Jet fragmentation and substructure correlations in pp and Pb-Pb at $\sqrt{s_{NN}}$ = 5.02 TeV with ALICE

Bas Hofman

On behalf of the **ALICE collaboration**

Utrecht University

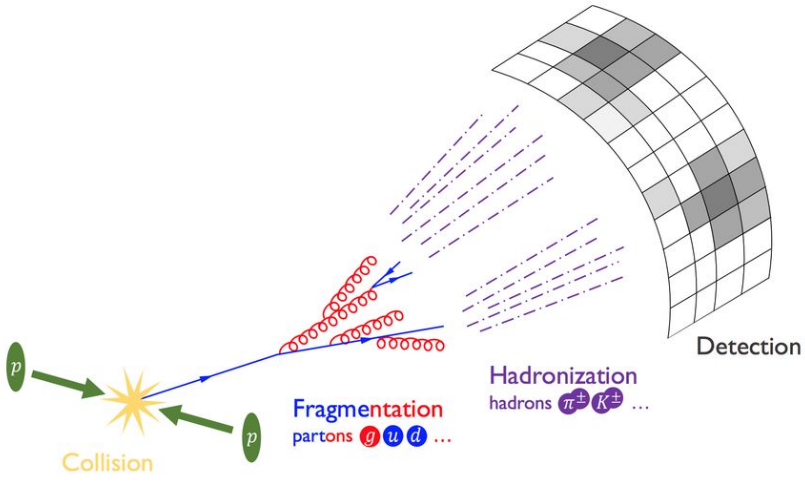
23 September 2024

Study of jet substructure correlations

Vacuum QCD:

Fragmentation: j_T vs. z

- Multidimensional test on QCD jet fragmentation
- Baseline for high mult. pp, p-Pb and Pb-Pb studies

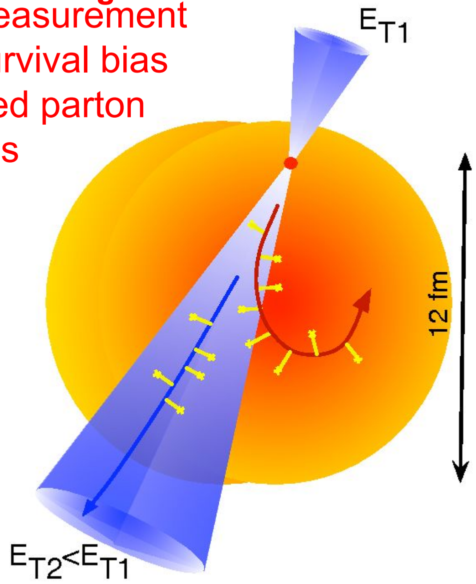


Cartoon by Eric M. Metodiev

QCD matter:

Soft Drop: θ_g vs. z_g

- Multidimensional measurement to disentangle jet survival bias from medium induced parton shower modifications



Cartoon from arXiv:1107.1964

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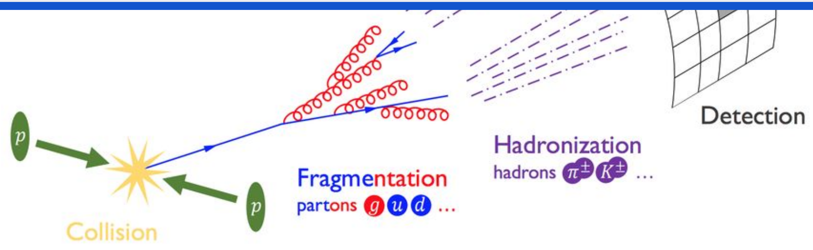
Also check **tomorrow's session 1 poster** by **Jaehyeok Ryu** who presents a new ALICE measurement of jet fragmentation!!



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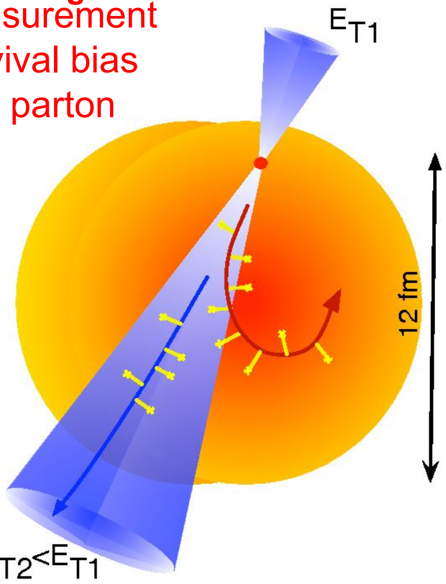

