Strong constraints on jet modification in centrality-dependent p+Pb collisions by ATLAS

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11th International Conference on **Hard and Electromagnetic Probes** of High-Energy Nuclear Collisions
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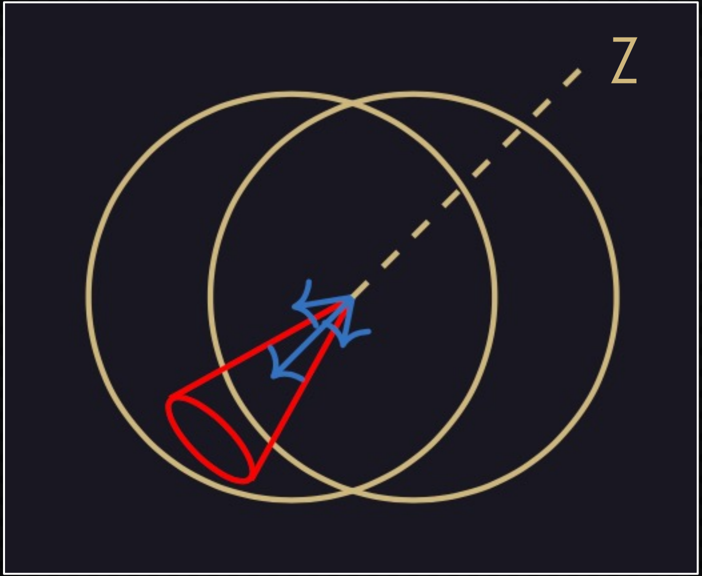
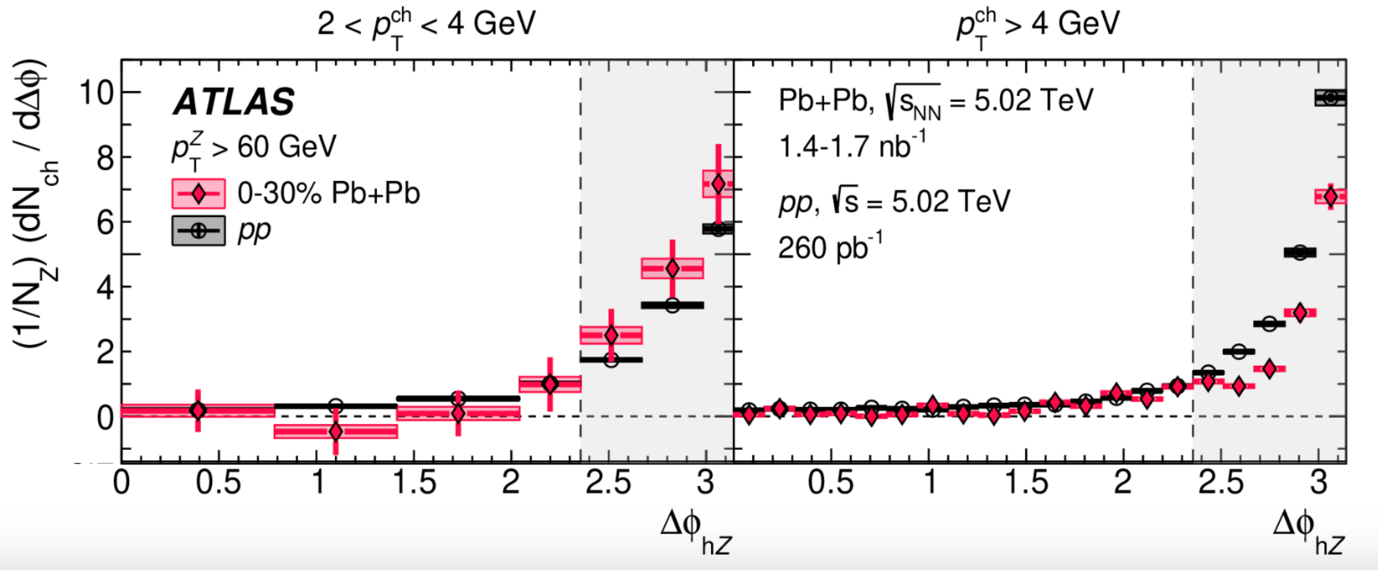
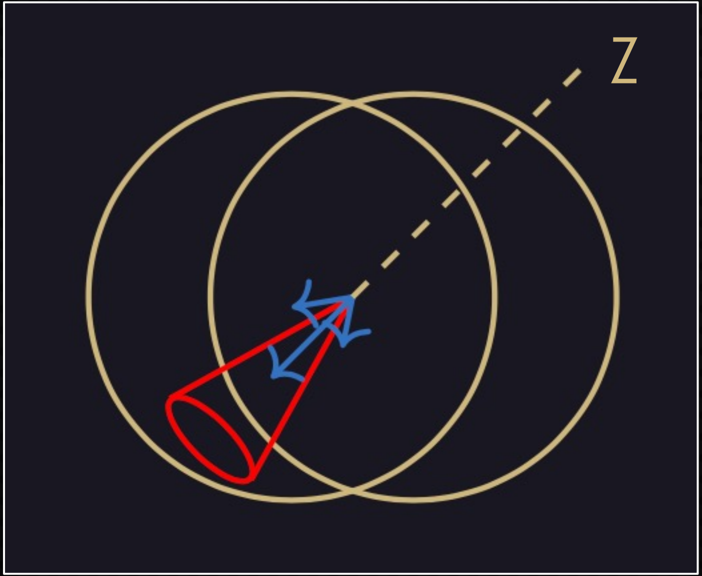
Jet Quenching in Pb+Pb Collisions

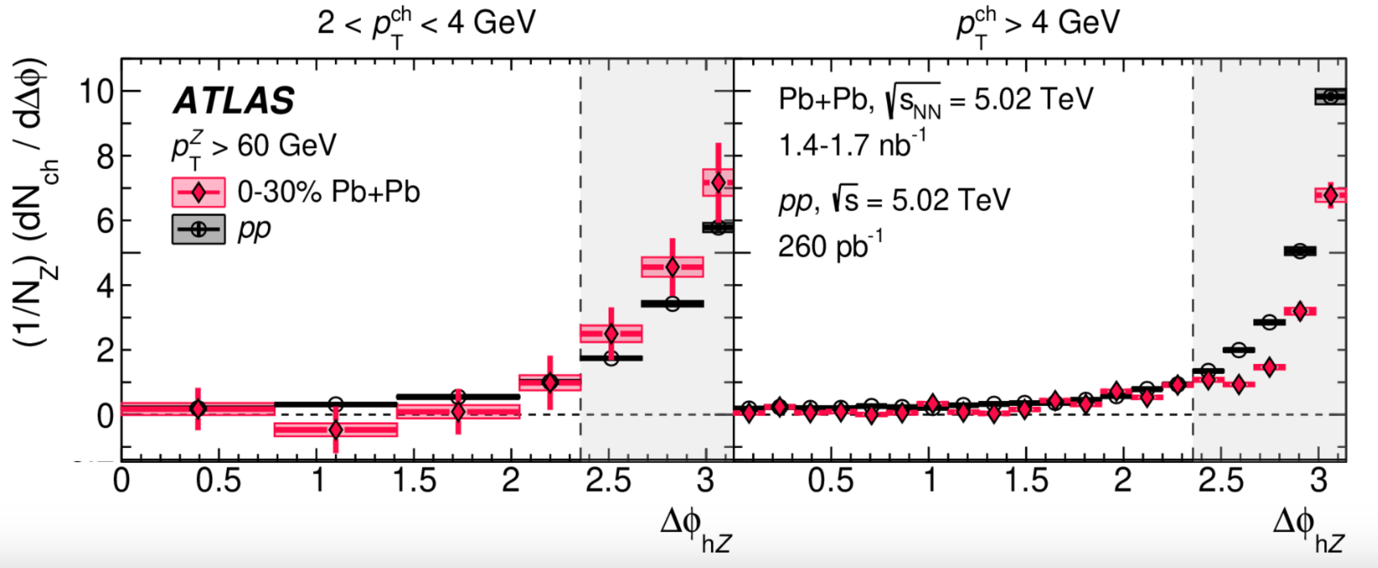


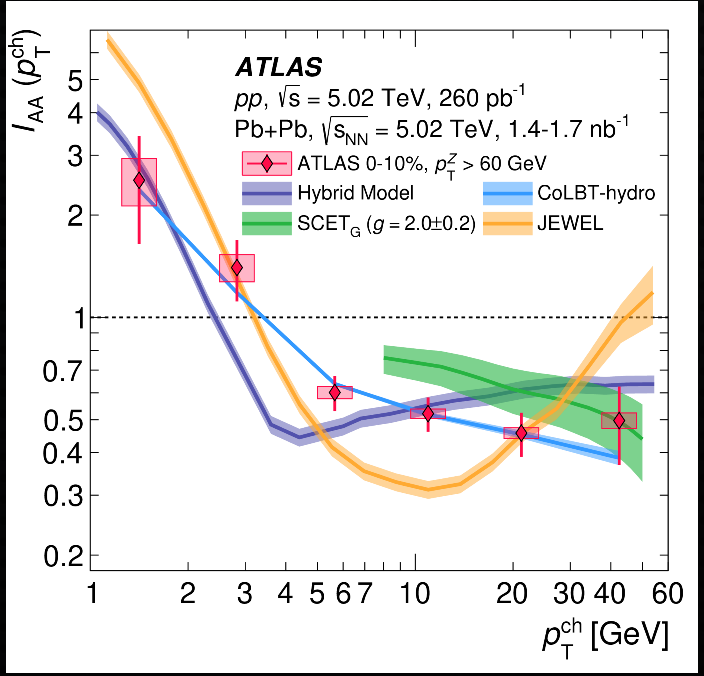


ATLAS: Phys. Rev. Lett. 126 (2021) 072301

Jet Quenching in Pb+Pb Collisions





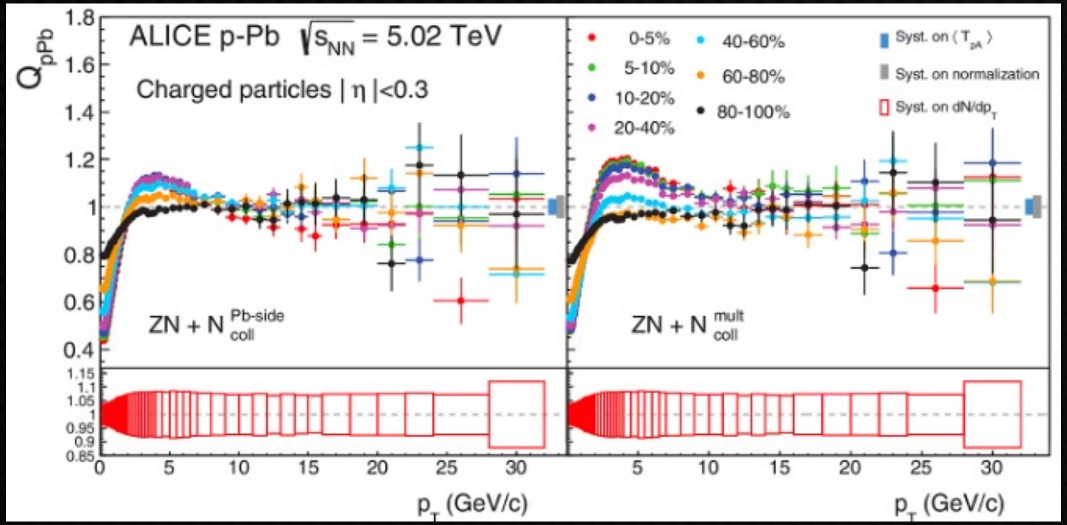


QGP significantly suppresses hadrons (p_T > 4 GeV) opposite Z-bosons.

Enhancement of hadrons (p_T < 4 GeV), redistribution of lost energy?

