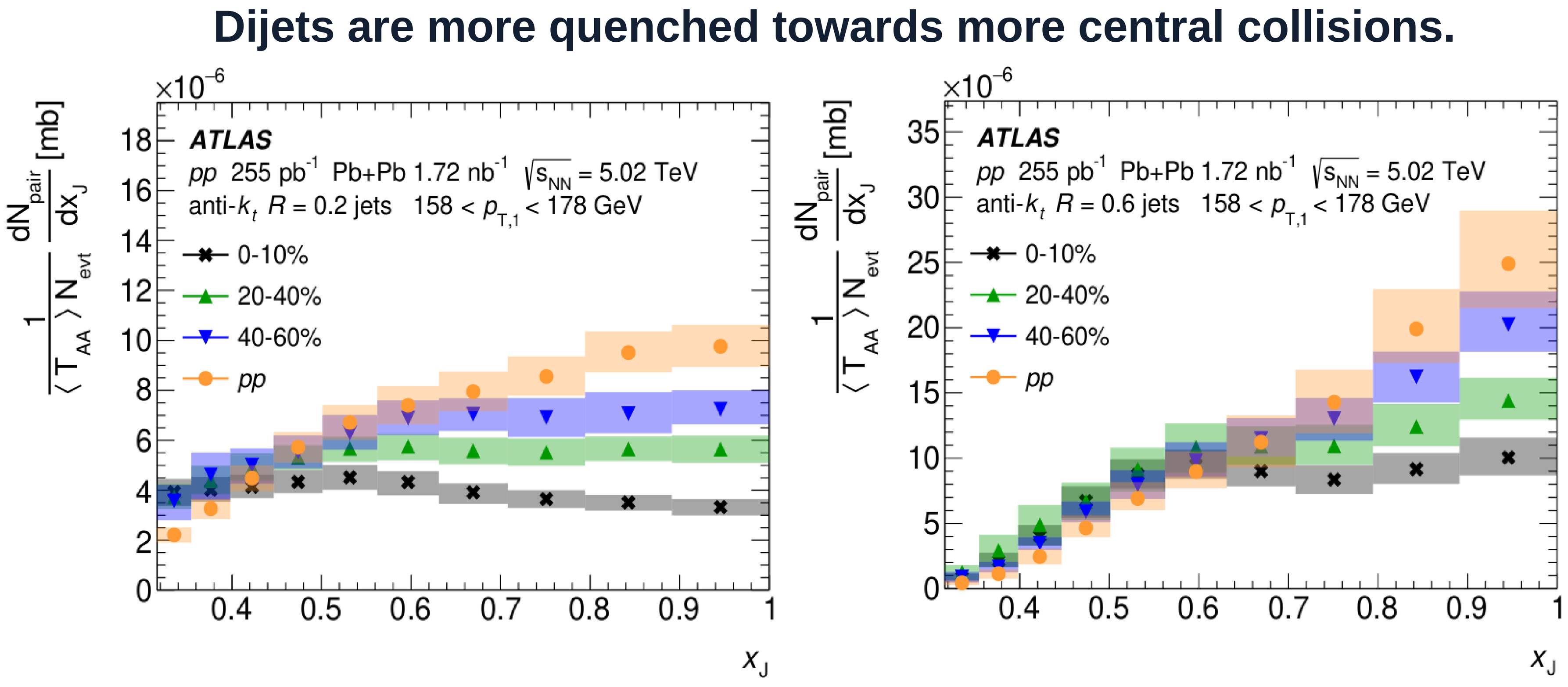


Relative systematic uncertainties in the absolutely normalized x_J distributions for R=0.2 (left) and R=0.6 (right) jets in central Pb+Pb collisions.