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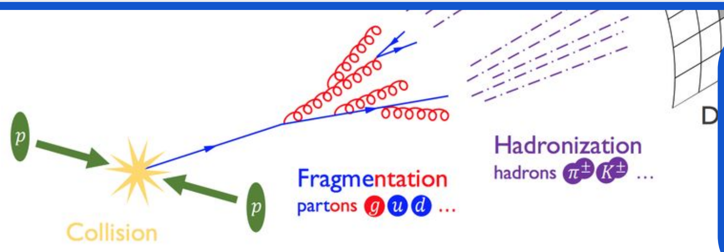

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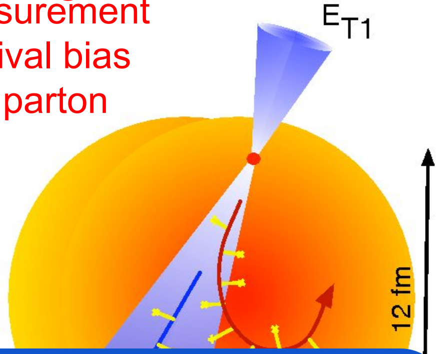
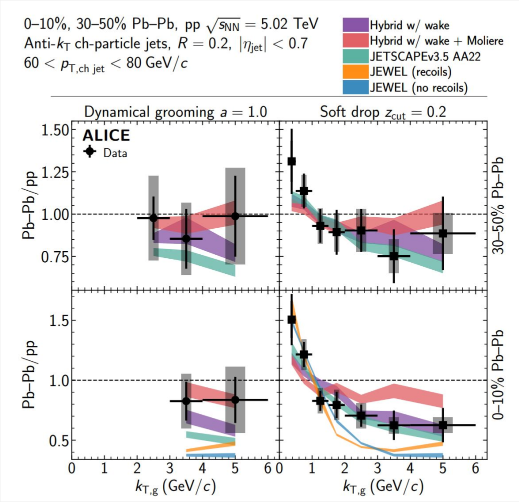


<u>Tomorrow at 9</u> Anjali Nambrath will also present the first ALICE measurements of EECs in pp and p-Pb!

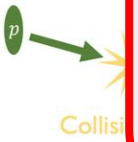
Study of jet substructure correlations

New ALICE paper searching for scatterings off of quasi particles in QGP using groomed jets (SD + Dynamical Grooming) arXiv:2409.12837



Fragme

- Multidimen
- Baseline f



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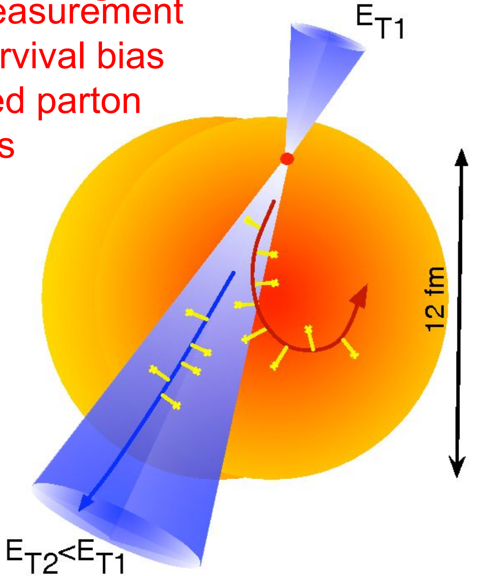

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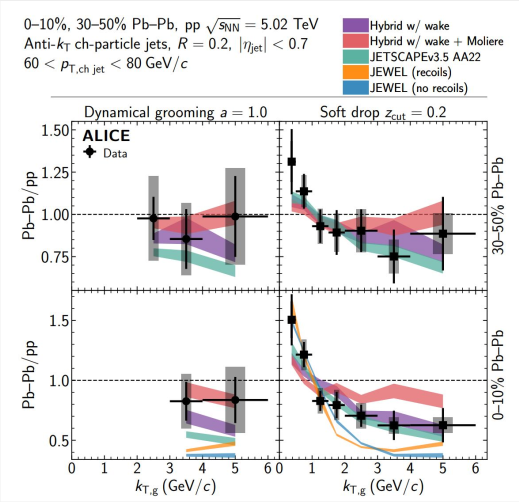

Soft Drop: θ_g vs. z_g

Models suggest observable sensitive to Molière scattering but no evidence so far

May be masked by yield suppression due to jet energy loss

More work to do!