ATLAS: Phys. Rev. Lett. 126 (2021) 072301

Searches for jet quenching in p+Pb



Single charged particle yields
No large suppression but
uncertainty on event selection bias,$\langle N_{coll} \rangle$
Hence referred to as Q_{pPb} instead of R_{pPb}

ALICE: Phys. Rev. C (91) 064905

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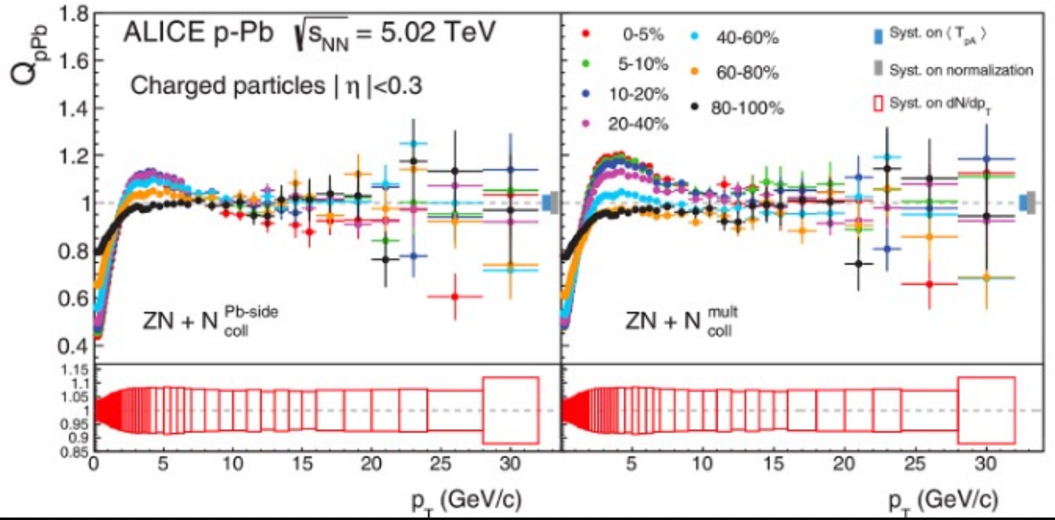

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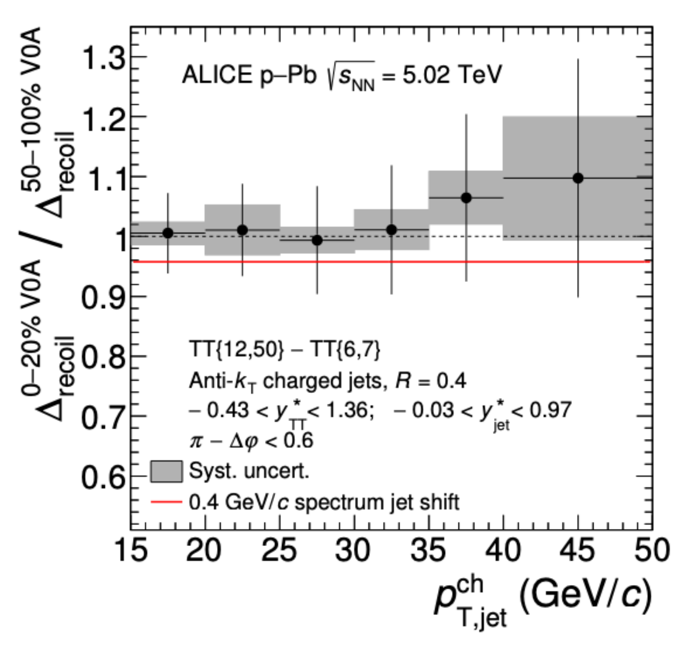


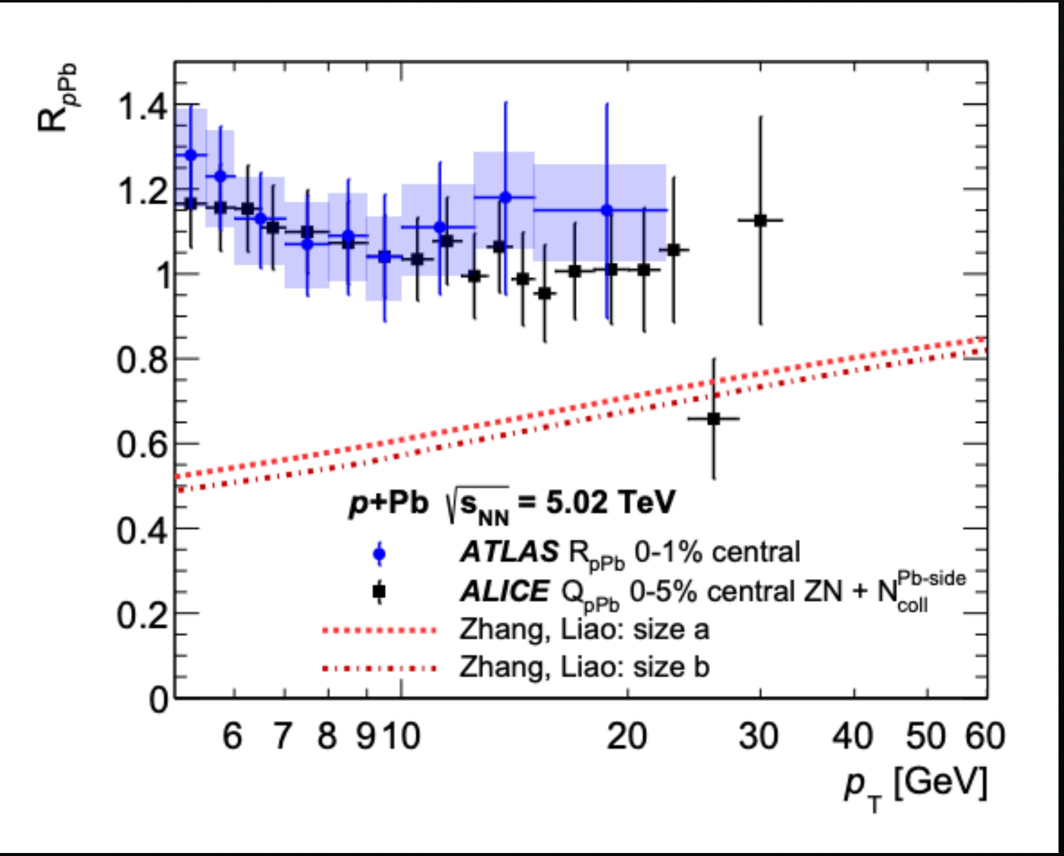
Hadron-jet correlations as a function of event activity

"average medium-induced out-of-cone energy transport for jets with R=0.4 and 15 < $p_{T,ch.jet}$< 50 GeV/c is measured to be less than 0.4 GeV/c at 90% confidence"

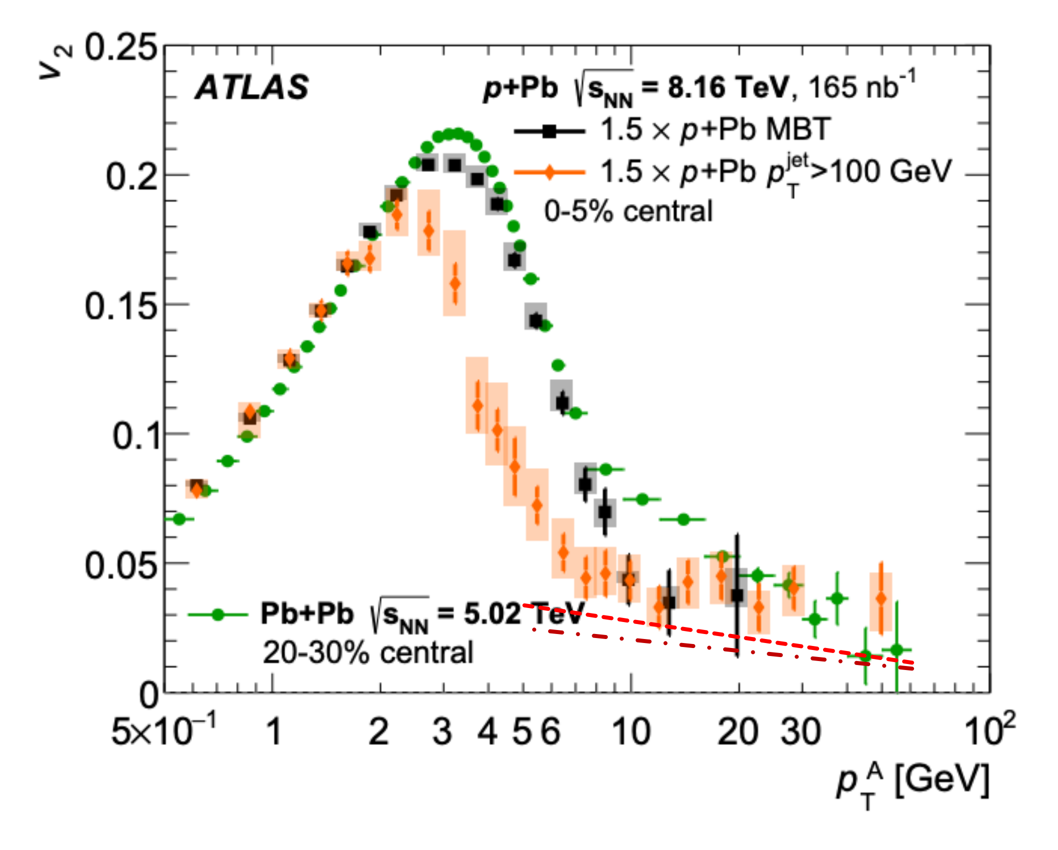
ALICE: Phys. Lett. B 783 (2018) 95

p+Pb high p_T puzzle?

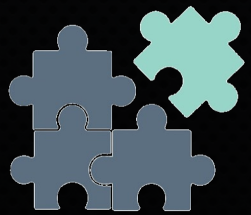
High pT RpPb consistent with unity



High p_T v_2 non-zero and similar to that in PbPb

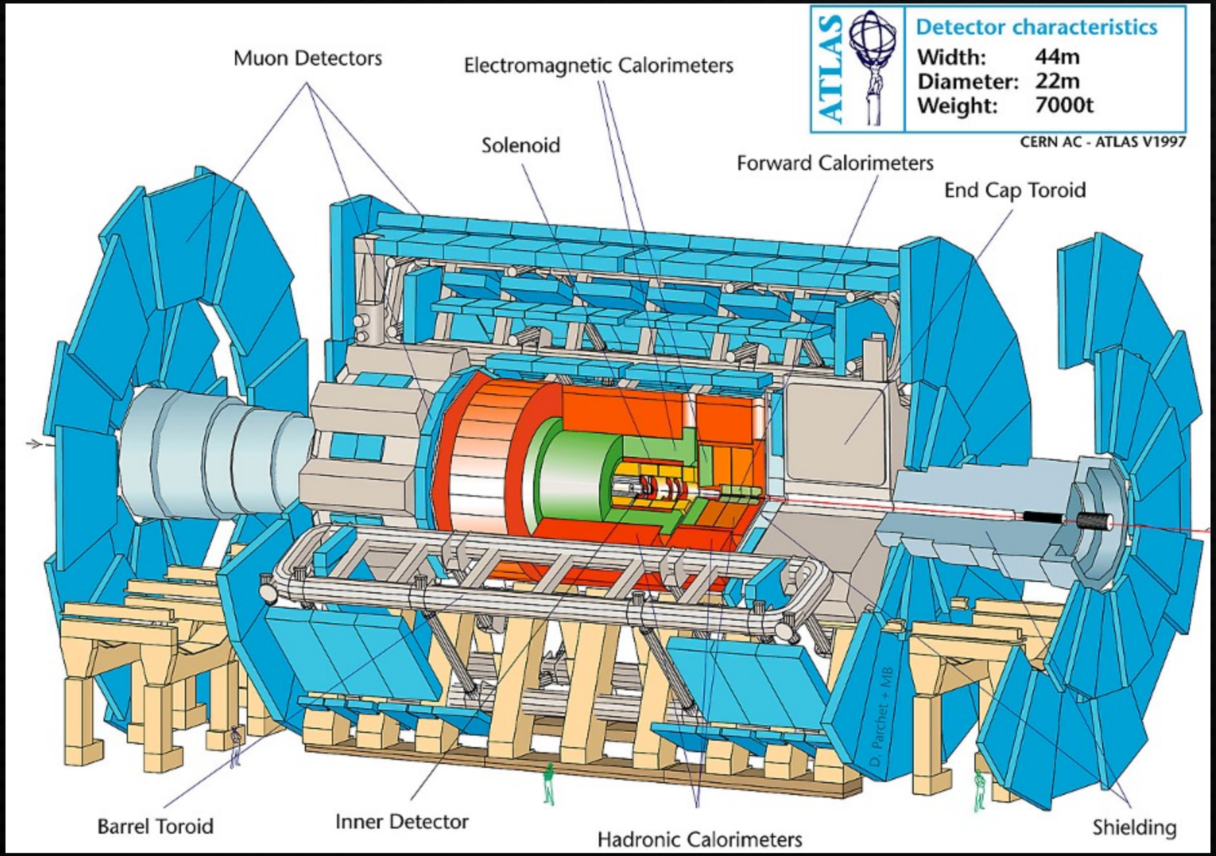


Zhang, Liao model that describes v_2 via energy loss substantially overpredicts R_{pPb} suppression