RESULTS AND CONCLUSIONS

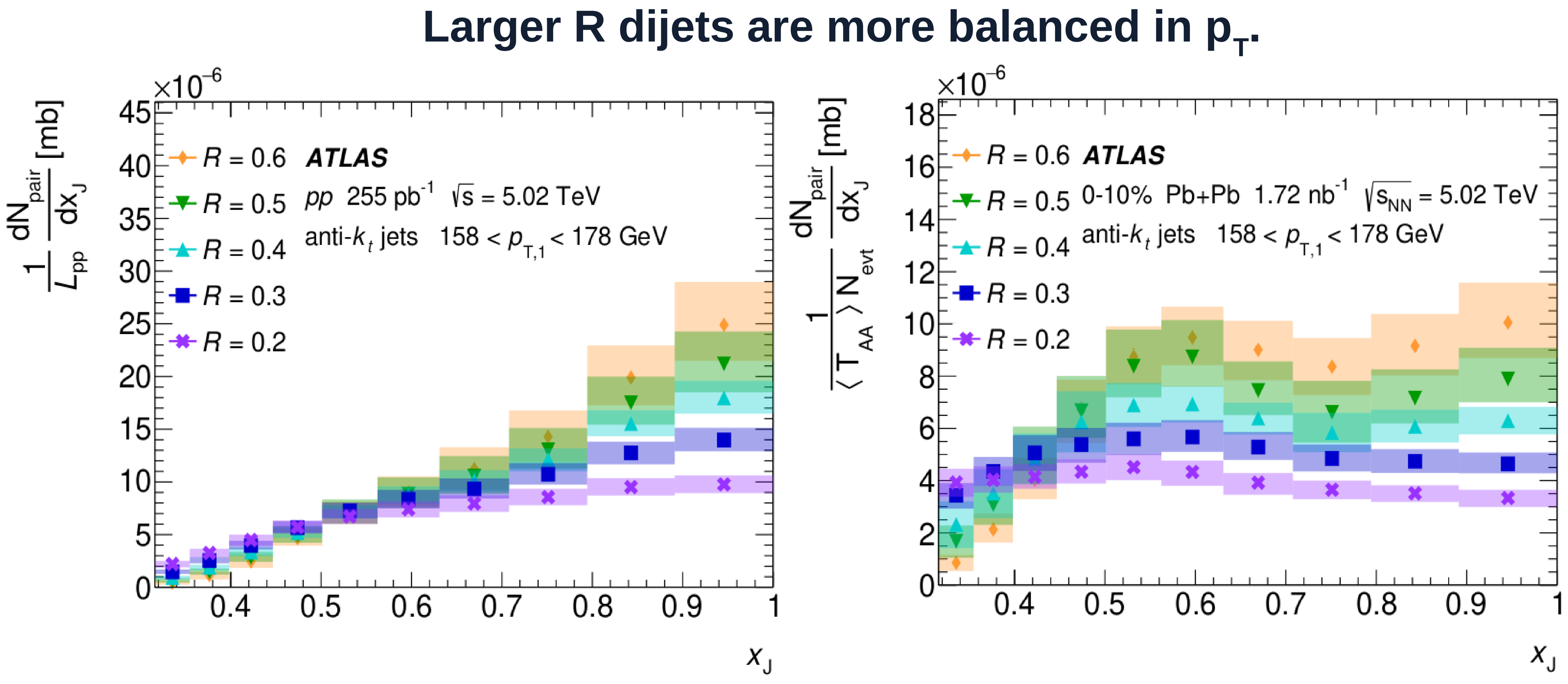
Studied dijets of R = 0.2, 0.3, 0.4, 0.5, 0.6 with p_T ranging from 100 to 562 GeV in Pb+Pb and pp collisions at $\sqrt{s_{NN}}$ =5.02 TeV.

Dijets are more quenched towards more central collisions.