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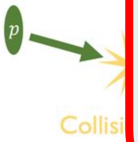
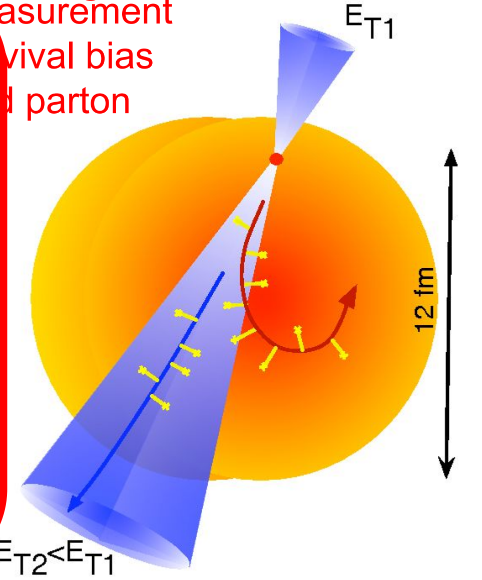
vival bias
d parton





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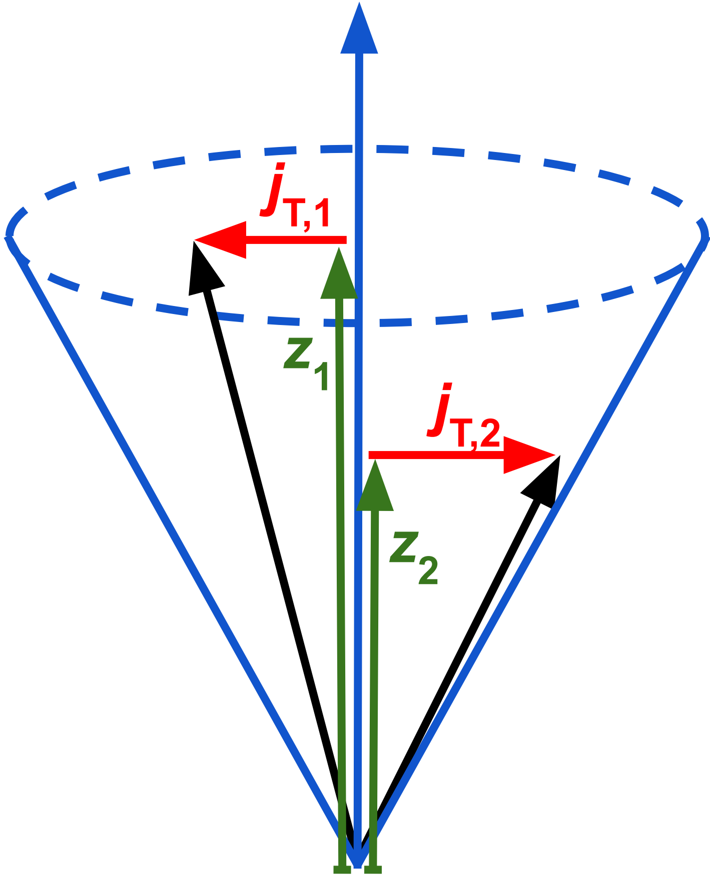
Jet fragmentation: Observable

- **Measure transverse momentum (j_T) of particles in jets differentially in jet momentum fraction of particles (z)**



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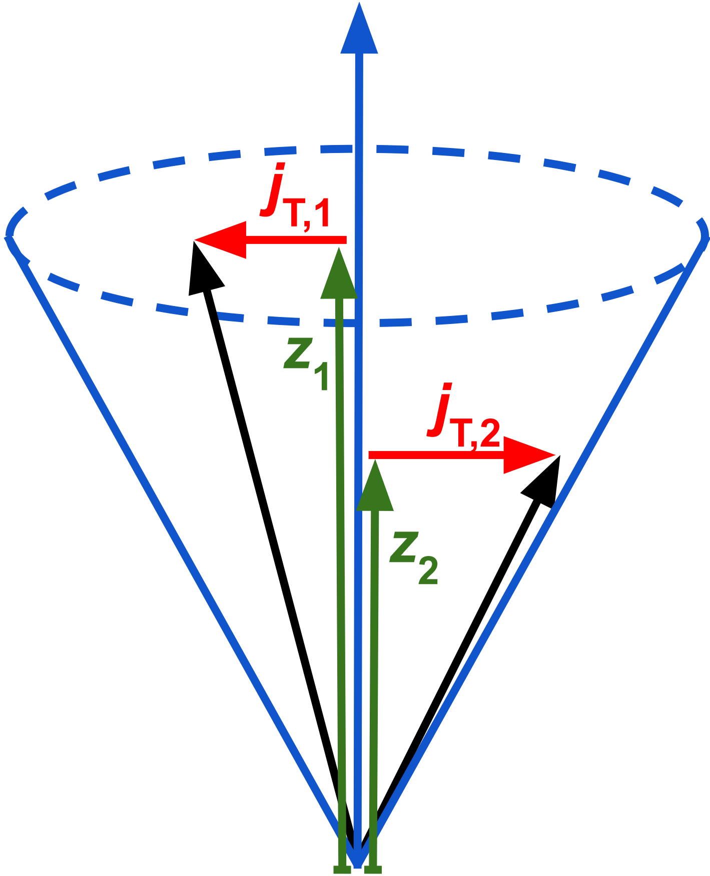