ATLAS: Eur. Phys. J. C 80 (2020) 73

ATLAS data set and analysis

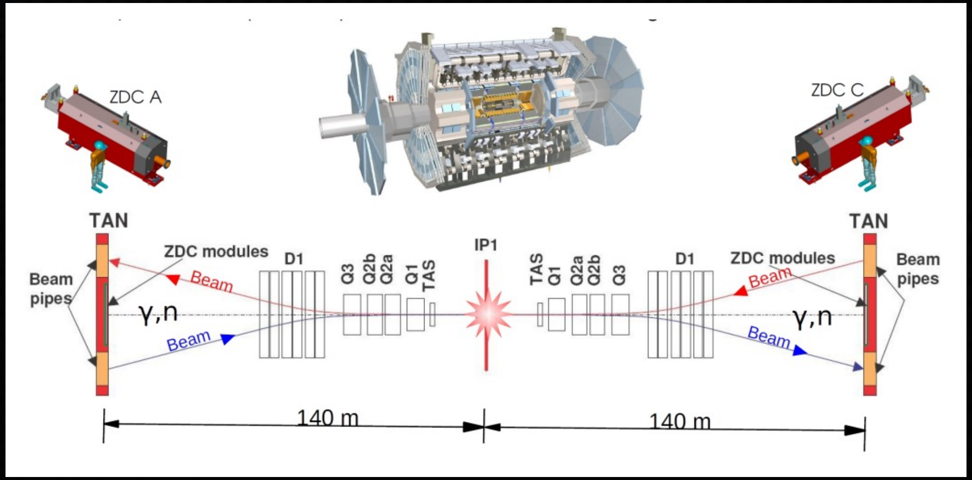


pp collected in 2017
2.6 – 260 pb^{-1} luminosity

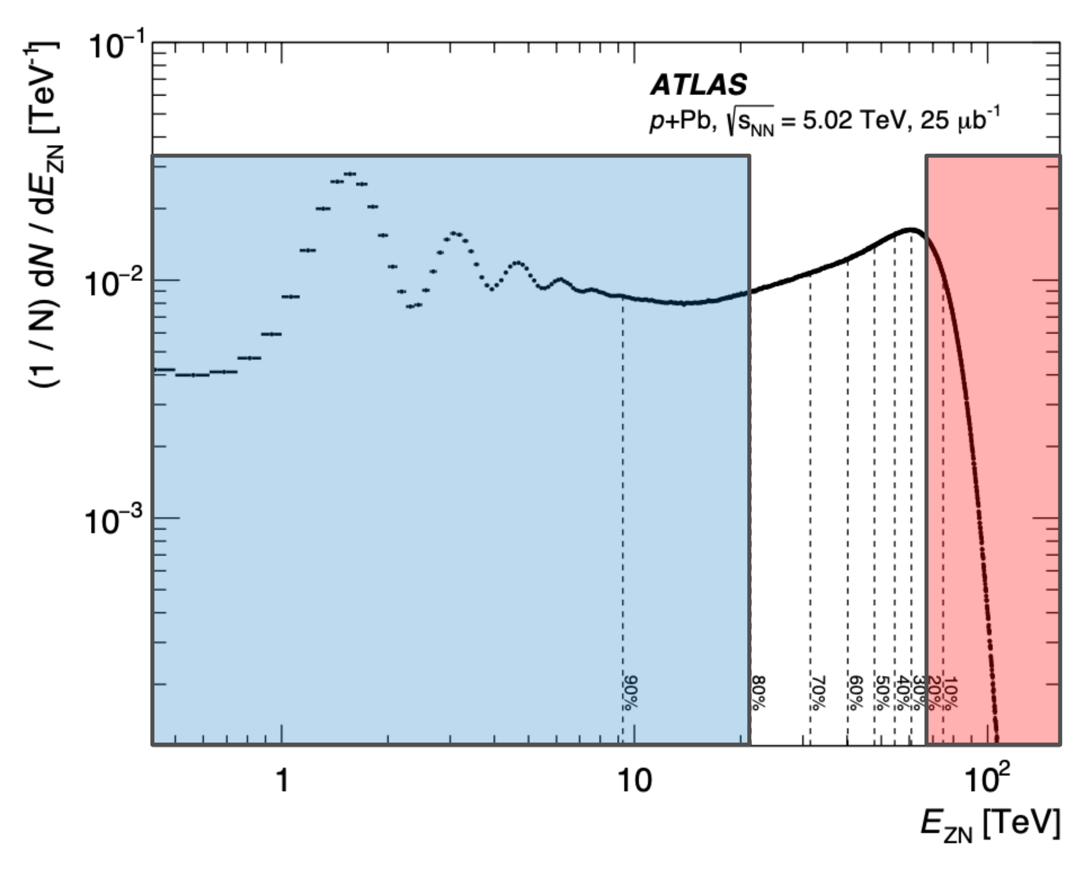
pPb collected in 2016
0.36 nb^{-1} luminosity

- Jets are reconstructed with EMCal and Hcal
- Charged particles via inner tracking detectors

- Centrality (nuclear overlap) is determined by the ATLAS Zero Degree Calorimeter (ZDC)



Event Selection in p+Pb Collisions



ATLAS paper accepted to Phys. Rev. Lett. [https://arxiv.org/abs/2206.01138]

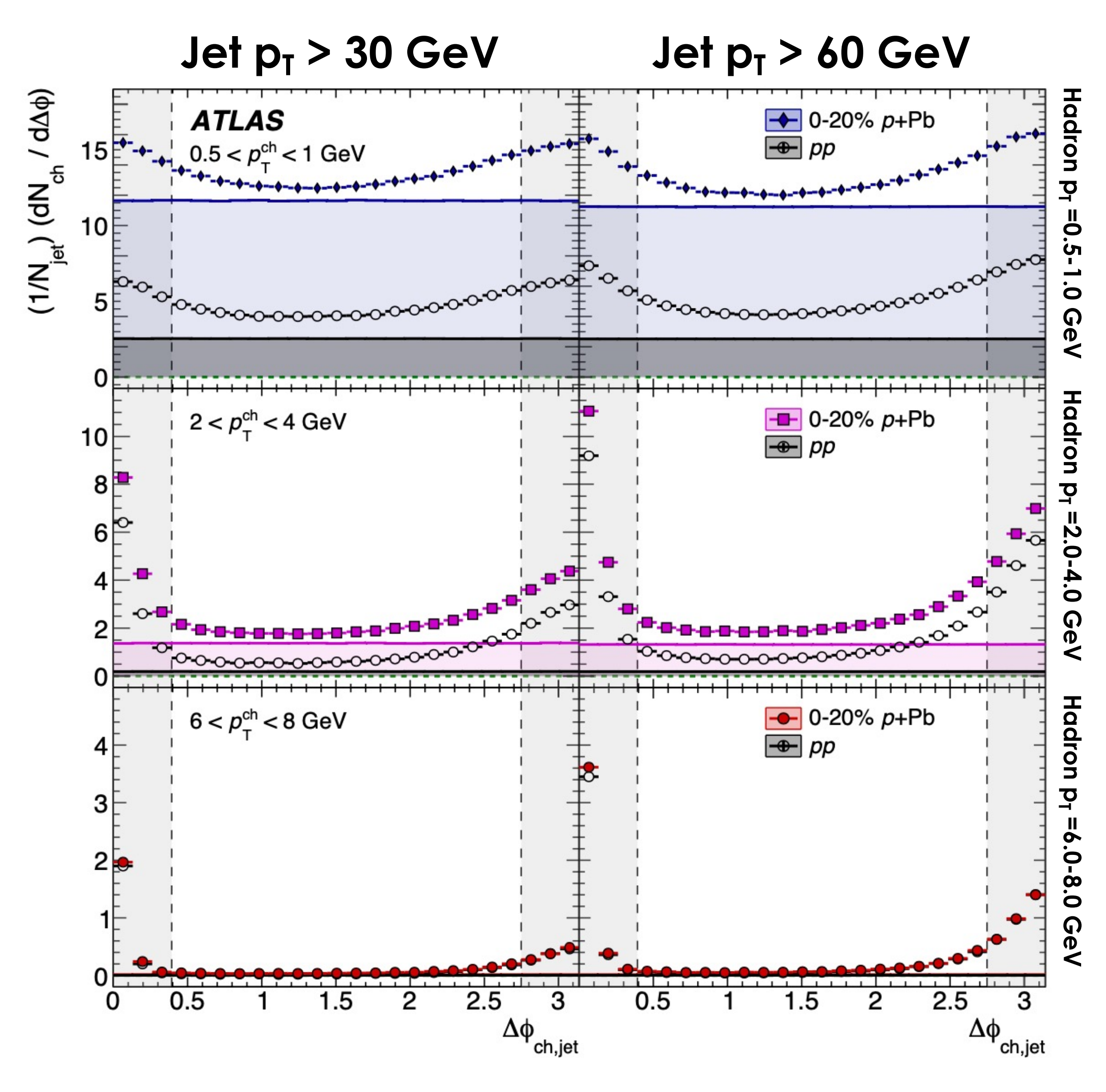
Select events by Pb-going ZDC energy to reduce any selection correlation with central barrel jets and hadrons

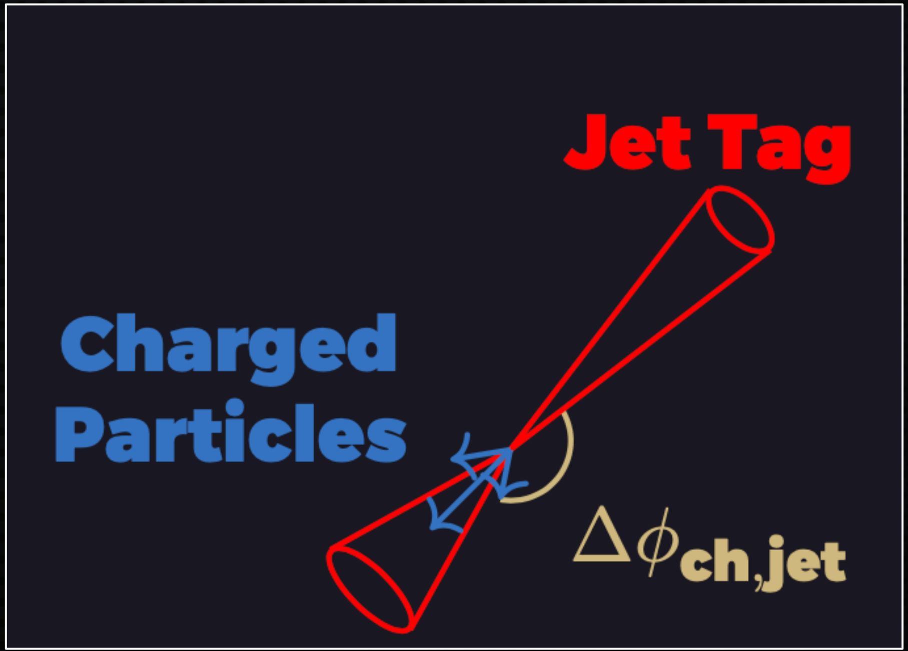
Using ZDC with similar acceptance, ALICE estimated:

$\langle N_{coll} \rangle$ = 13.6 ± 1.5 (0-20% cent.)
$\langle N_{coll} \rangle$ = 1.2 ± 1.3 (80-100% cent.)