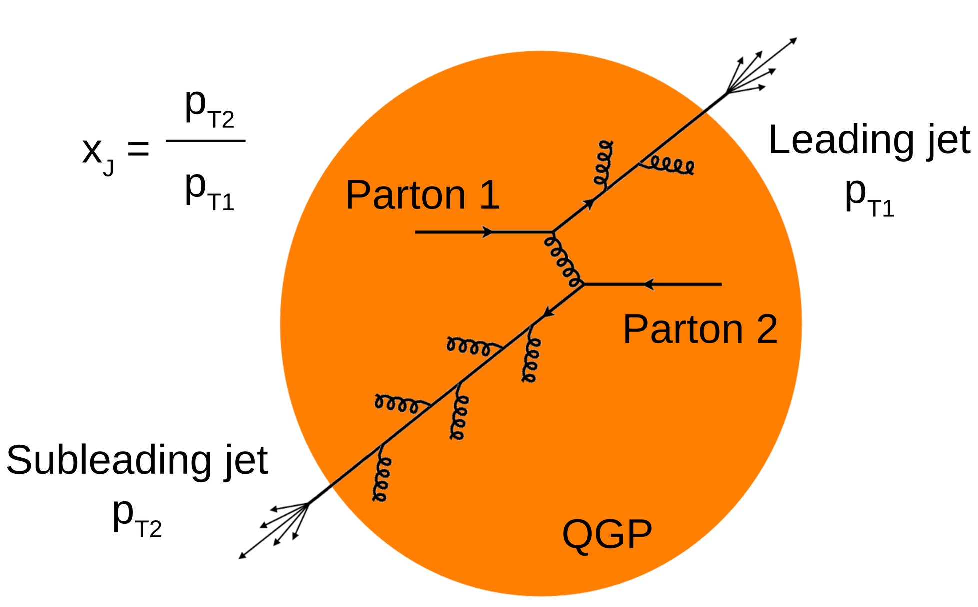


x_J distributions for R=0.2 (left) and R=0.6 (right) jets.

Larger R dijets are more balanced in p_T.

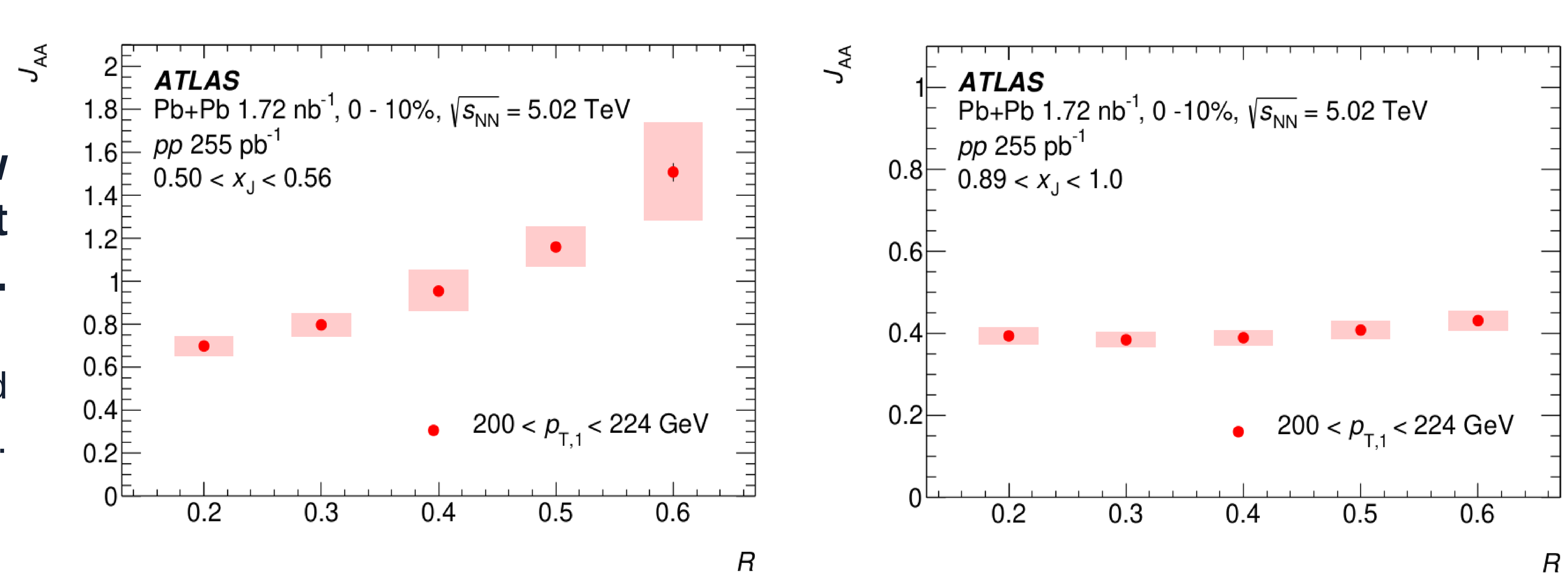


x_J distributions for various jet radii in pp (left) and central Pb+Pb (right) collisions.