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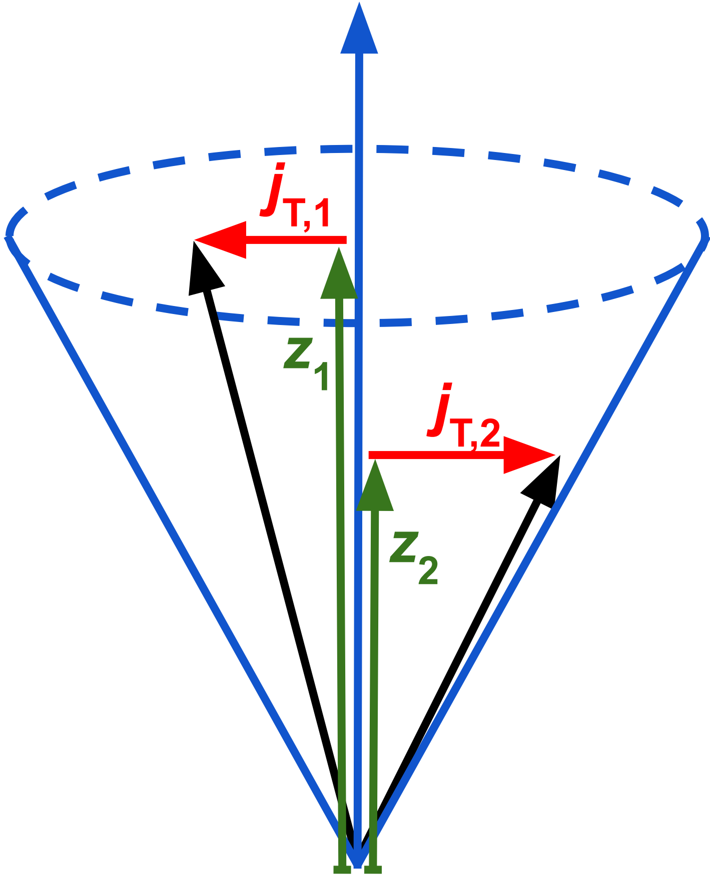
- Possibly disentangle hadronization and perturbative jet fragmentation

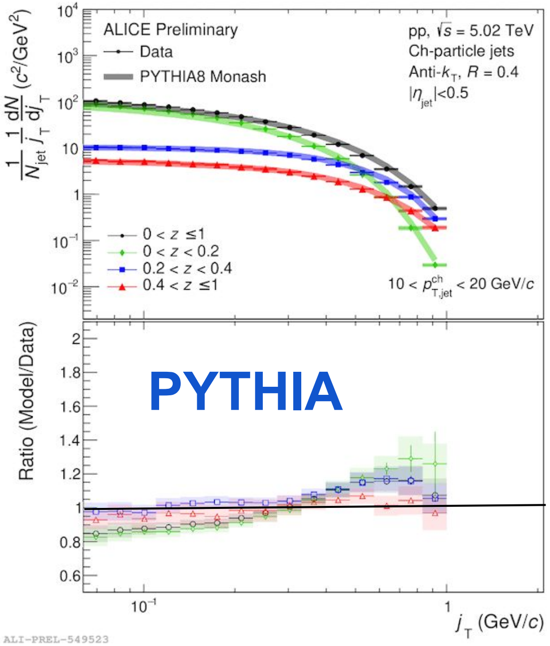


Jet fragmentation: Model comparison

- j_T distributions compared to model predictions

- Measured differentially for: Inclusive, low, mid and high z

$10 < p_{T,jet} < 20$ GeV/c



PYTHIA: arXiv:1410.3012

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- PYTHIA over estimates low z, high j_T