ALICE: Phys. Rev. C 91 (2015) 064905

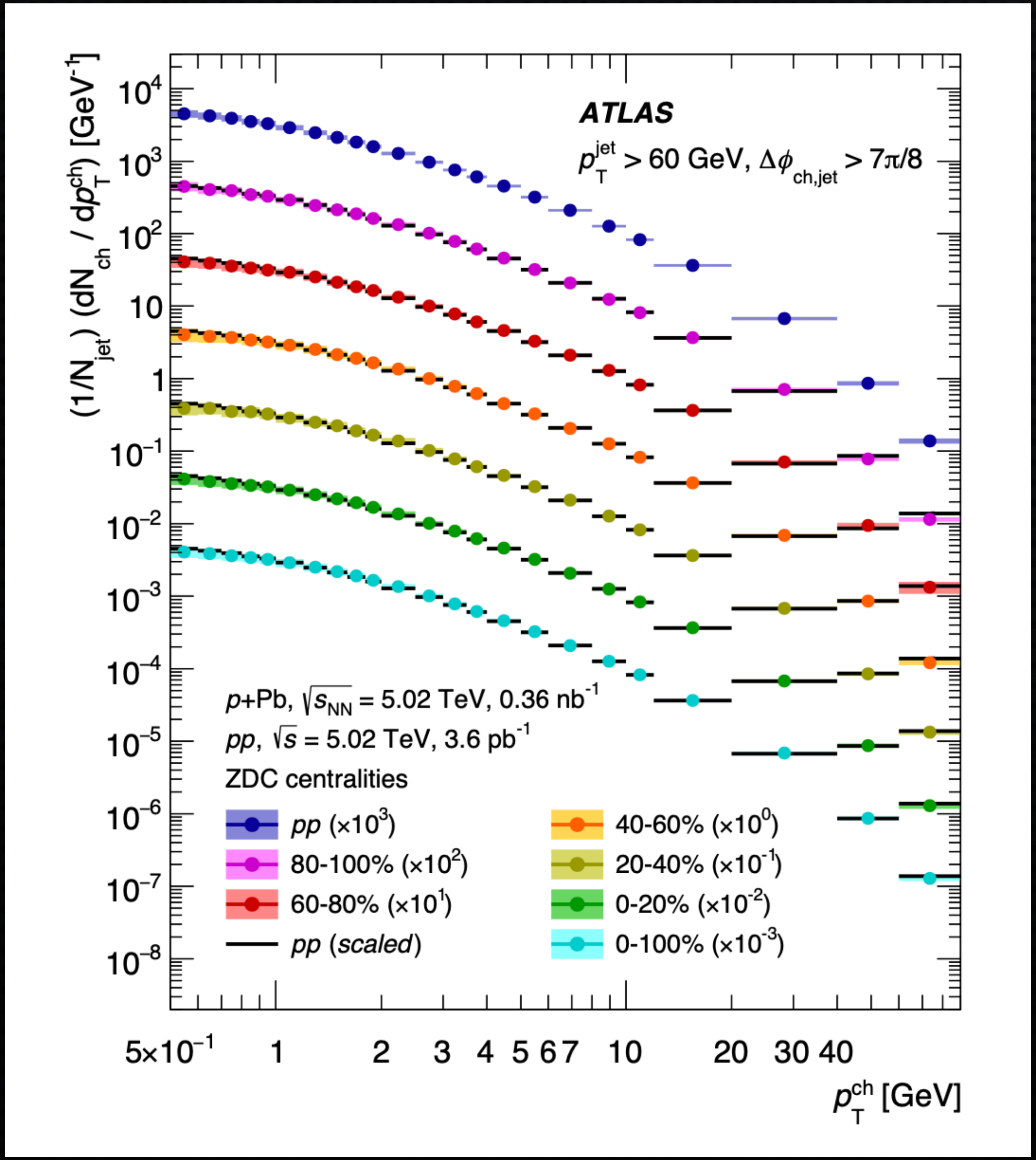
Jet-hadron angular correlations

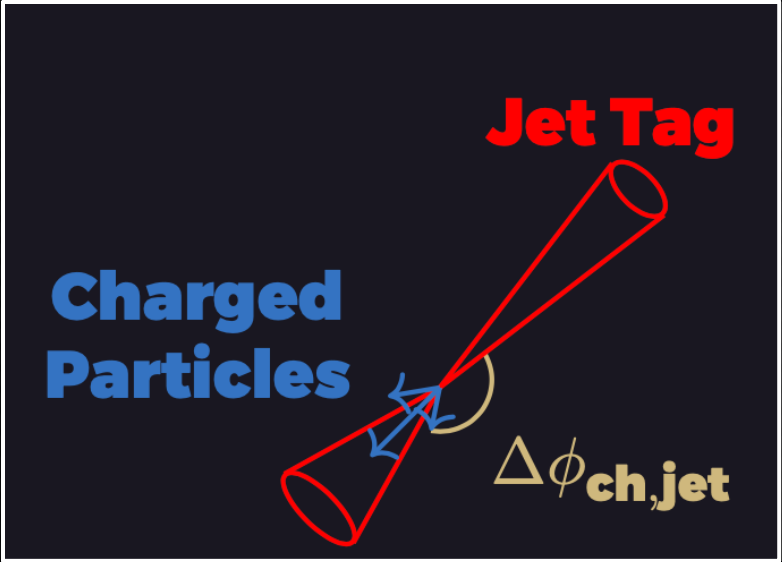




Quantify charged hadron yields as a function of p_T on "near-side" ($\Delta\phi < \pi/8$) and "away-side" ($\Delta\phi > 7\pi/8$) regions.

Quantified hadron yields per jet



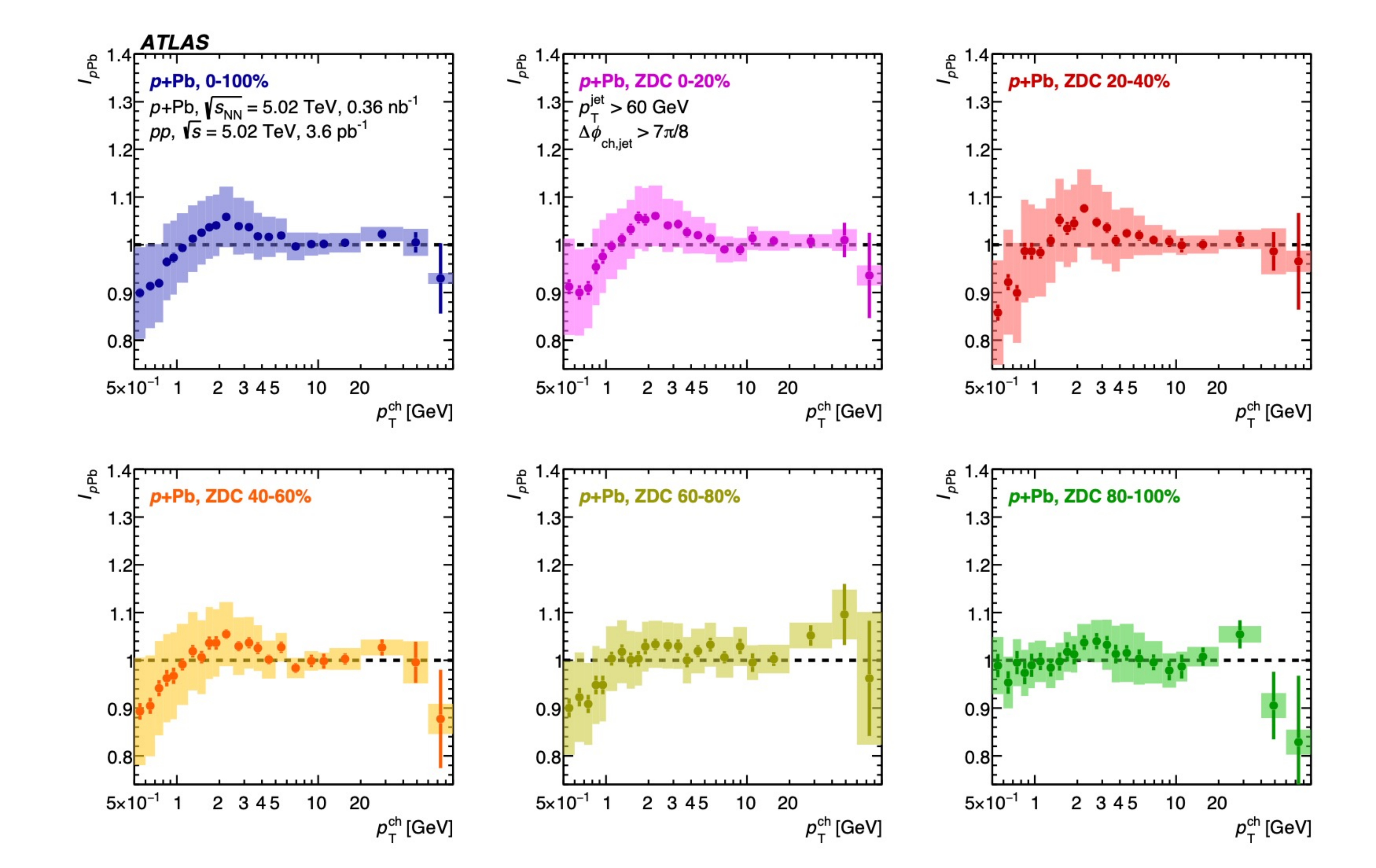


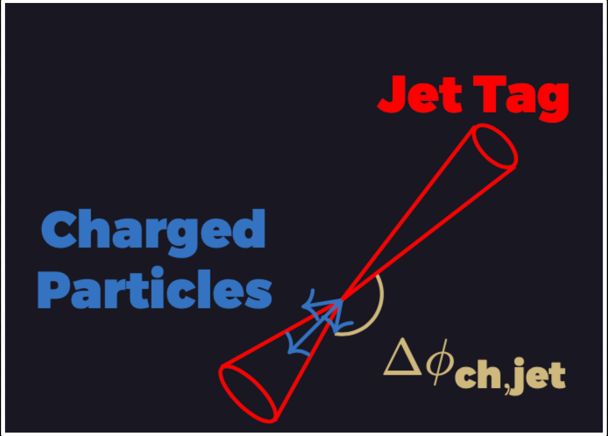
Then calculation the ratios

$$I_{pPb} = \frac{\text{Particles per jet in p+Pb}}{\text{Particles per jet in p+p}}$$

