Jet Quenching and Medium response using γ + jet events

HP2024
NAGASAKI

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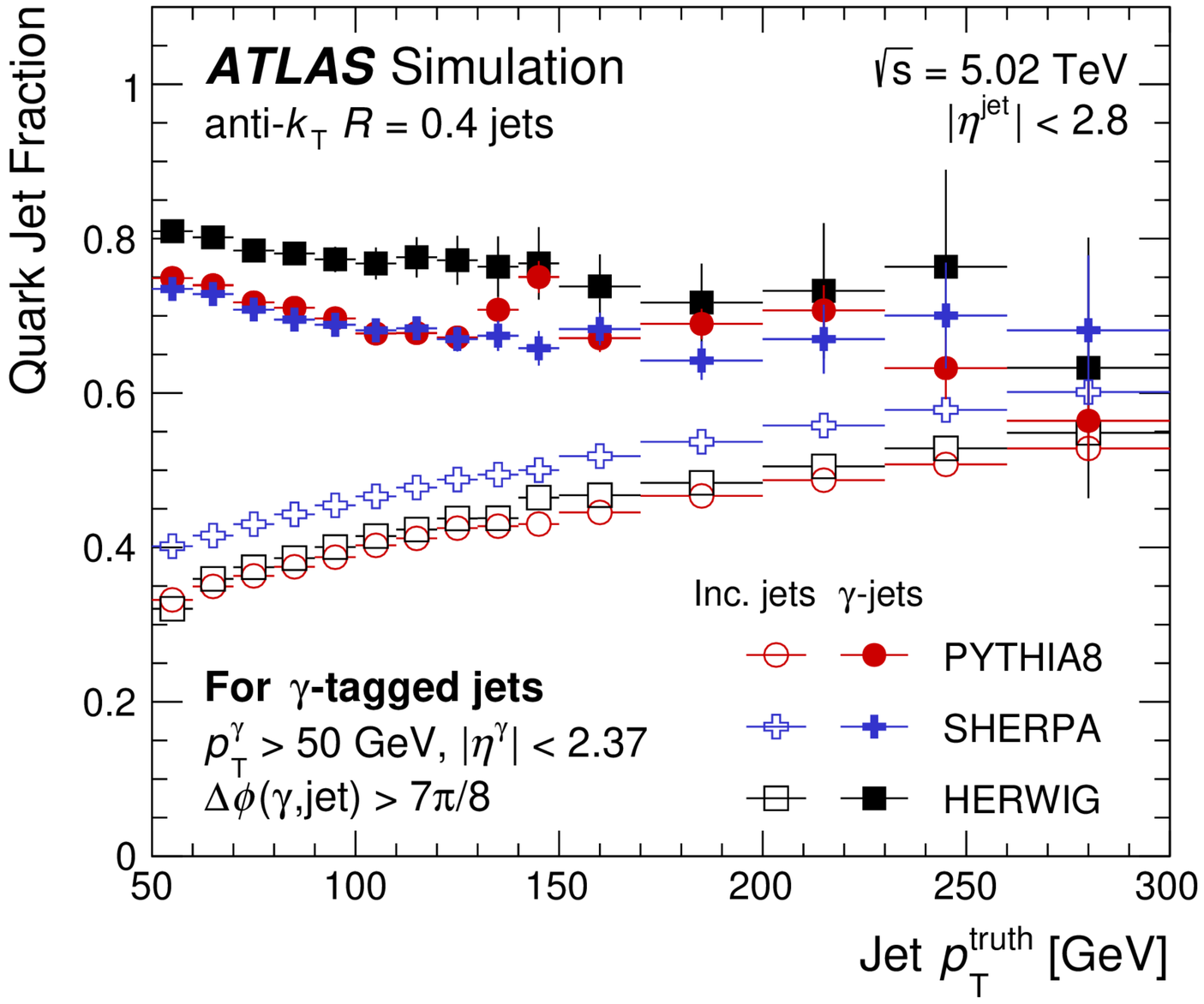
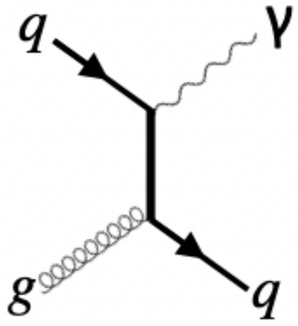
*on behalf of the **ATLAS collaboration***
25/09/2024

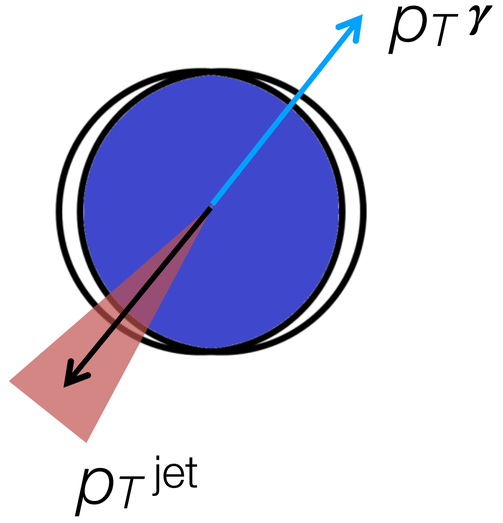
Probing flavour dependence of energy loss with γ-tagged jets

Phys. Lett. B 846 (2023) 138154



Photon-tagged jets → sample dominated by ***quark-initiated jets***
(quark gluon Compton scattering)



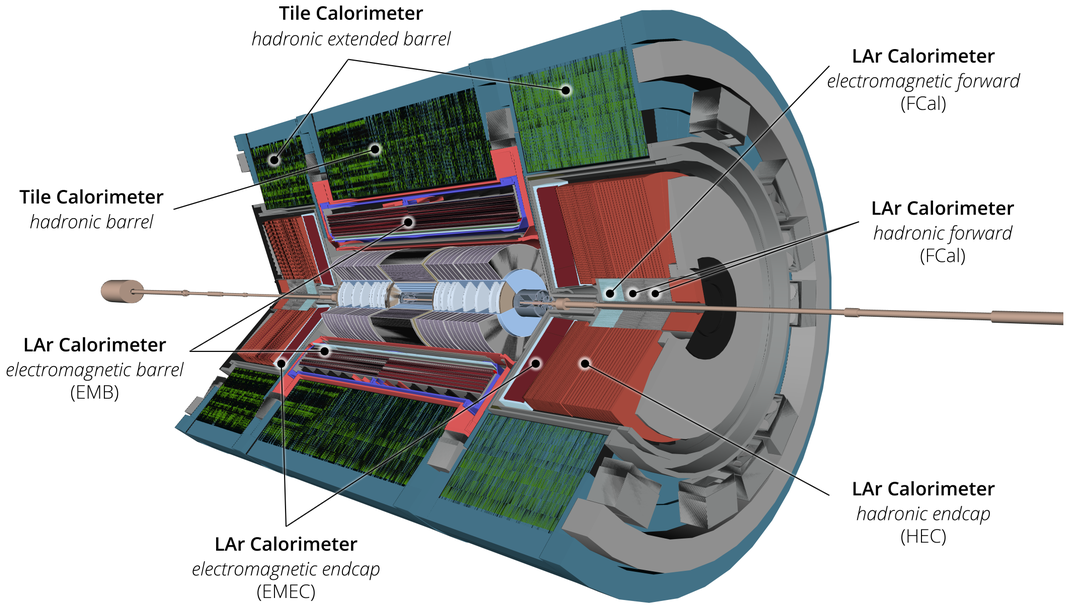


Measurement procedure

ATLAS detector

(objects like jets and γ mosty reconstructed in calorimeters but other components obviously used as well)

JINST 19 (2024) P05063



Jets: **UE subtracted towers** built from EM + HAD calorimeters

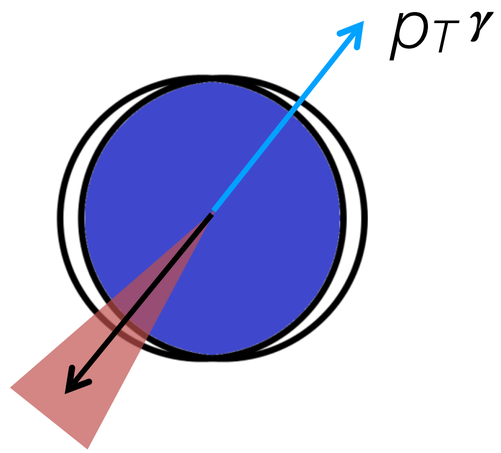
Photons: **UE subtracted cels** of EM calorimeter

Data sets

pp 260 pb^{-1} (2017)

Pb+Pb 1.7 nb^{-1} (2018)

Objects selection



Photons:

$p_T{}^{\gamma} > 50$ GeV

$|\eta| < 1.37$ || $1.52 < |\eta| < 2.37$

Shower shape

Isolation

Jets:

AntiKt R=0.4

$p_T{}^{\text{jet}} > 50$ GeV

$|\eta| < 2.8$

$\Delta\phi\,(\gamma,\text{jet}) > 7\pi/8$

Measurement procedure

Analysis steps

Construct raw distributions

Subtract mixed event
(Subtract combinatoric contribution by correlating signal photons to jets in minimum bias events; Pb+Pb only)

Purity correction
(Subtract jets correlated with non-signal γ)

Unfold for detector effects
(2D unfolding of jet and γ p_T with efficiency and fake corrections)

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(2D unfolding of jet and γ p_T with efficiency and fake corrections)

Uncertainties

Jets (3-8%)
(Energy scale & resolution; combinatoric background jet subtraction)

Photons (4-15%)
(Energy scale & resolution; data/MC shower shape difference; purity; isolation condition)

Unfolding (1-5%)
(Sensitivity to the prior, MC statistics)

Global uncertainties (2-4%)
(T_{AA} and luminosity)