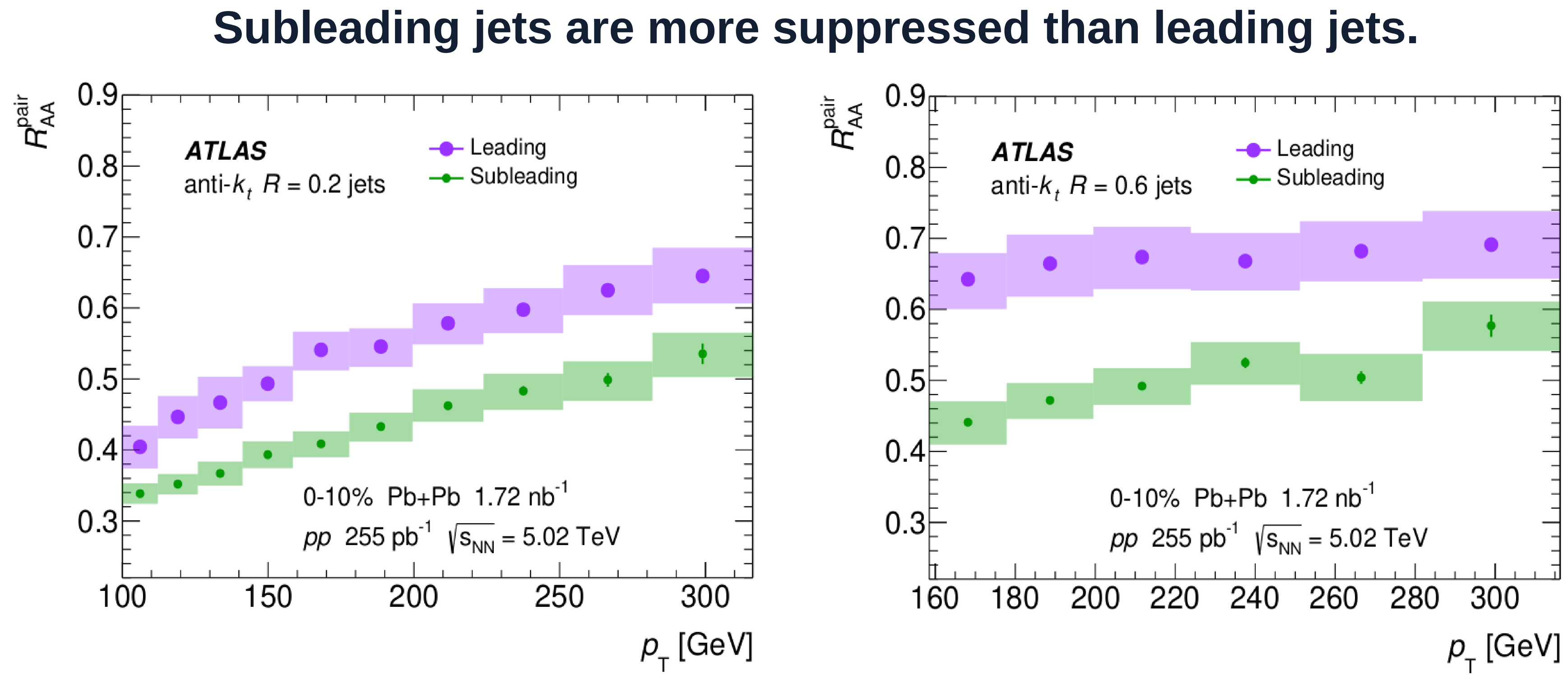


Imbalanced dijets show more dependence on the jet radius than balanced dijets.