No explicit dependence on <N_{coll}>

"Away-side" Jet-hadron I_{pPb}

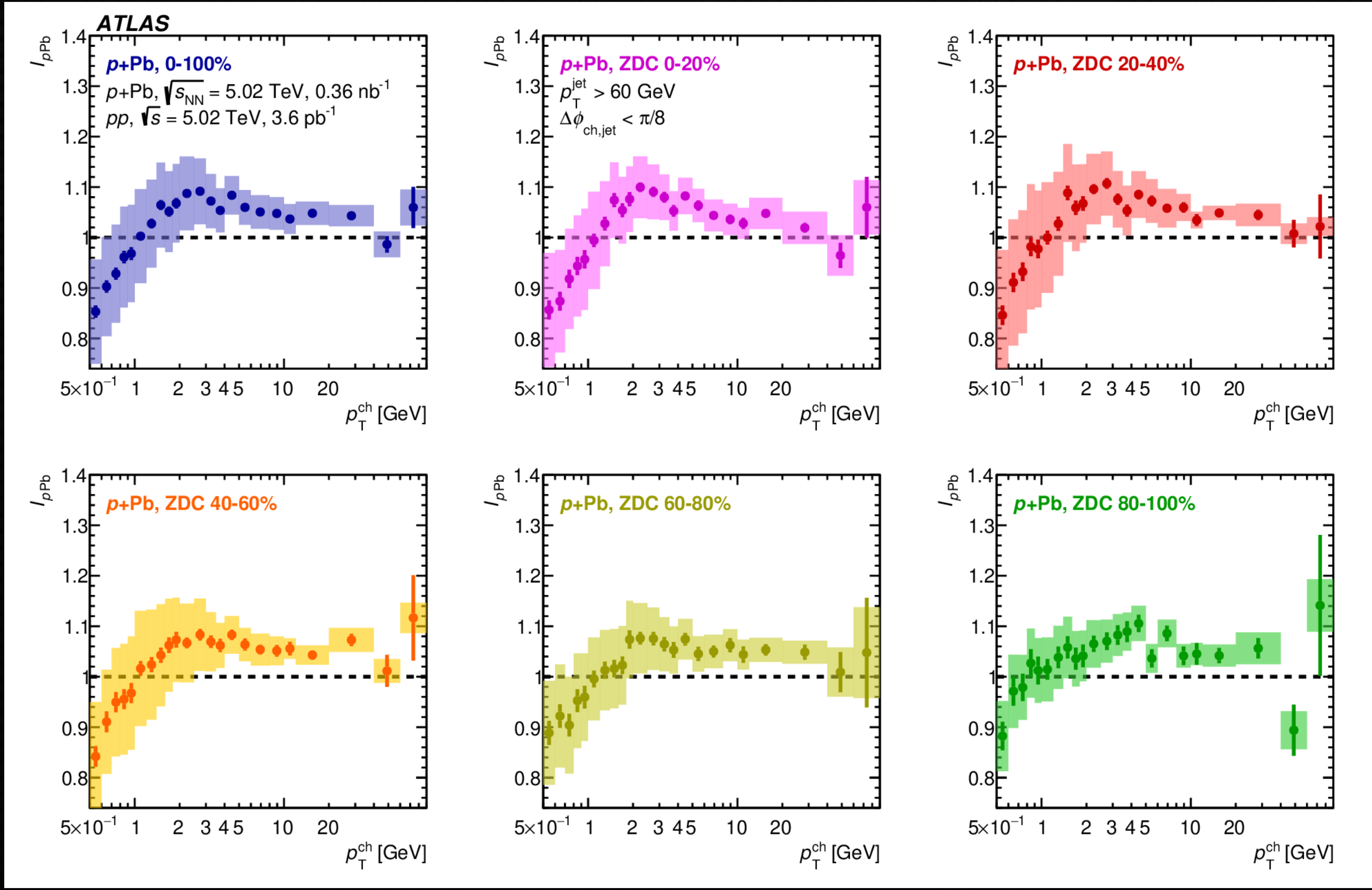


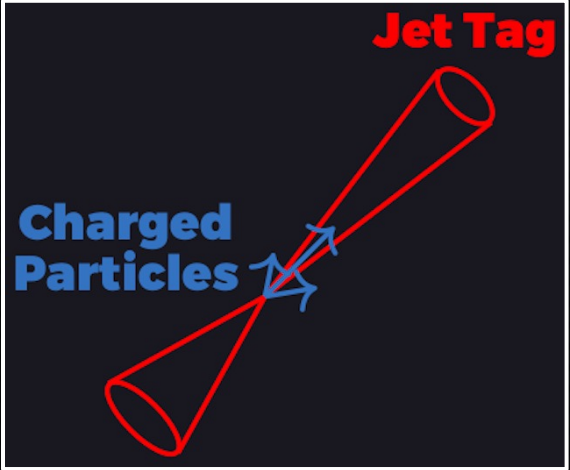


I_{pPb} "away-side" consistent with unity within a few percent for p_T > 4 GeV

Hint of enhancement near p_T ~ 2 GeV, but within systematic uncertainties

"Near-side" Jet-hadron I_{pPb}

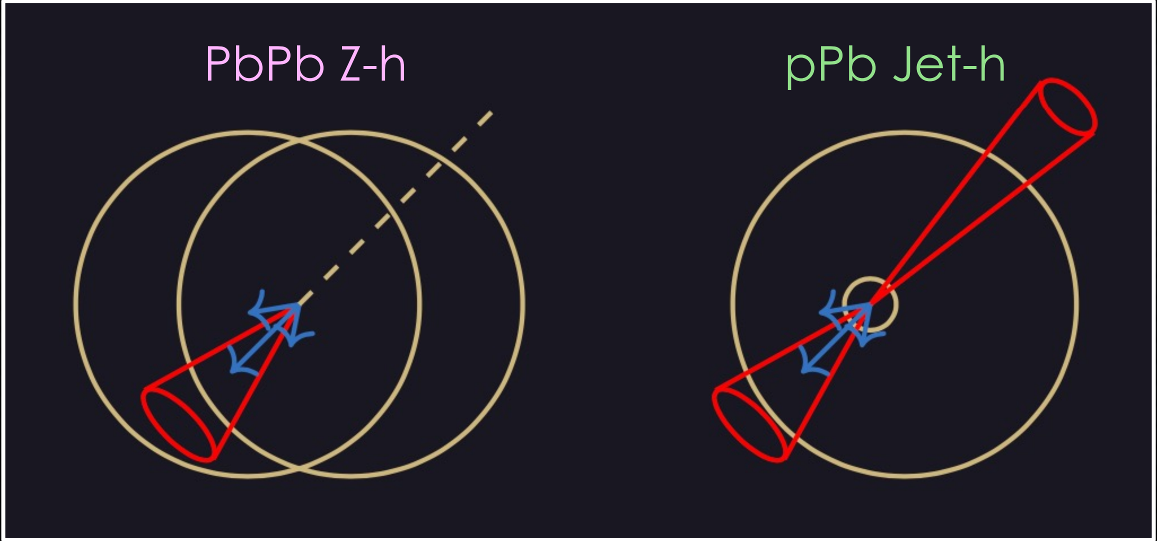




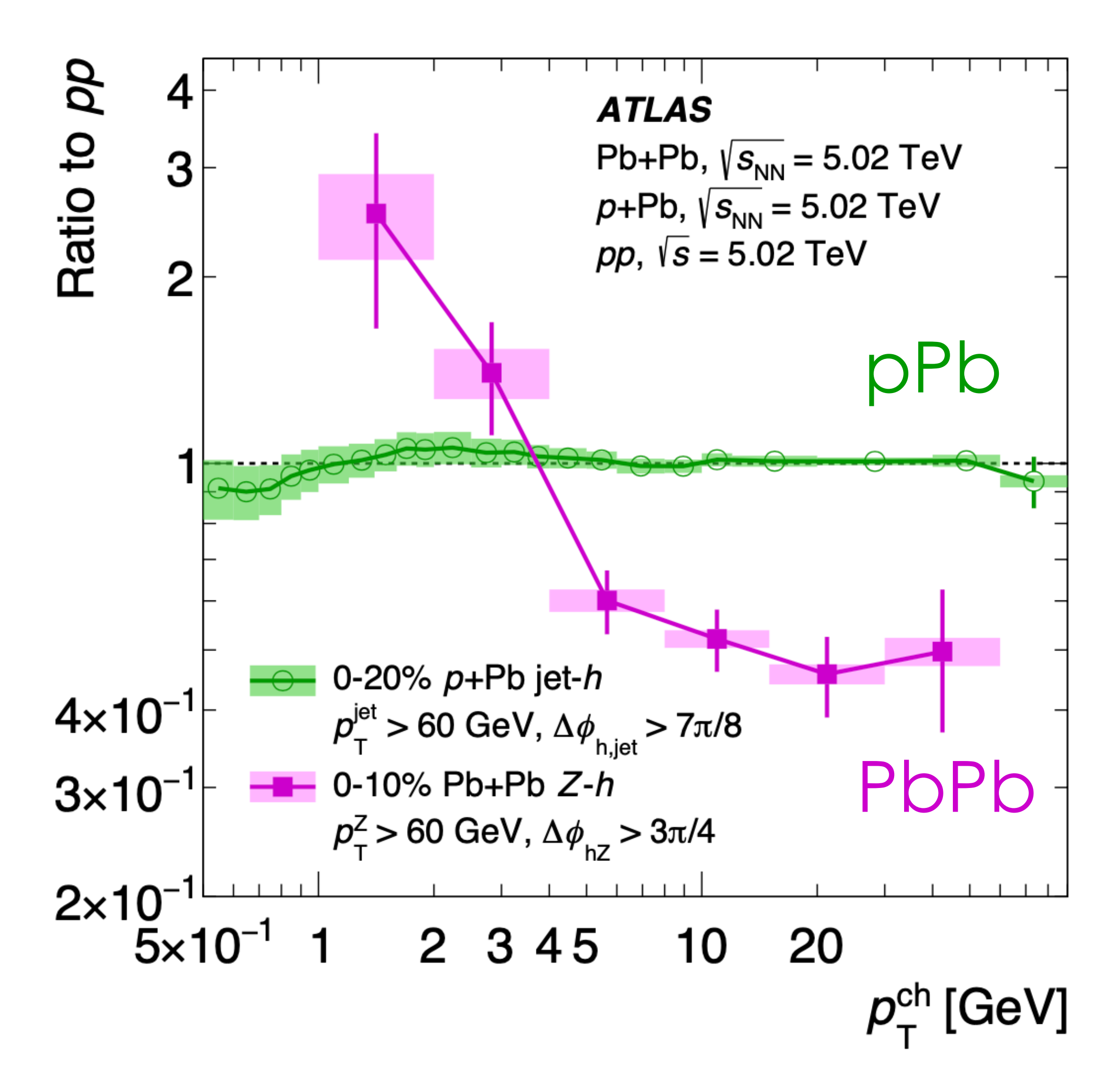
I_{pPb} "near-side" consistent with few percent enhancement above unity for $p_T > 4$ GeV

Hint of depletion at low $p_T < 1$ GeV

Pb+Pb and p+Pb: Setting the scale



No evidence of quenching in I_{pPb} observable



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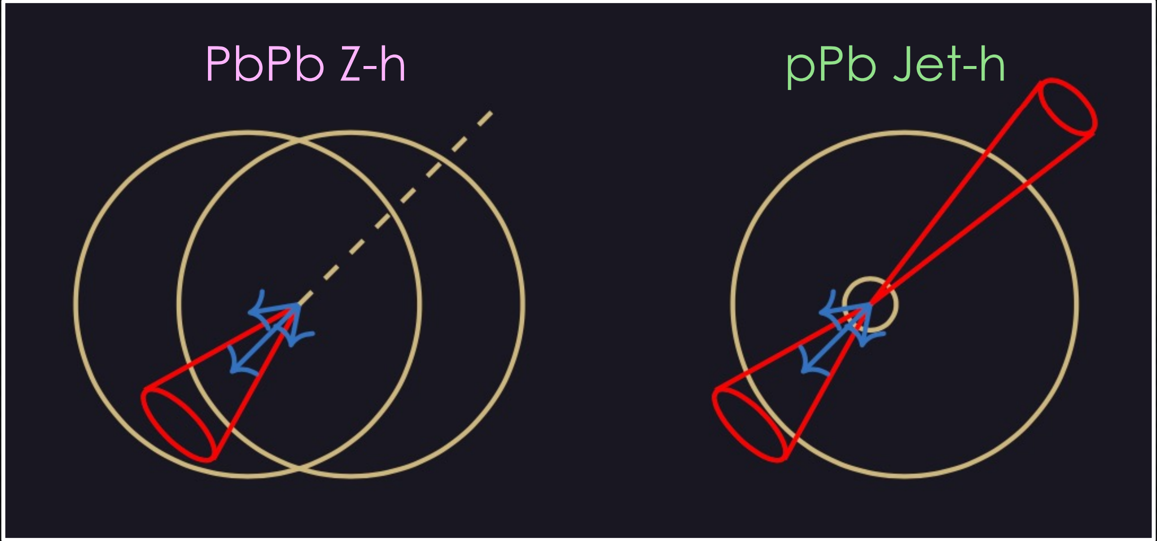
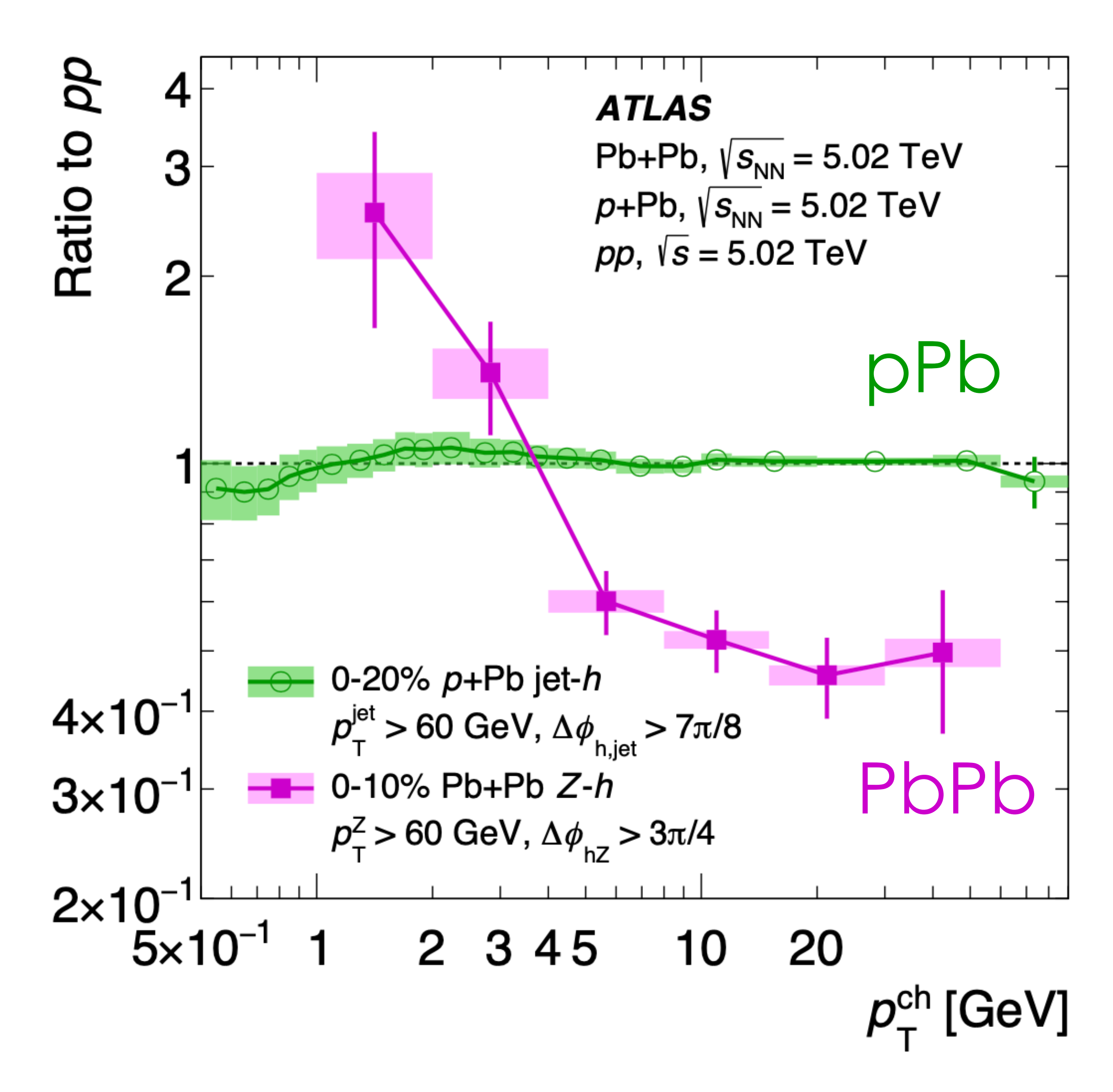
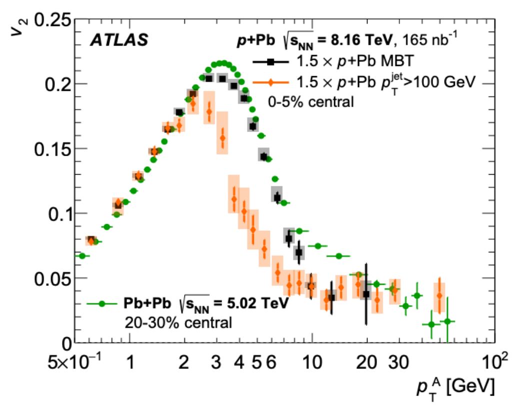