γ-tagged jet spectra and R_{AA}

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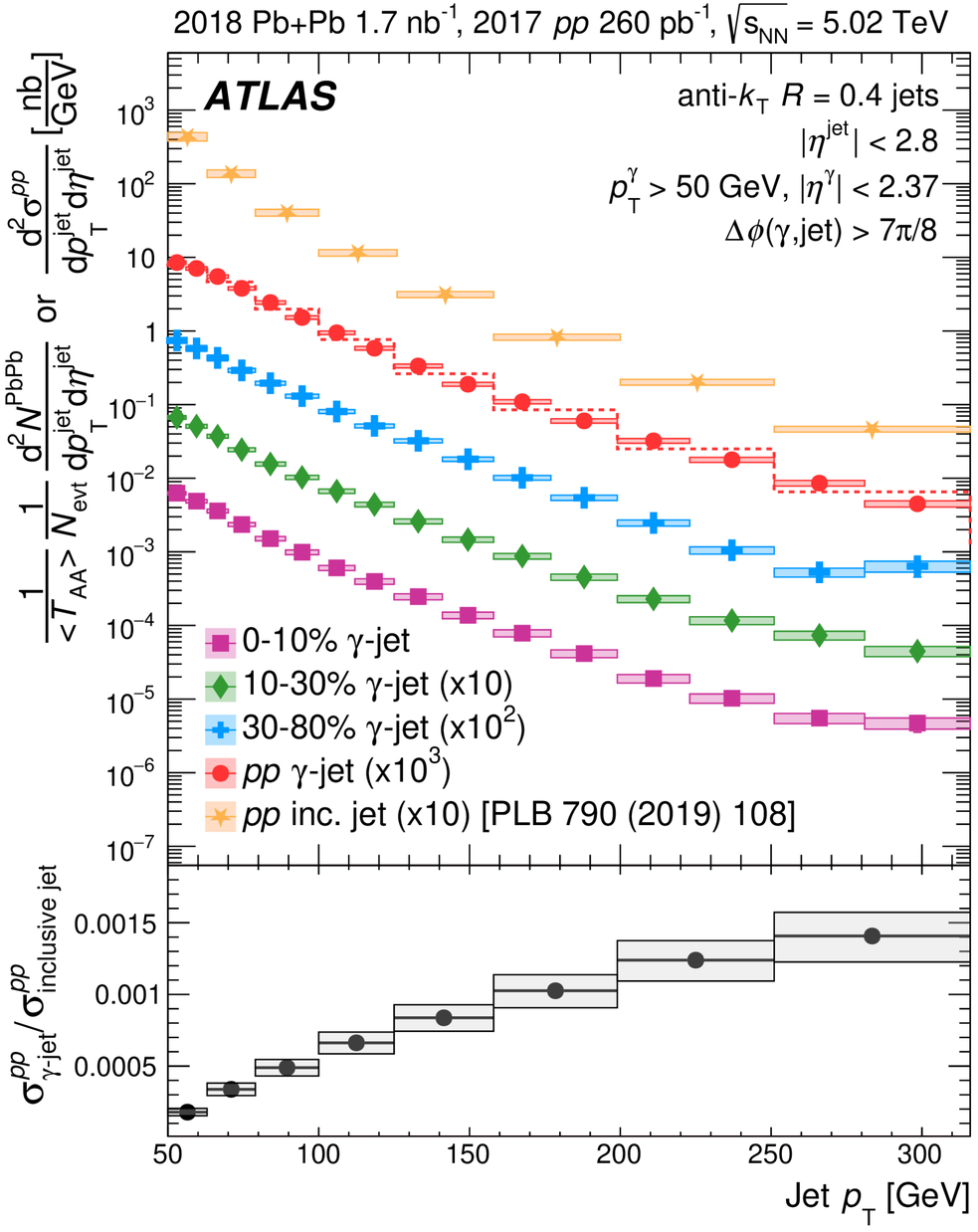

- $\langle T_{AA}\rangle$ normalised γ-tagged jet yields in different centrality bins in Pb+Pb and differential cross section in pp collisions
- ***σ(γ-jet)*** in pp collisions has a less steep spectrum than ***σ(inclusive-jet)***
  - ➡ Must be considered in comparisons between two samples

γ-tagged jet spectra and R_{AA}

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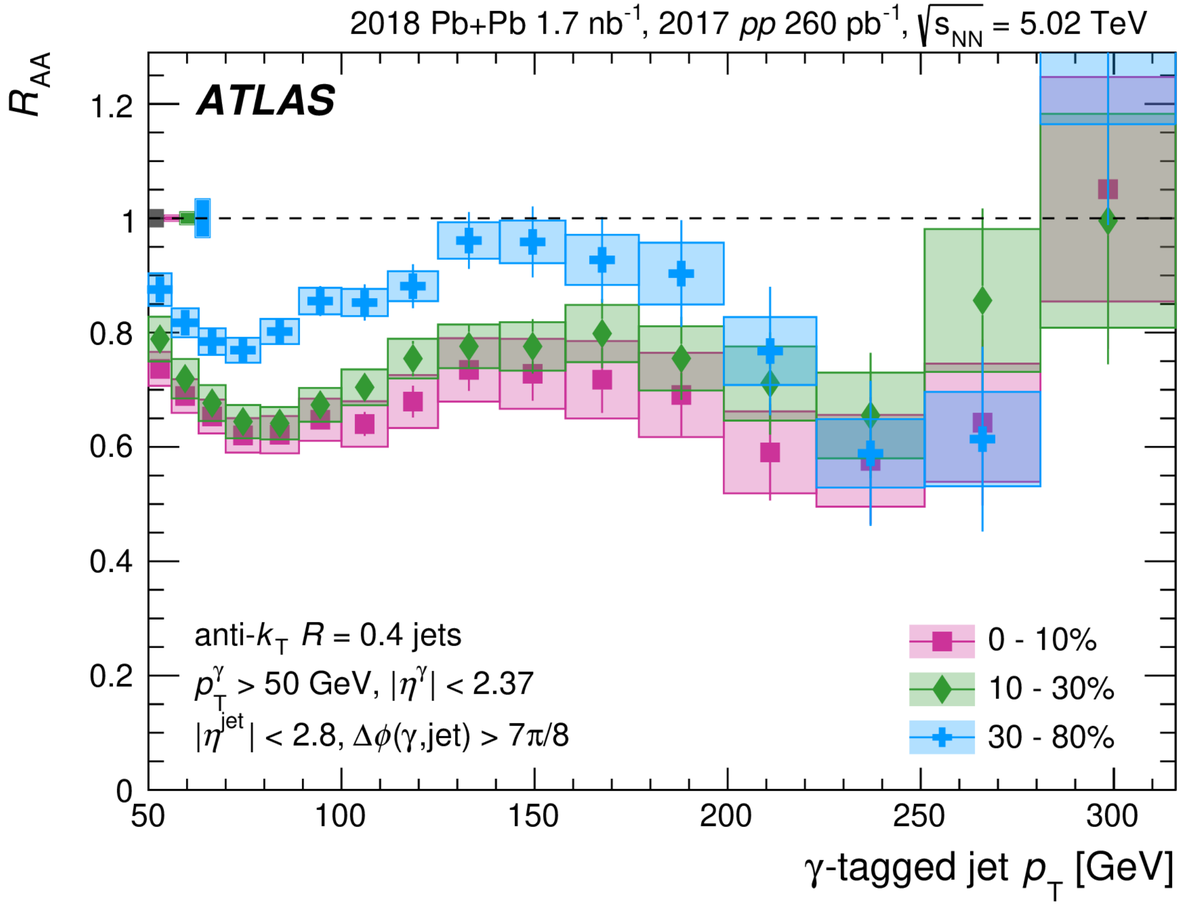