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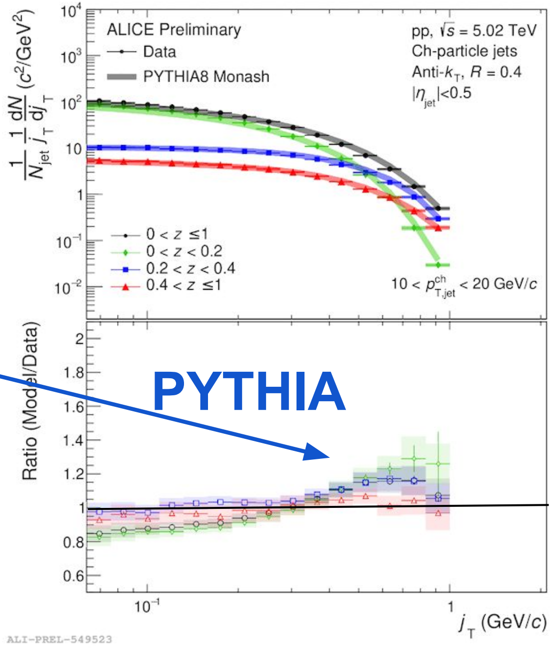

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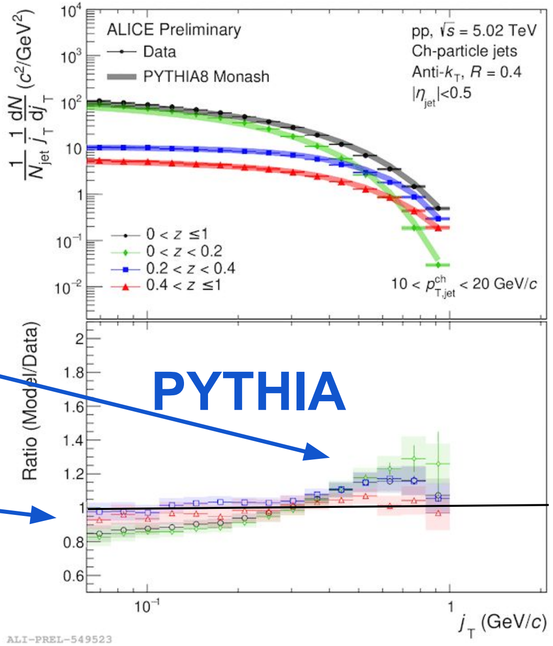

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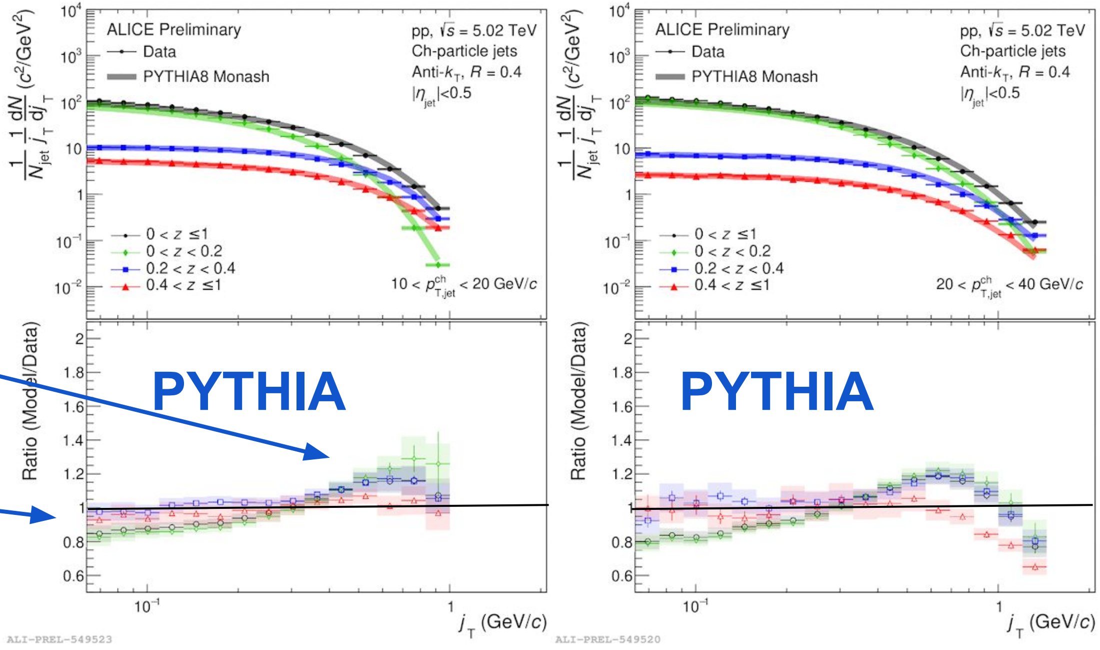
10 < $p_{T,jet}$ < 20 GeV/c 20 < $p_{T,jet}$ < 40 GeV/c