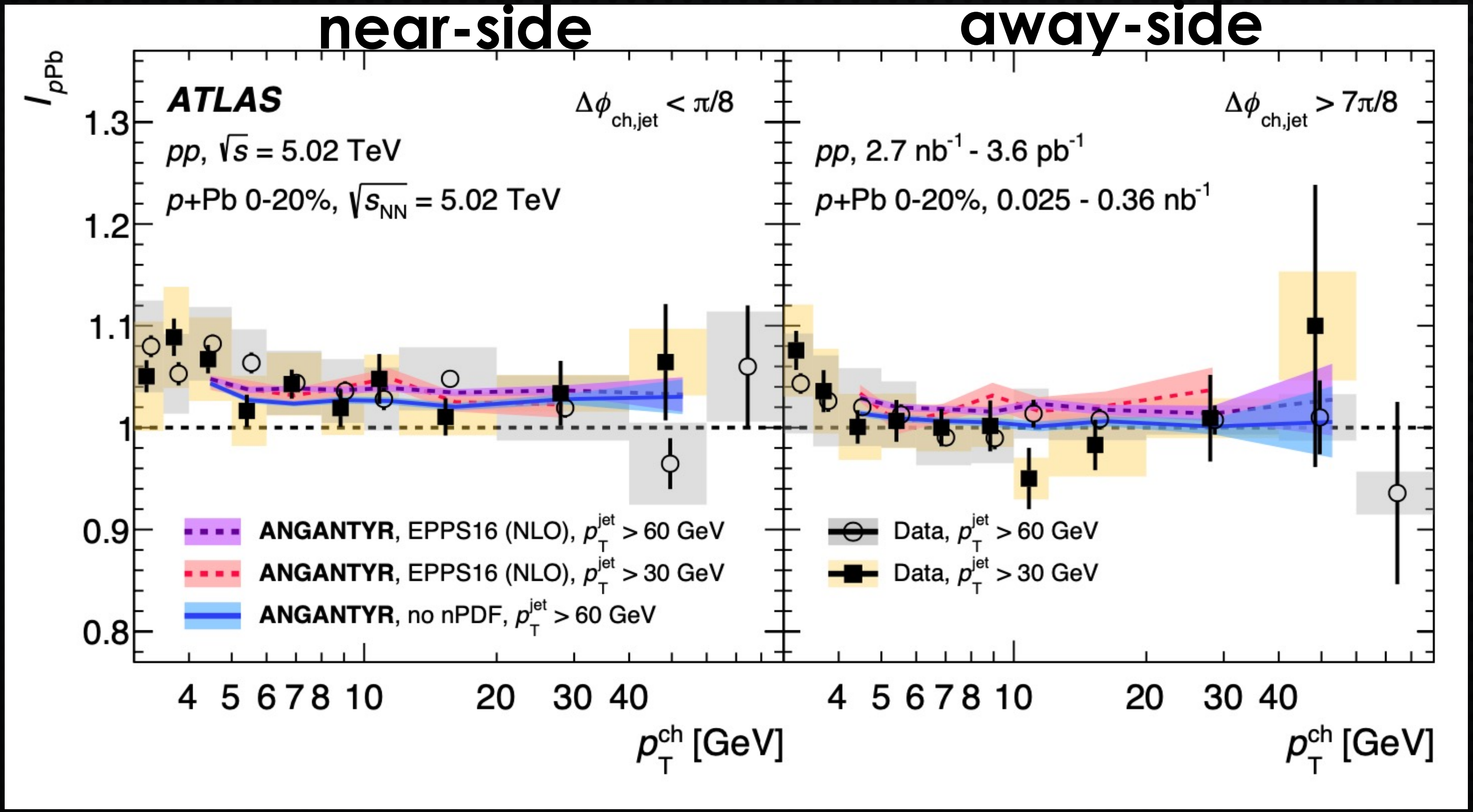


No evidence of quenching in I_{pPb} observable



But remember,
high p_T v_2 is comparable
pPb and PbPb,
and is explained by jet
quenching in Pb+Pb case

No quenching scenario (Angantyr) comparison



Angantyr: J. High Energ. Phys. (2018) 2018: 134

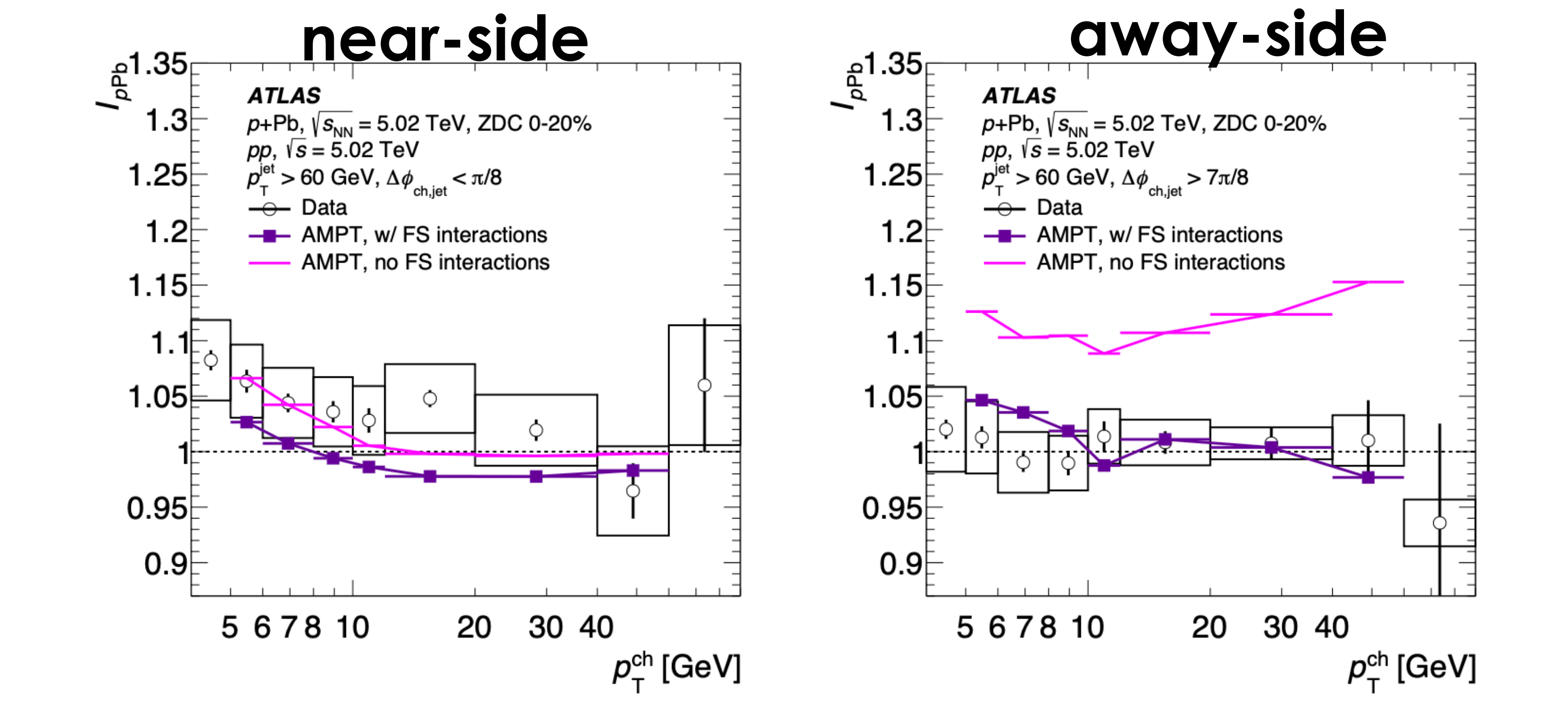
Angantyr – extension of PYTHIA for pA, AA physics. No final state interactions, i.e., no jet quenching

Consistent with data: ~3% enhancement on near side

Consistent with data: unity value on away side

No large effect from nPDF; Unclear source of enhancement

Final state interaction (AMPT) comparison



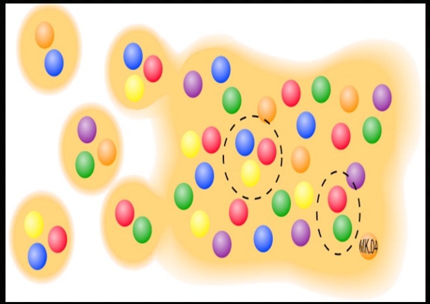
AMPT: Lin et al., Phys. Rev. C72 (2005) 064901

AMPT yields enhancement on away-side without final state interactions, that are cancelled by final state interaction to yield $I_{pPb} \sim 1$