- More suppression in central Pb+Pb as expected due to larger quenching effect

γ-tagged jet spectra and R_{AA}

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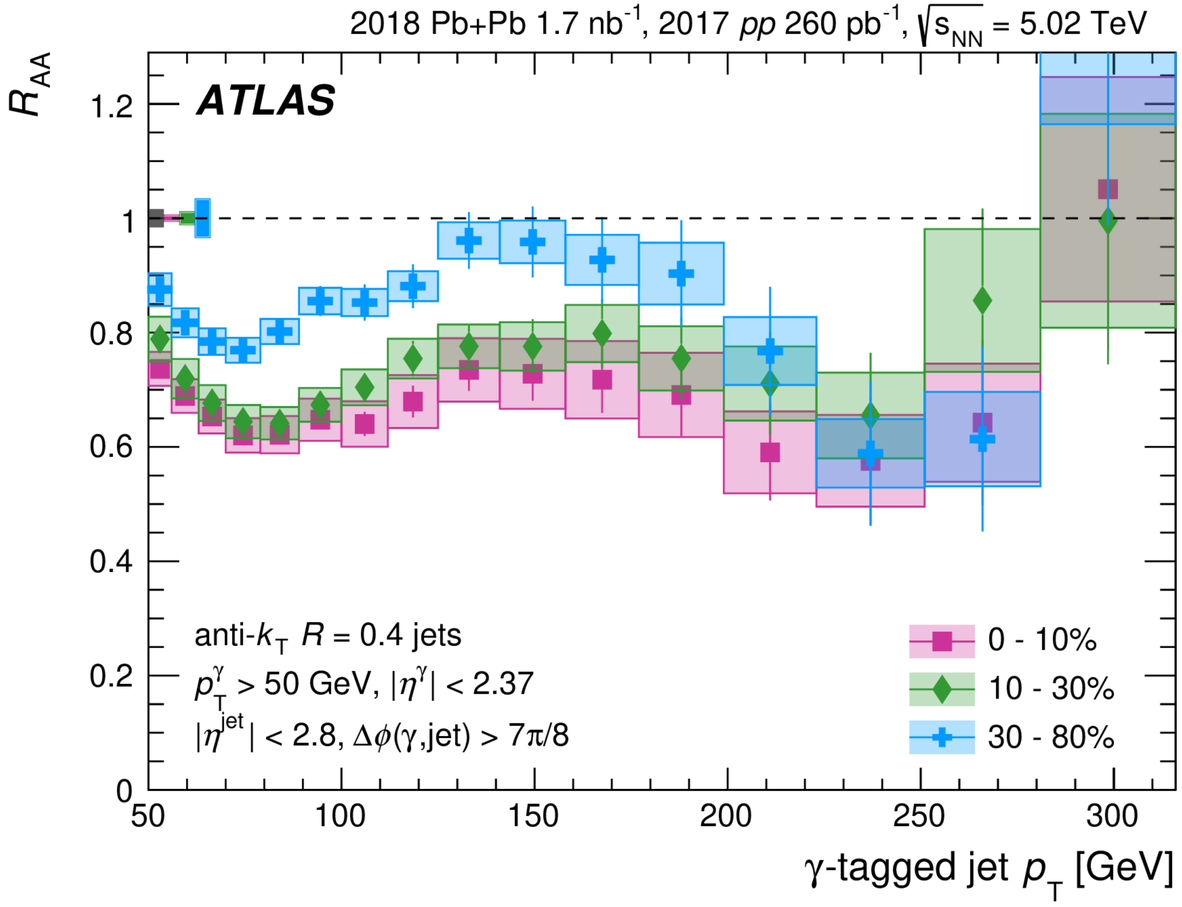
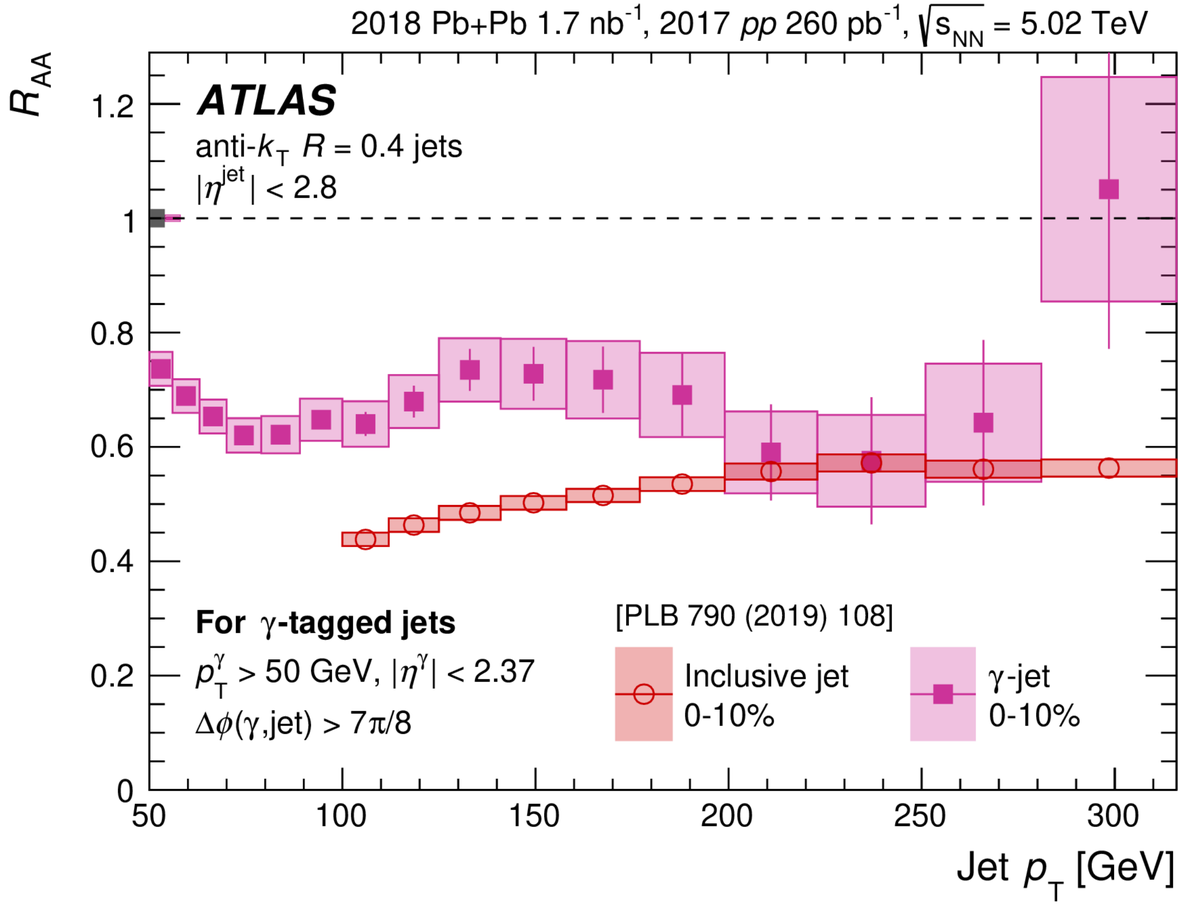
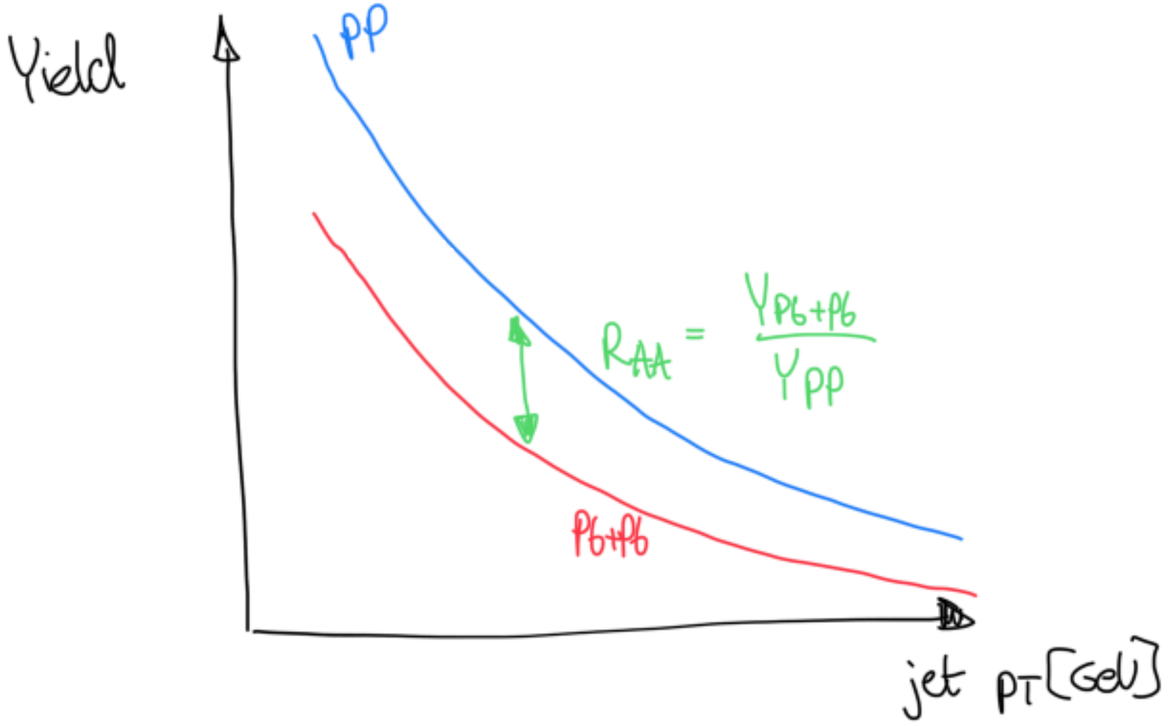




- Comparison of γ-tagged jets with inclusive jets in 0-10%
  - ➡ Up to p_T of 200 GeV γ-tagged jets less suppressed

Different look at jet energy loss

- Energy loss expressed in Δp_T or fractional energy loss (S_{loss}) greatly reduce sensitivity to the spectral shape



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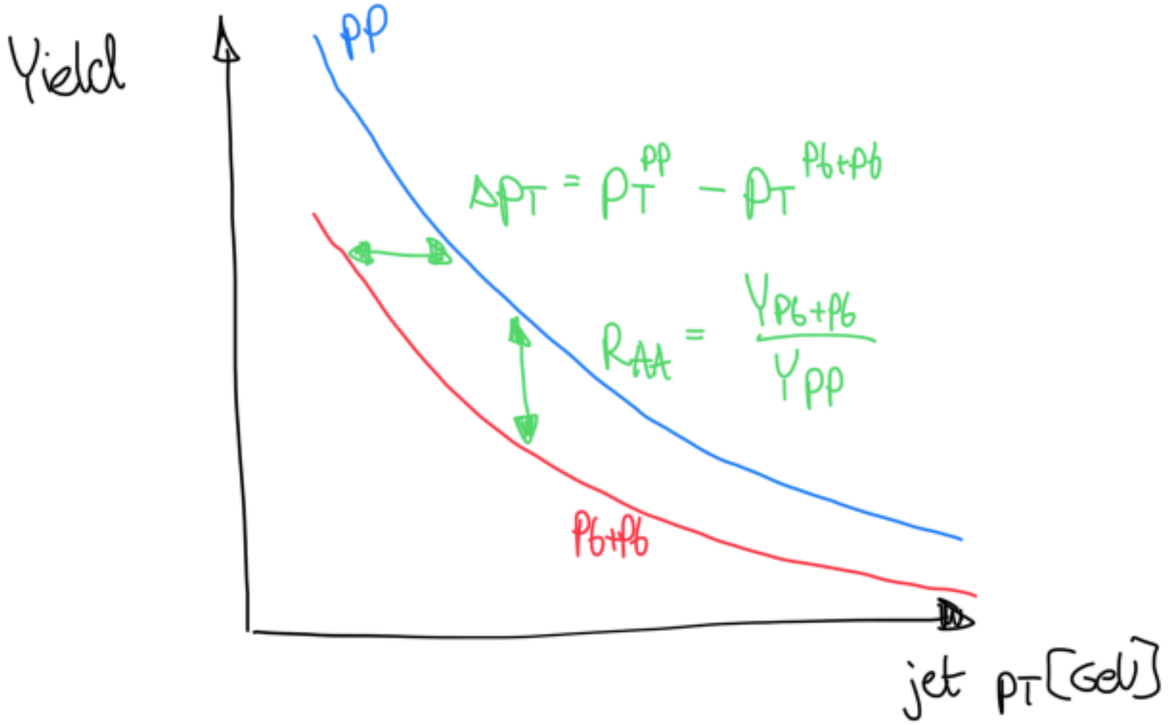