J_{AA} vs. R for imbalanced (left) and balanced (right) dijets in central Pb+Pb collisions.

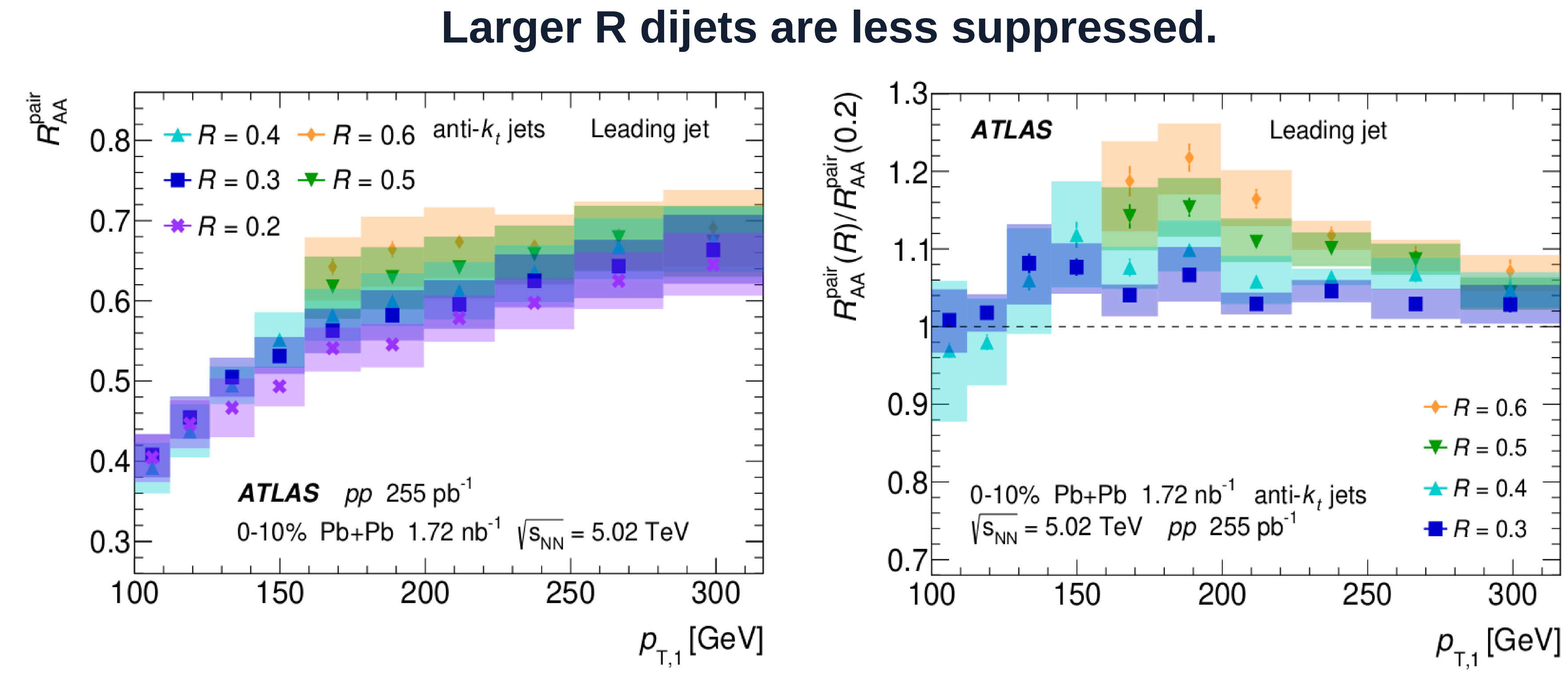


Subleading jets are more suppressed than leading jets.



Leading and subleading jet R_{AA}^{pair} for R=0.2 (left) and R=0.6 (right) jets in central Pb+Pb collisions.

Larger R dijets are less suppressed.



R_{AA}^{pair} vs. p_{T1} for leading jets of various jet radii in central Pb+Pb collisions.

R/0.2 ratios of R_{AA}^{pair} vs. p_{T1} for leading jets of various jet radii in central Pb+Pb collisions.