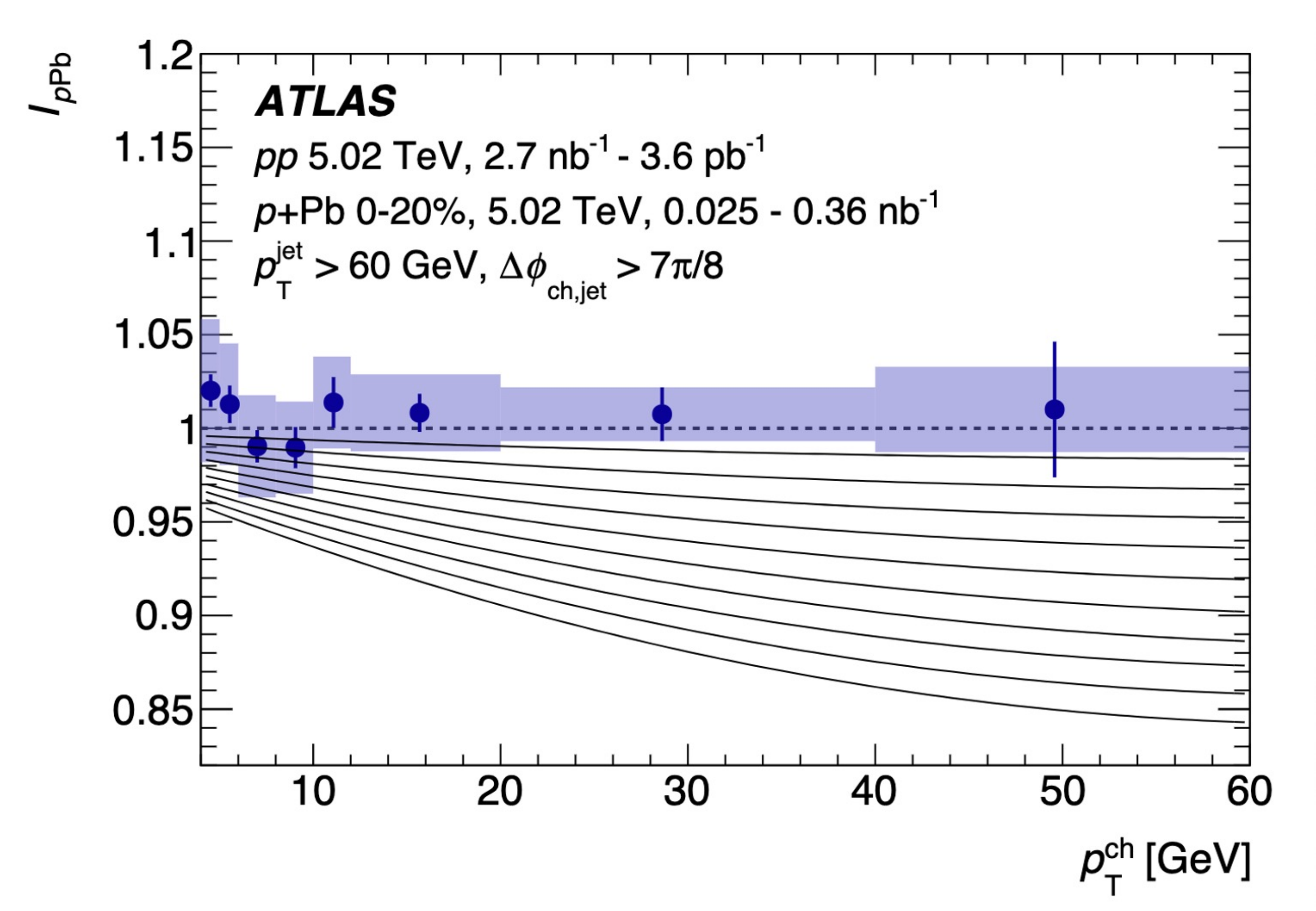
However, calculations yield $R_{pPb} \ll 1$

AMPT with string melting forms all hadrons via coalescence by spatial proximity, no fragmentation.

Not to be used for jet physics, particularly for p_T > 3 GeV…



Constraining parton energy loss in p+Pb



Parton energy loss constraint: 0.2 ± 0.5% and < 1.4% at 90% confidence level

Energy loss calculation

Test scenarios where initial parton loses a percentage of its energy before undergoing vacuum-like fragmentation.

Scenarios shown:

0.5%, 1.0%, 1.5%, 2.0% …, 5.0%

Summary

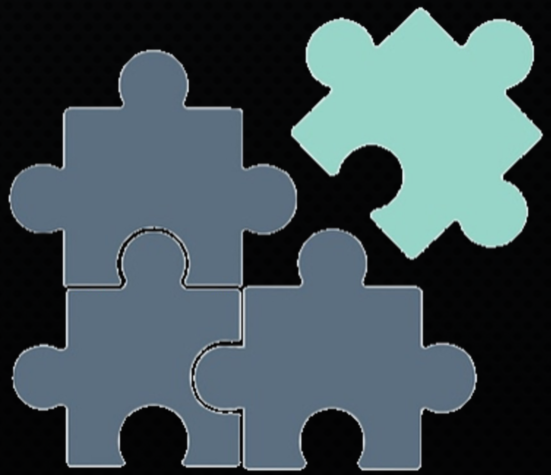
Strong constraints on jet quenching in centrality-dependent p+Pb collisions at 5.02 TeV from ATLAS

ATLAS paper accepted to Phys. Rev. Lett. [https://arxiv.org/abs/2206.01138]

- Per-jet hadron yields quantified via I_{pPb}
- Near-side yields show modest enhancement (few percent) as described by Angantyr
- Away-side yields consistent with unity and constrain energy lost by parton before fragmenting in vacuum to hadrons (p_T > 4 GeV)

Parton energy loss constraint: $0.2 \pm 0.5\%$
and < 1.4% at 90% confidence level

- Puzzle remains unsolved with regards to these non-jet quenching measures and high p_T v_2.



https://twiki.cern.ch/twiki/bin/view/AtlasPublic/HeavyIonsPublicResults

EXTRA SLIDES

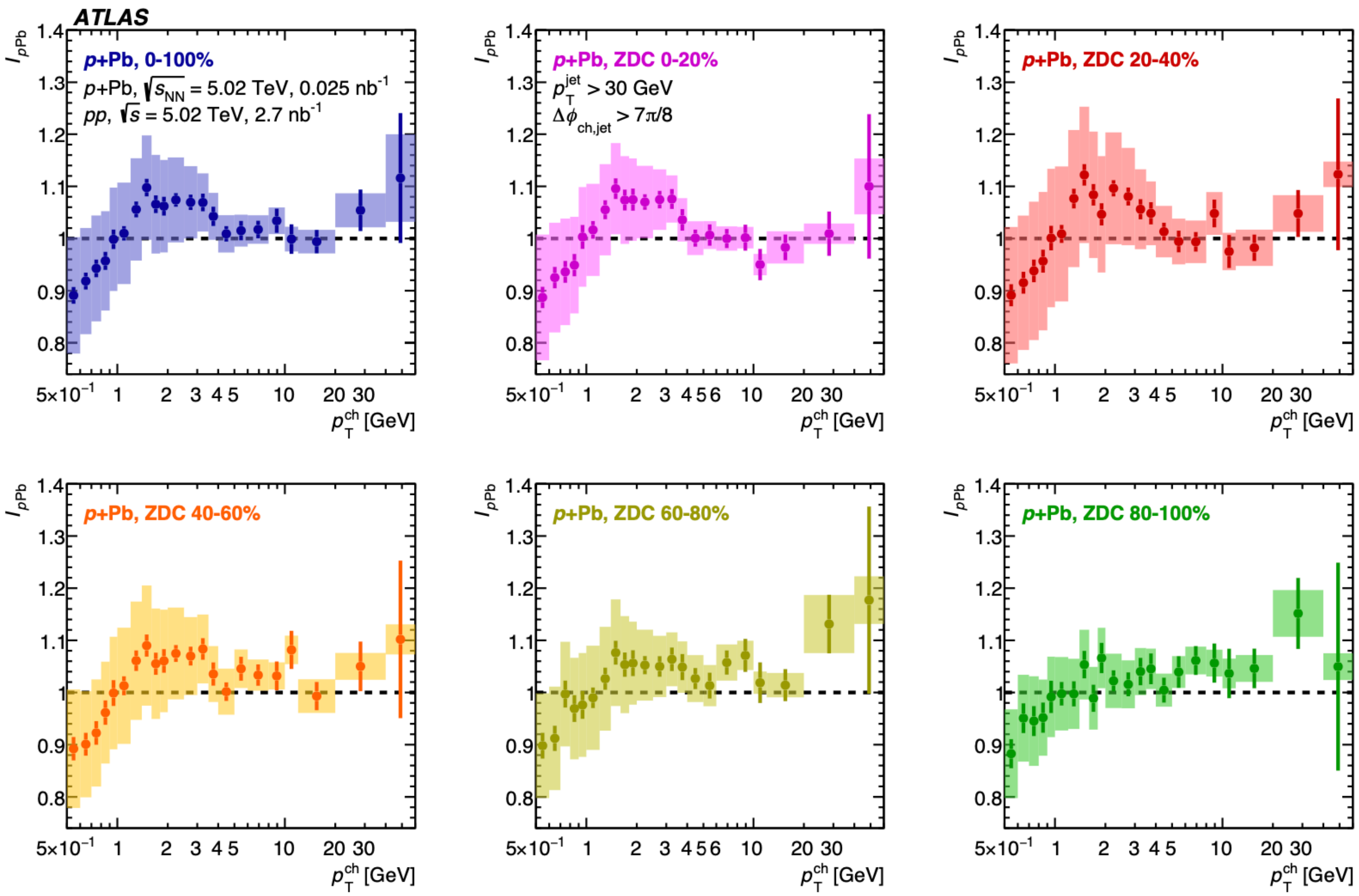
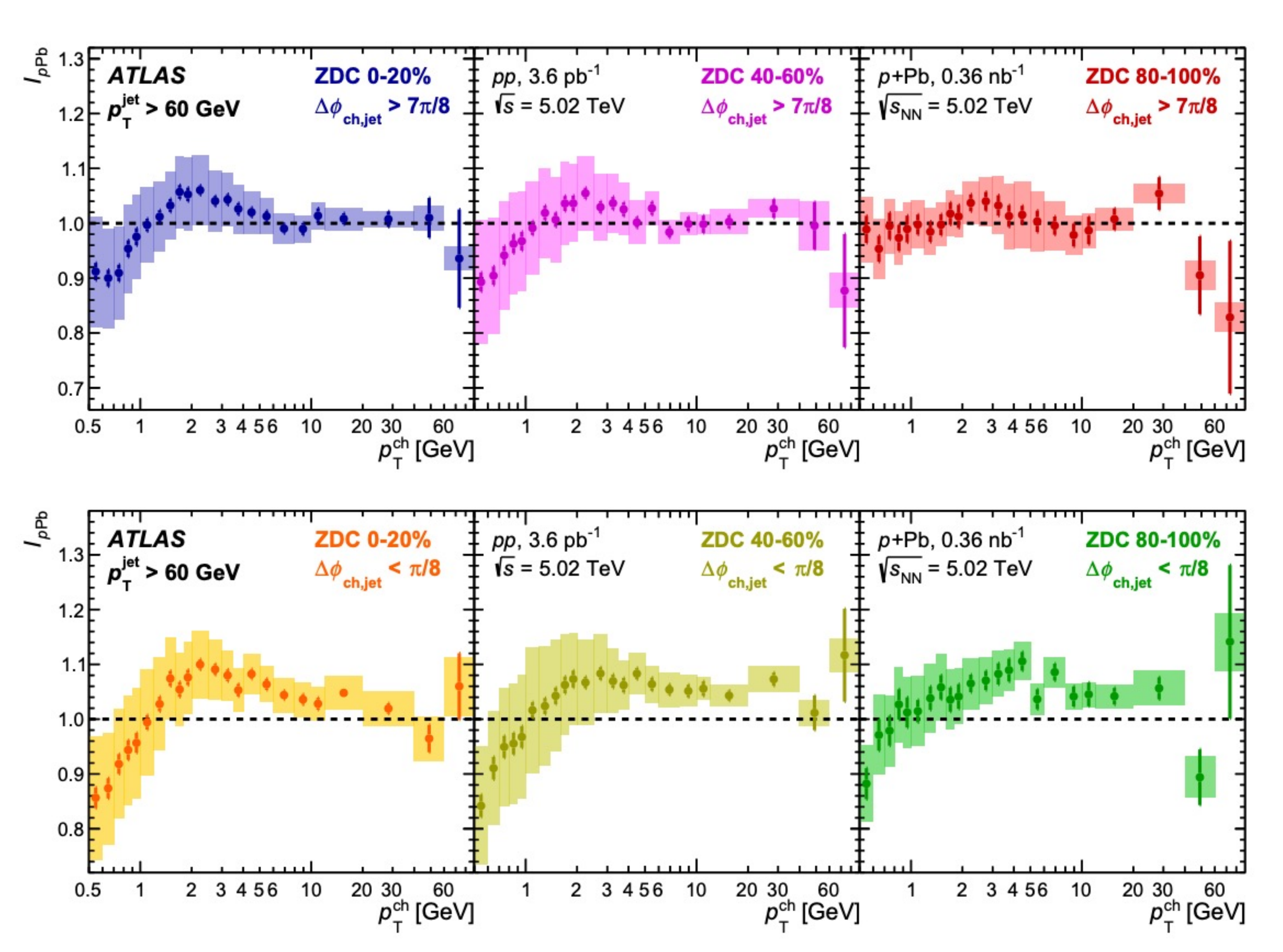
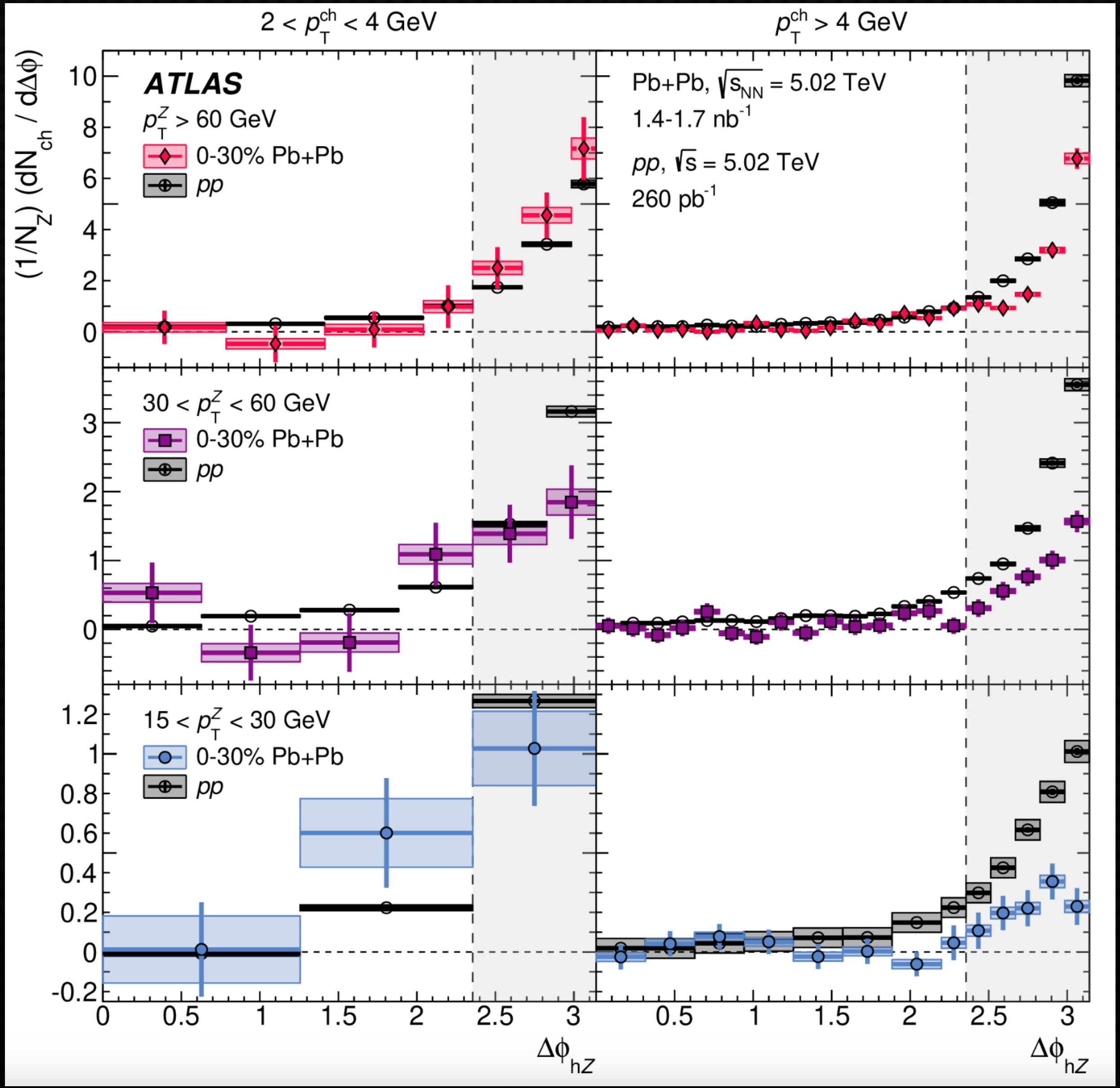