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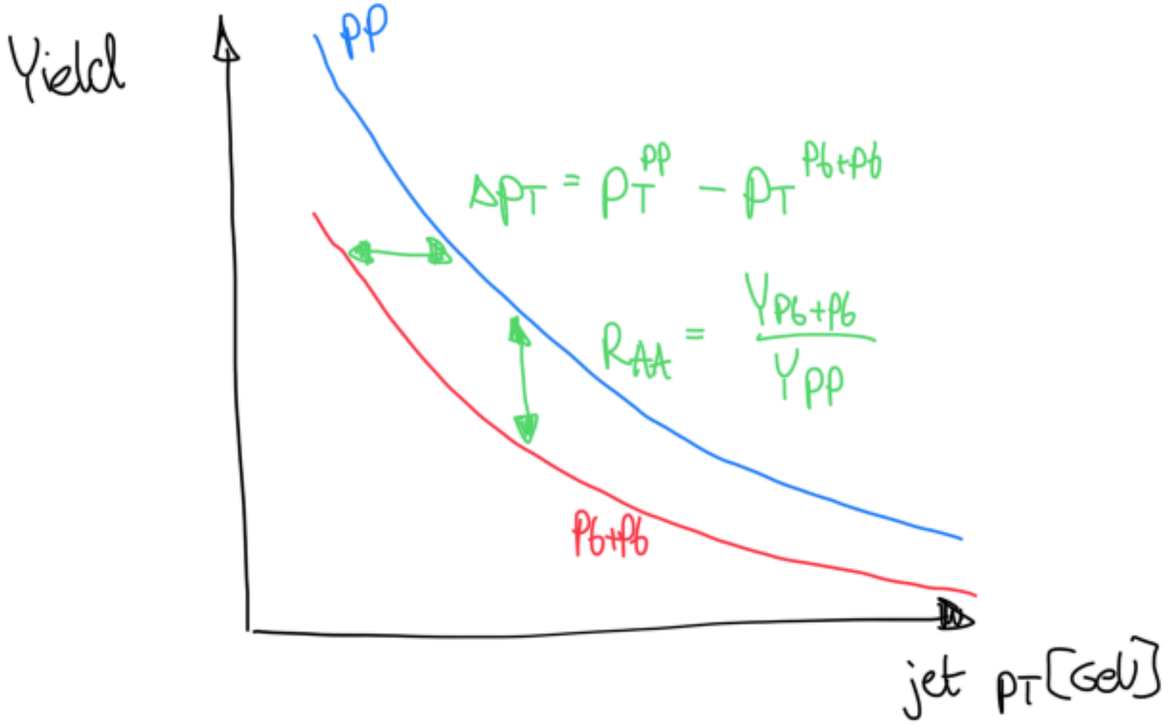

➡ Still, up to p_T of 200 GeV γ-tagged jets less suppressed

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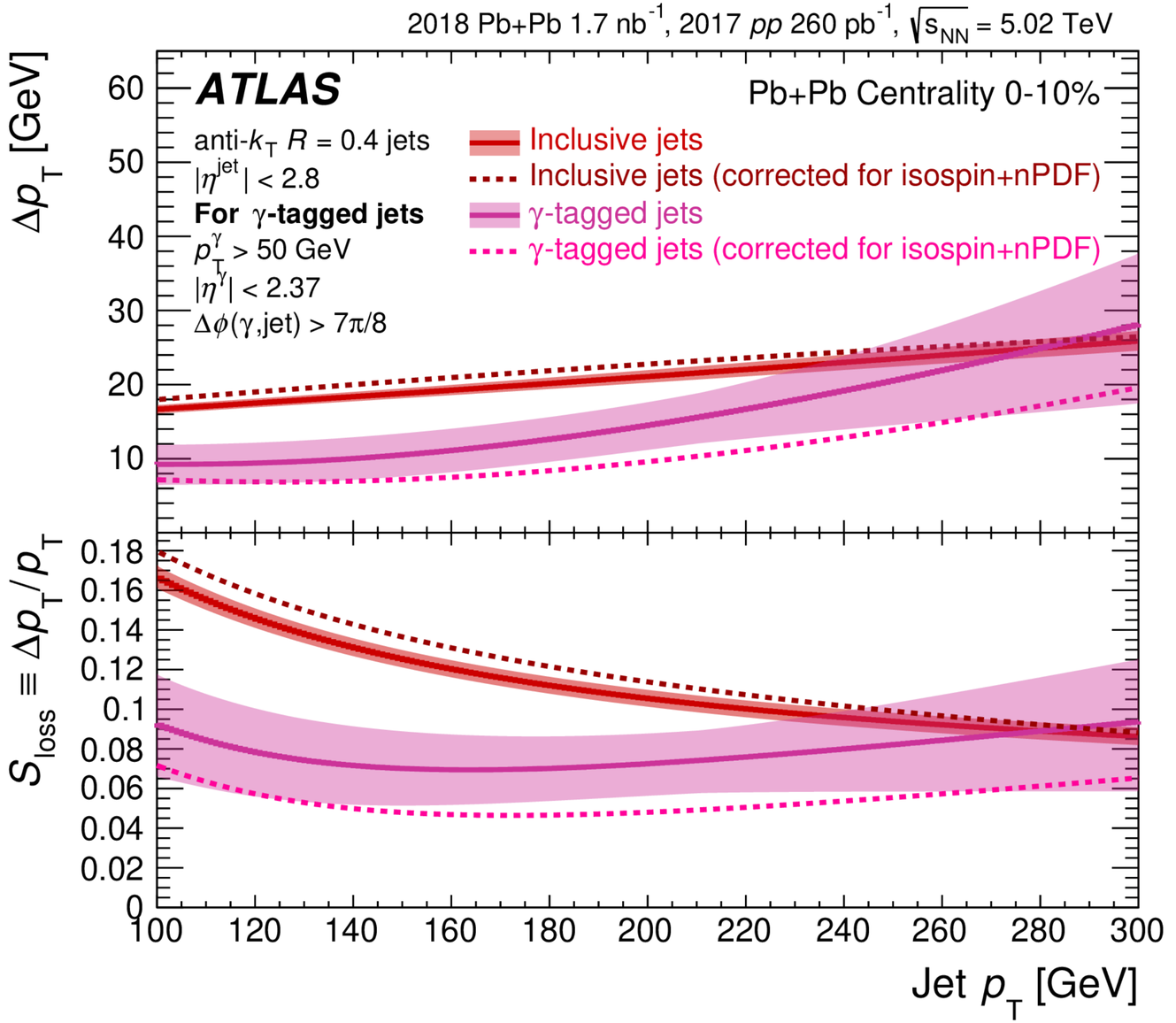