Figure 10: The ratio of per-jet charged particle yield in p+Pb and pp collisions, $I_{p\mathrm{Pb}}$, for hadrons opposite to a $p_{\mathrm{T}}^{\mathrm{jet}} > 30$ GeV jet ($\Delta\phi_{\mathrm{ch,jet}} > 7\pi/8$). Results are shown for different ZDC-selected p+Pb centralities in each panel. Statistical uncertainties are shown as vertical lines and systematic uncertainties as filled boxes.

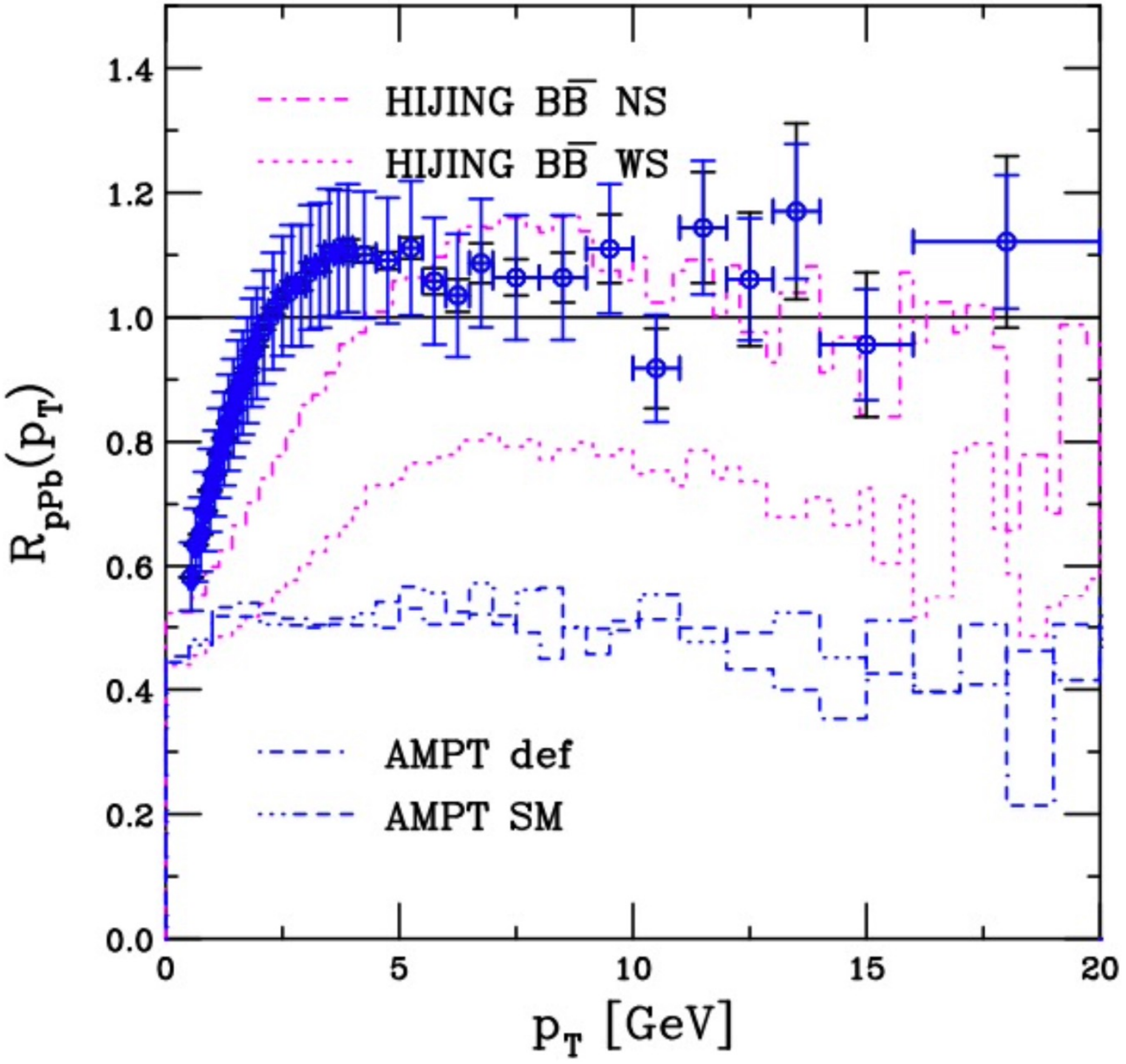


ATLAS
p_T^{jet} > 60 GeV
ZDC 0-20%
$\Delta\phi_{ch,jet} > 7\pi/8$
pp, 3.6 pb^{-1}
$\sqrt{s}$ = 5.02 TeV
ZDC 40-60%
$\Delta\phi_{ch,jet} > 7\pi/8$
p+Pb, 0.36 nb^{-1}
$\sqrt{s_{NN}}$ = 5.02 TeV
ZDC 80-100%
$\Delta\phi_{ch,jet} > 7\pi/8$
ATLAS
p_T^{jet} > 60 GeV
ZDC 0-20%
$\Delta\phi_{ch,jet} < \pi/8$
pp, 3.6 pb^{-1}
$\sqrt{s}$ = 5.02 TeV
ZDC 40-60%
$\Delta\phi_{ch,jet} < \pi/8$
p+Pb, 0.36 nb^{-1}
$\sqrt{s_{NN}}$ = 5.02 TeV
ZDC 80-100%
$\Delta\phi_{ch,jet} < \pi/8$
I_{pPb}
p_T^{ch} [GeV]



$2 < p_T^{ch} < 4$ GeV
$p_T^{ch} > 4$ GeV
ATLAS
$p_T^Z > 60$ GeV
0-30% Pb+Pb
pp
Pb+Pb, $\sqrt{s_{NN}}$ = 5.02 TeV
1.4-1.7 nb^{-1}
pp, $\sqrt{s}$ = 5.02 TeV
260 pb^{-1}
$30 < p_T^Z < 60$ GeV
0-30% Pb+Pb
pp
$15 < p_T^Z < 30$ GeV
0-30% Pb+Pb
pp
$(1/N_Z)\ (dN_{ch}\ /\ d\Delta\phi)$
$\Delta\phi_{hZ}$
$\Delta\phi_{hZ}$

https://arxiv.org/pdf/1301.3395.pdf



Strong constraints on jet modification in centrality-dependent p+Pb collisions by ATLAS

30 Mar 2023, 10:20

20m

Stadthalle (Aschaffenburg)

Talk

Jets and their modifi...

Parallel: Jets and their ...

15’ + 5’ (Q&A)

Speaker

Jamie Nagle (University of Colora...

Description

Small systems such as pp or p+Pb collisions exhibit evidence of collective behavior strikingly similar to that in Pb+Pb collisions. However, while jet quenching is readily observed in Pb+Pb collisions, no evidence has been found in small systems to date, raising fundamental questions about the nature of the system created in these collisions. This talk reports a measurement by the ATLAS experiment at the LHC which sets new, precise constraints on the possible amount of jet modification in central p+Pb events. To avoid possible biases on the centrality classification of p+Pb events, the collision centrality is categorized by the energy deposited by forward neutrons from the struck nucleus in the Zero Degree Calorimeter (ZDC). The measurement reports the yield of charged hadrons near and opposite in azimuth to reconstructed jets in p+Pb and pp collisions at 5.02 TeV. The ratio between p+Pb and pp, called the I_{pPb}, is consistent with unity within a few percent for hadrons with $p_{\mathrm{T}} > 4$ GeV at all centralities. These data provide new, strong constraints and can be used to set a quantitative limit on jet modification in central p+Pb collisions within a simple model.