Different look at jet energy loss

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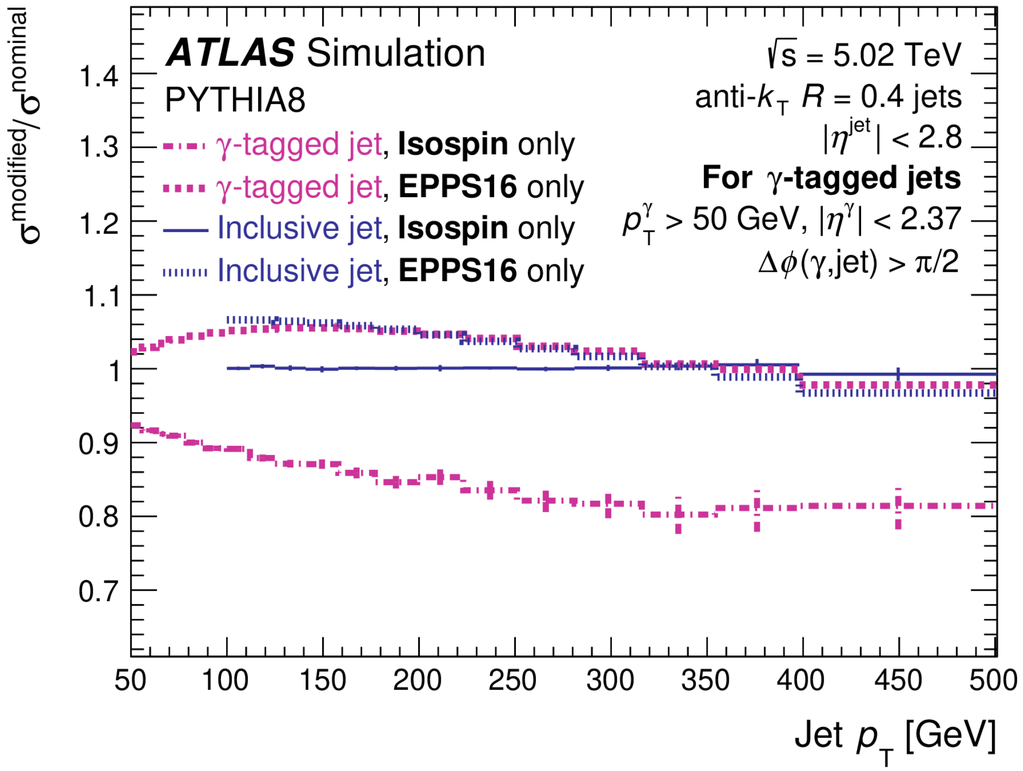
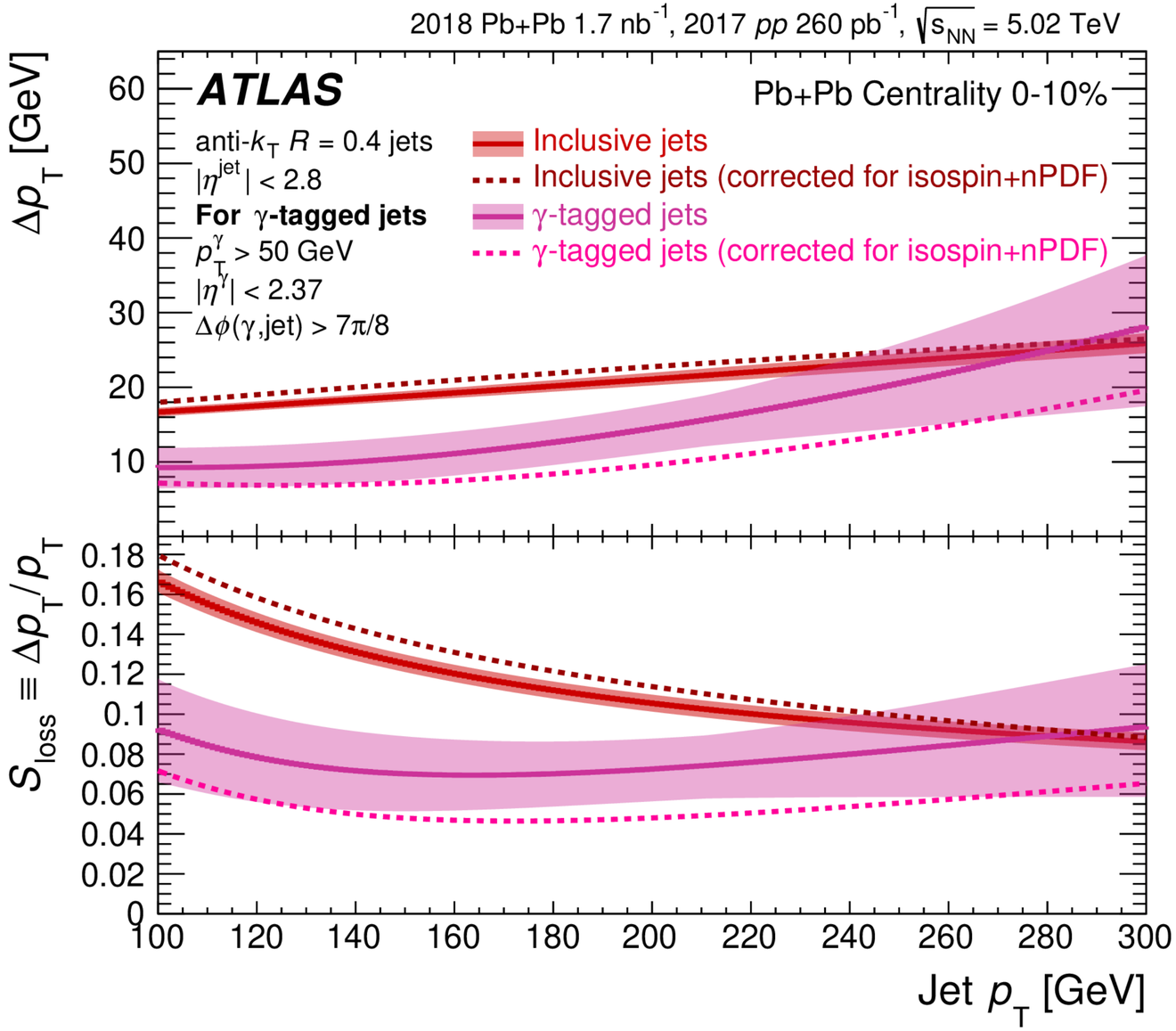
- Energy loss expressed in Δp_T or fractional energy loss (S_{loss}) greatly reduce sensitivity to the spectral shape

➡ Estimated the impact of Isospin and nPDF effects





Comparison with Theory

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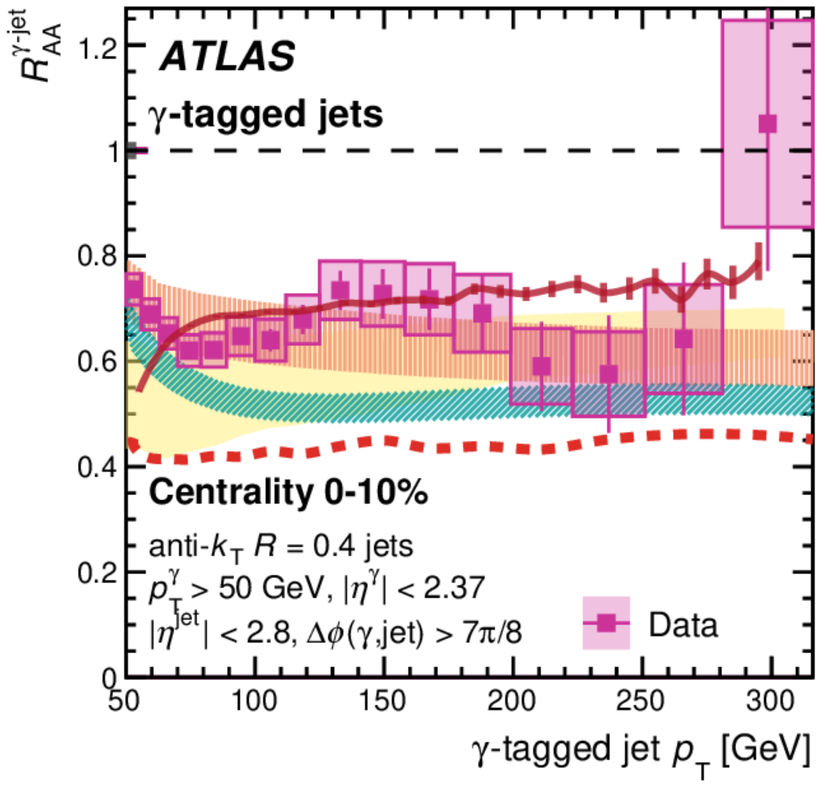
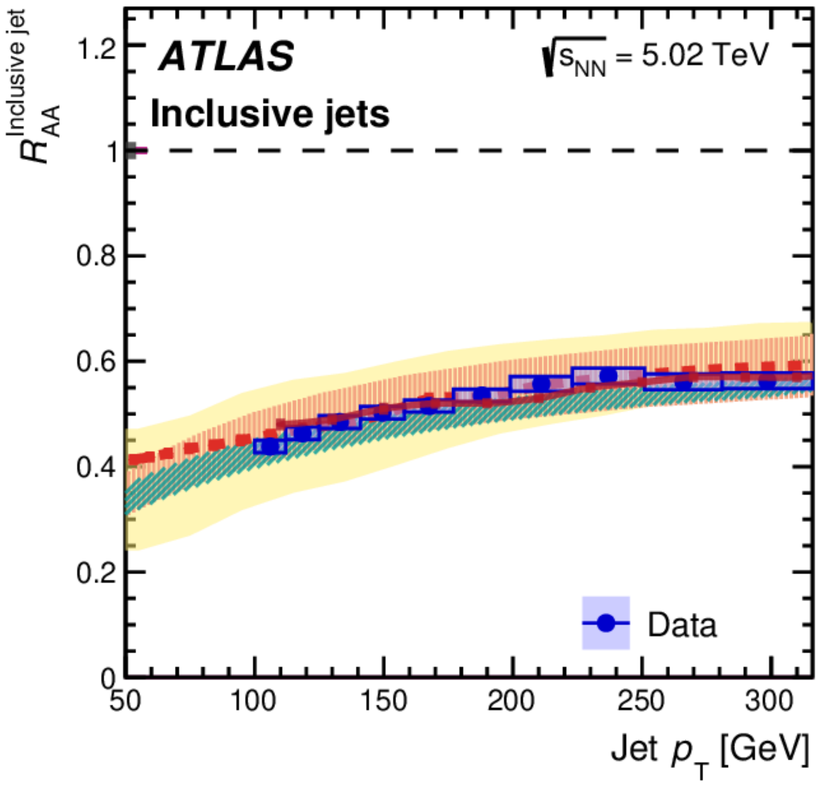
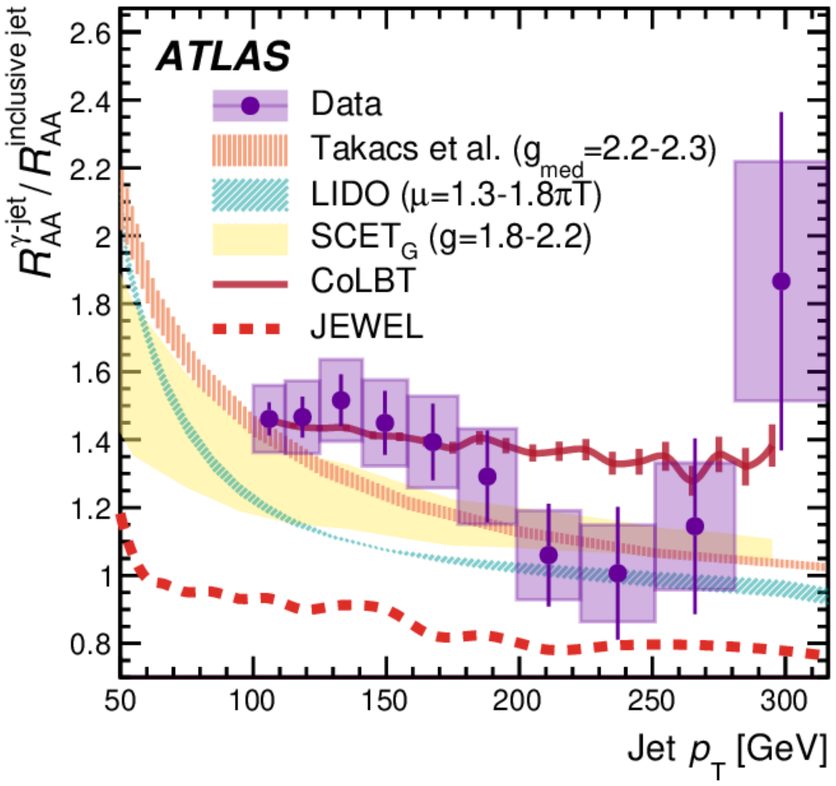
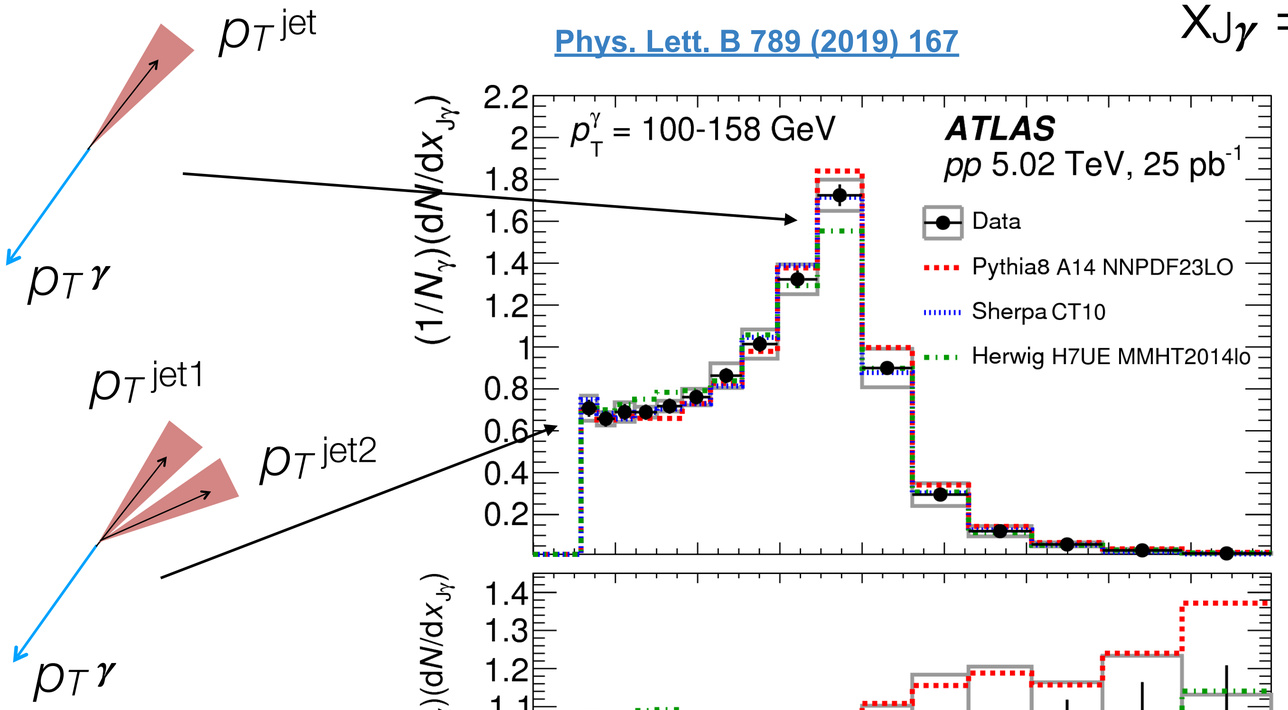






- γ-tagged jet R_{AA} in data is generally larger than the predictions
- Inclusive jet R_{AA} generally well described by calculations

Multi-jet final state in γ-tagged events



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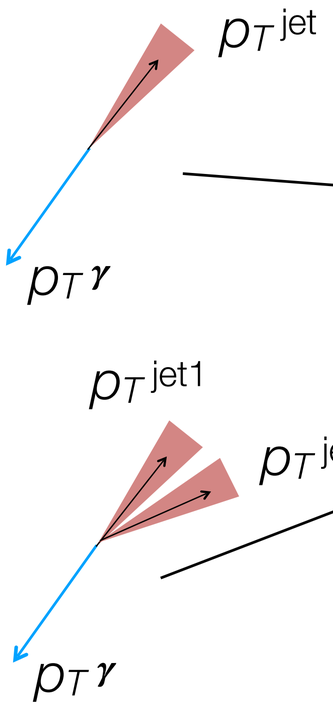
$x_{J\gamma} = p_T\,\text{jet}/p_T\gamma$

Multi-jet final state in γ-tagged events



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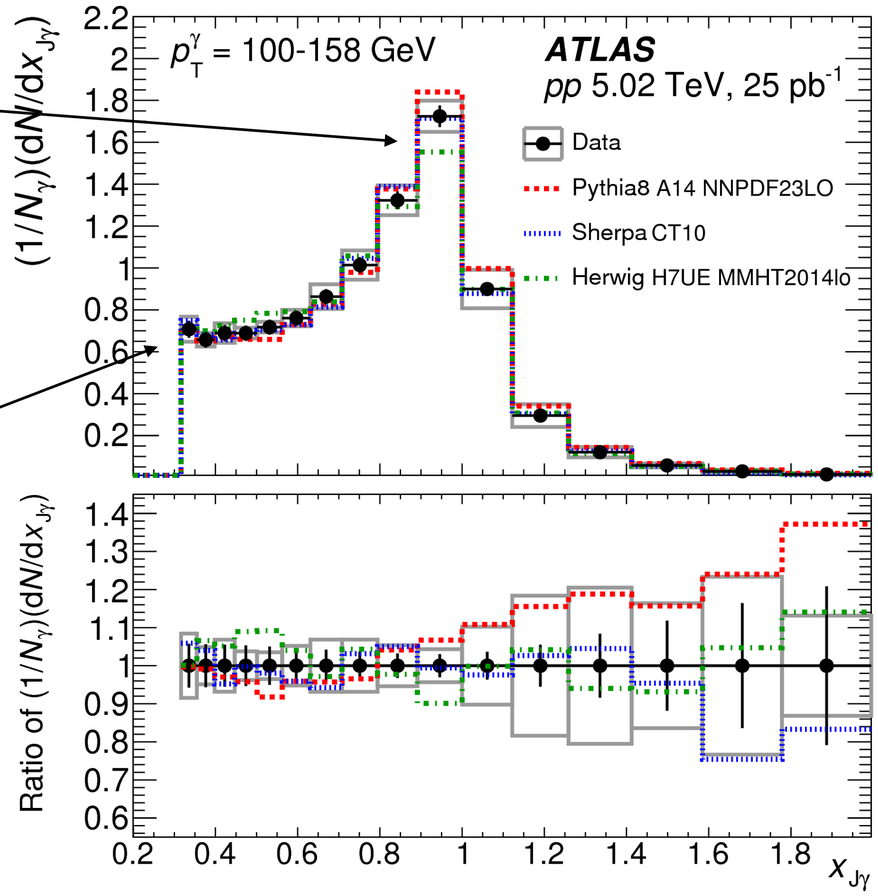
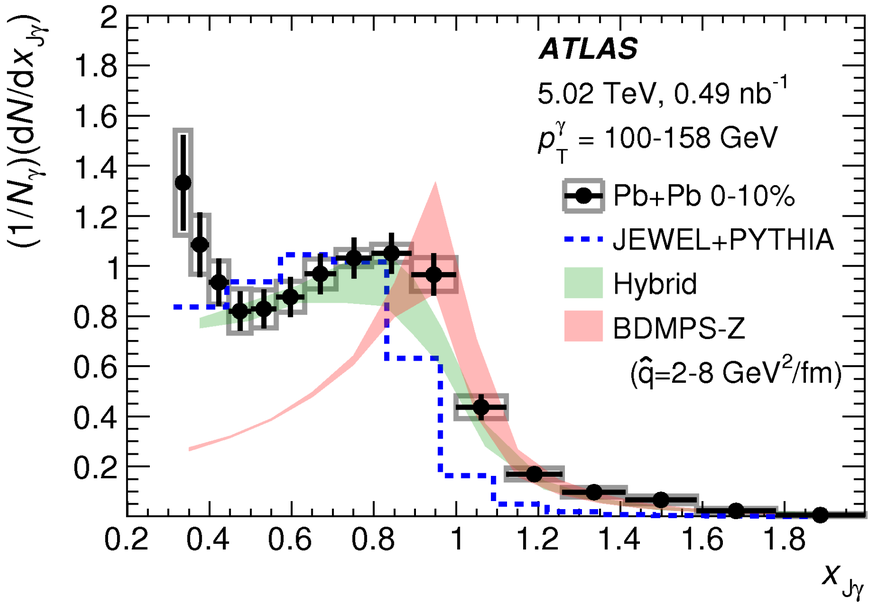
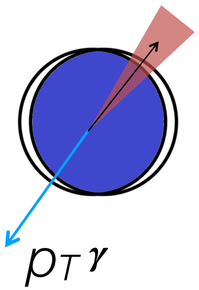






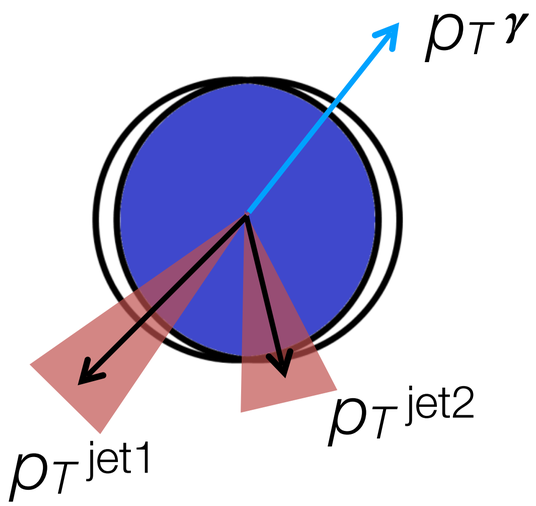
Measurement procedure

Data sets

pp 260 pb^{-1} (2017)

Pb+Pb 1.7 nb^{-1} (2018)

Objects selection



Photons:

$90 < p_T^{\gamma} < 180$ GeV

$|\eta| < 1.37$ || $1.52 < |\eta| < 2.37$

Shower shape

Isolation

Jets:

At least two AntiKt **R=0.2**

$p_T^{\text{jet}} > 30$ GeV

$|\eta| < 2.8$

$\Delta\phi(\gamma,\text{jet}) > \pi/2$

$\Delta R_{JJ} > 0.4$

$\Delta\phi(\gamma,JJ) > 7\pi/8$

Analysis steps

Construct raw distributions

Subtract Mixed Event

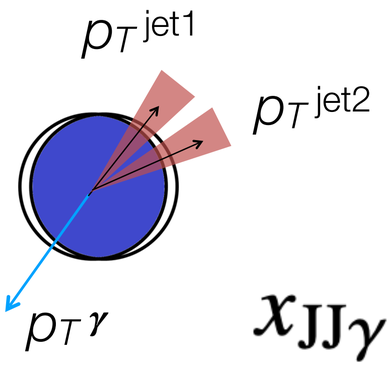
(Modified procedure to take into account multi-jet)

Purity correction

Unfold for detector effects

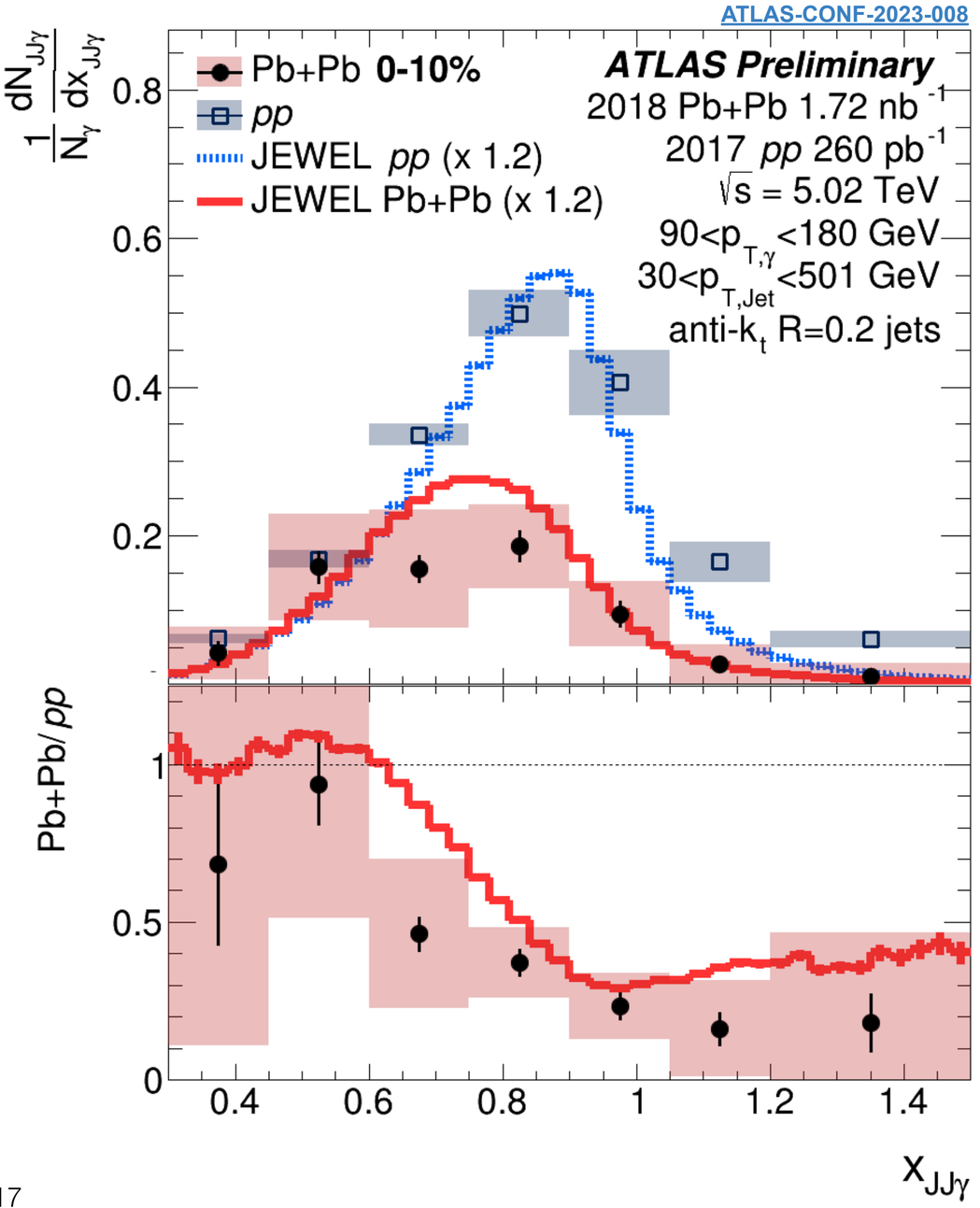
(Performed in three dimensions: observable of interest, p_T^{γ} and p_T^{jet2})

γ muliti-jet balance ($x_{JJ\gamma}$)

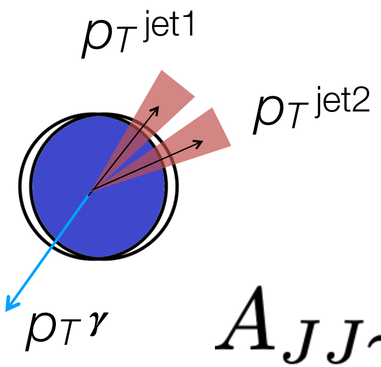


$$x_{\mathrm{JJ}\gamma} = (\vec{p}_1 + \vec{p}_2)_{\mathrm{T}} / p_{\mathrm{T},\gamma}$$

- Shift of the peak position in Pb+Pb with respect to the pp
- No more “shoulder” structure at low $x_{JJ\gamma}$ (as seen in $x_{J\gamma}$)

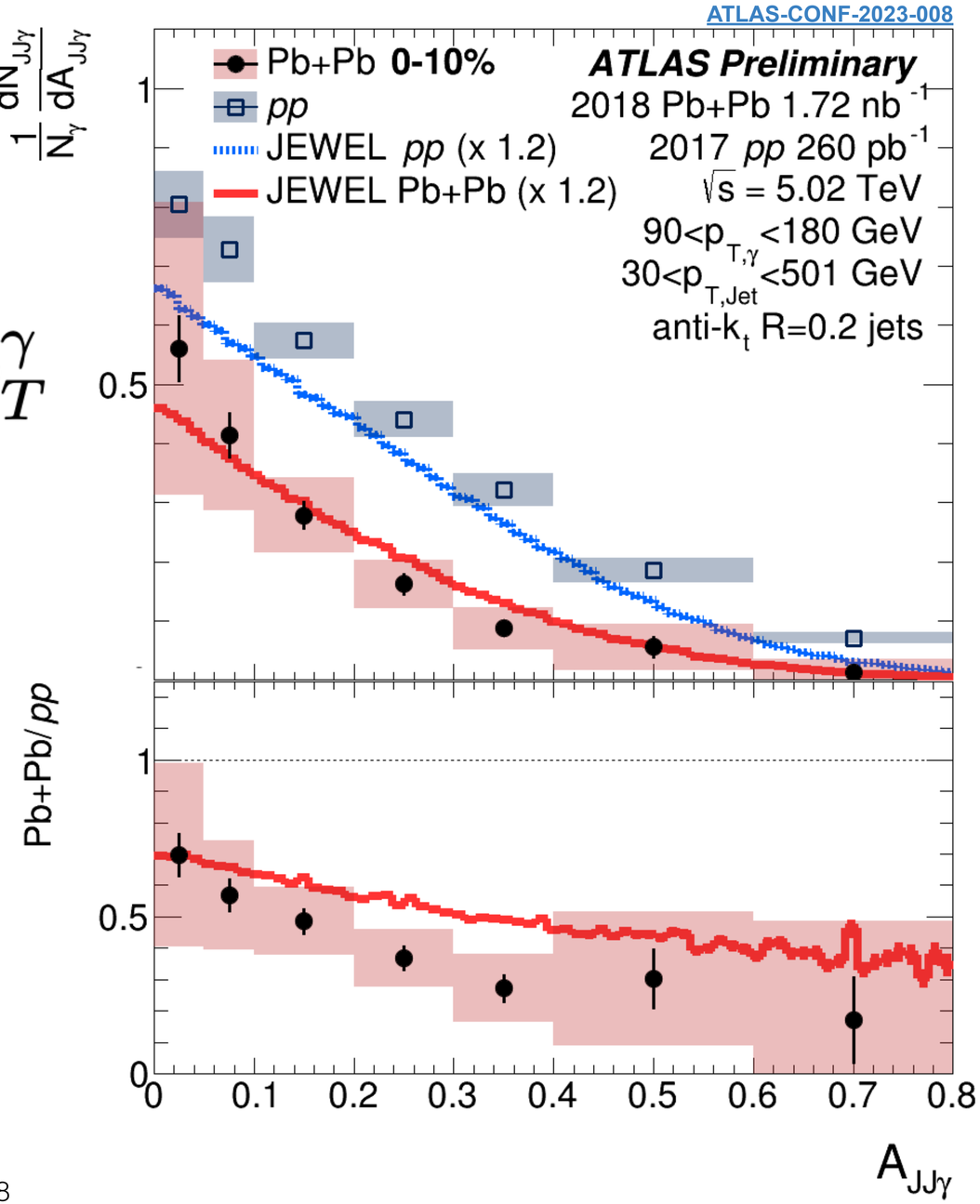


Difference between two jets p_T w.r.t γ p_T ($A_{JJ\gamma}$)

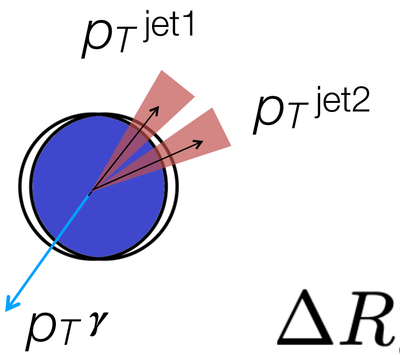


$$A_{JJ\gamma} = (p_T^{jet1} - p_T^{jet2})/p_T^{\gamma}$$

- Observable sensitive to p_T balance of two jets
  - ➡ Balanced jet pair - ***low*** $A_{JJ\gamma}$
  - ➡ Asymmetric jet pair - ***high*** $A_{JJ\gamma}$
- Suggests stronger suppressions of asymmetric pairs

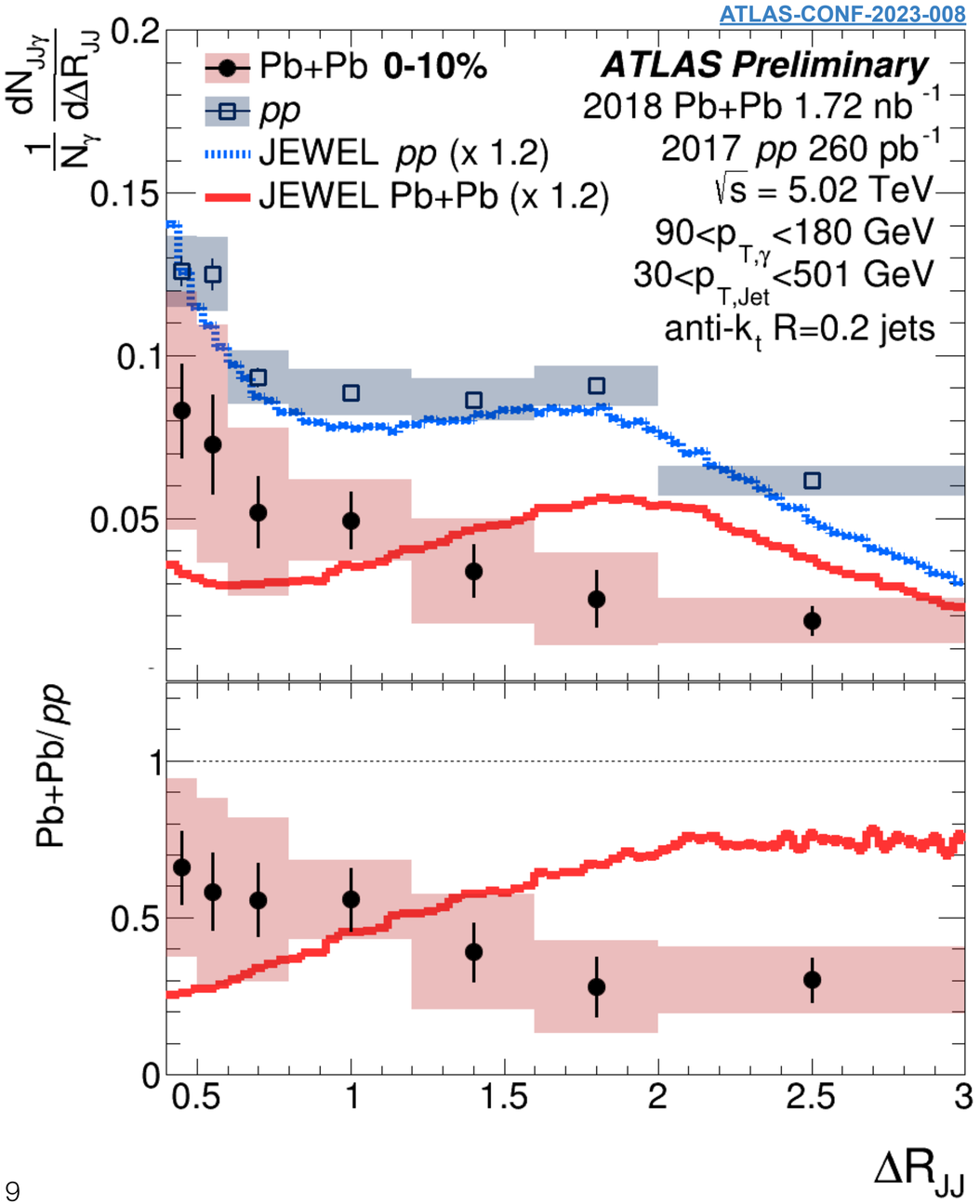


Angle between two jets (ΔR_{JJ})

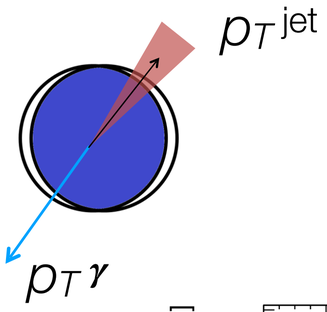


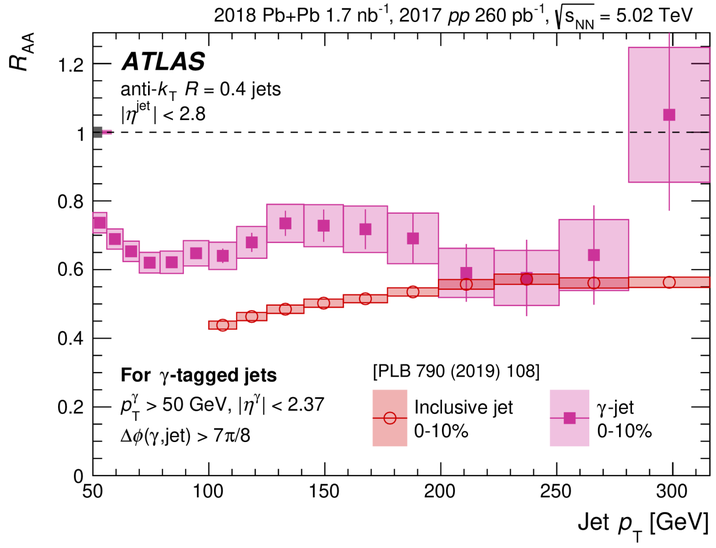
$$\Delta R_{JJ} = \sqrt{\Delta\phi_{1,2}^2 + \Delta\eta_{1,2}^2}$$

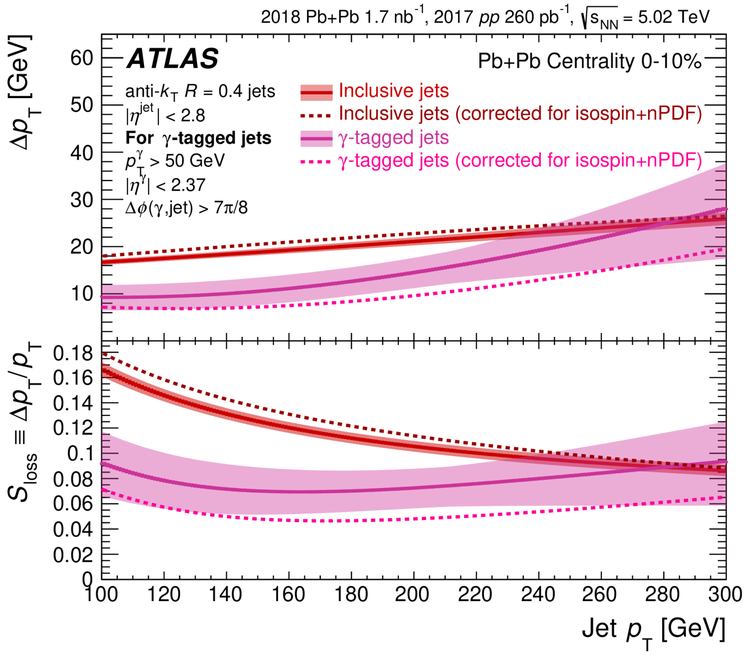
- Potentially sensitive to medium resolution of multiple colour charges
- Hint of stronger suppression of jets with larger ΔR_{JJ}

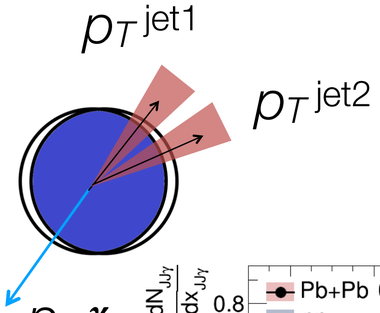


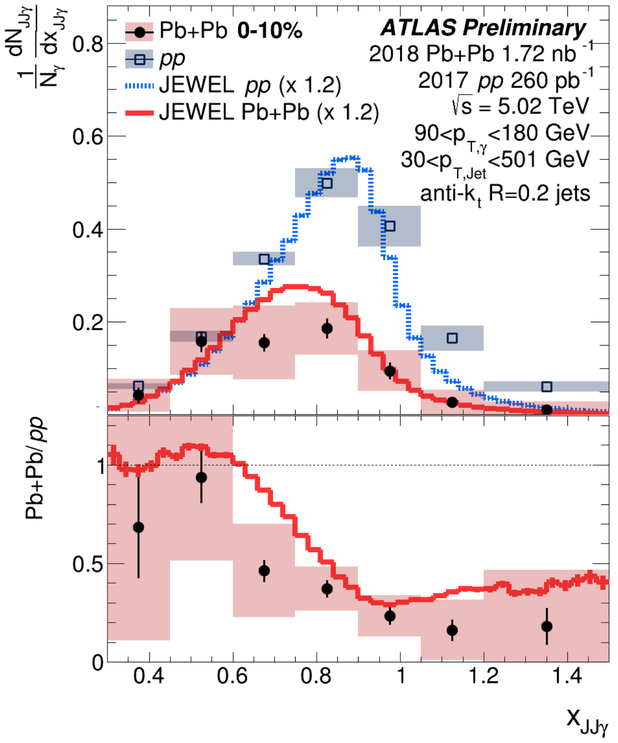
Summary











- γ-tagged jets have been measured in PbPb and pp and have been compared with inclusive jet
- Strong evidence of larger energy loss of gluon than quark jets

- First analysis of γ-tagged multi-jet system in Pb+Pb (preliminary) with new observables