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- High j_T suppressed for high p_T

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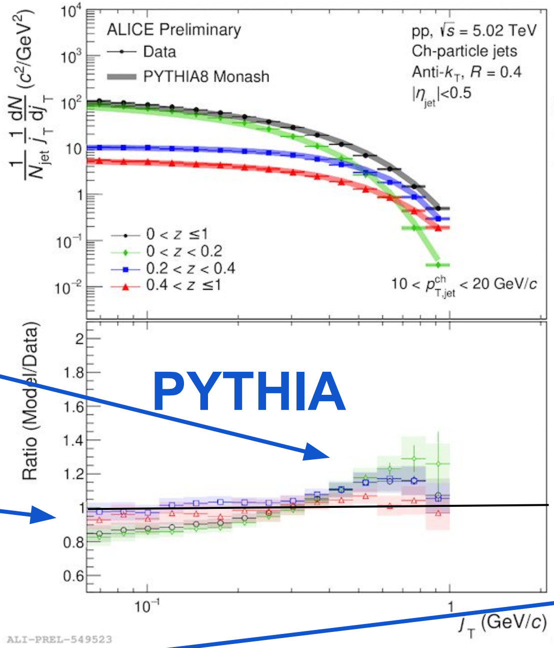
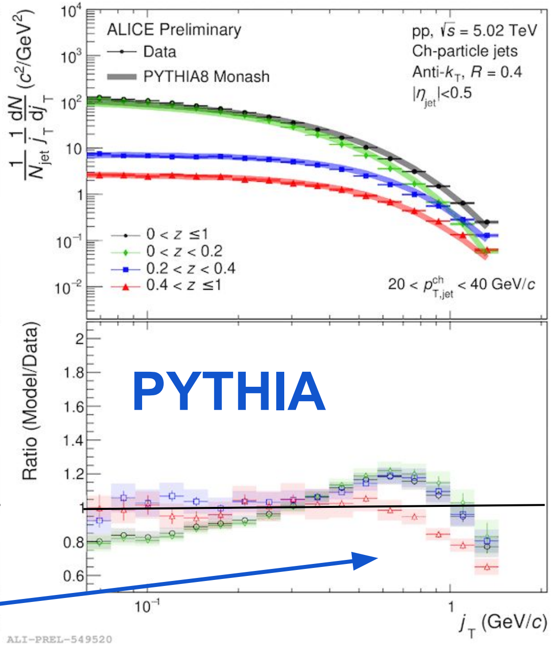


$20 < p_{T,jet} < 40$ GeV/c



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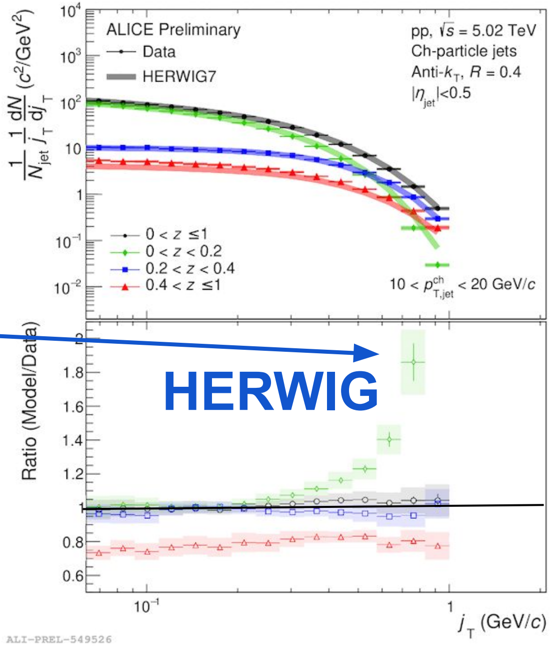

HERWIG: arXiv:0803.0883

- j_T distributions compared to model predictions
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- HERWIG underestimates high z region

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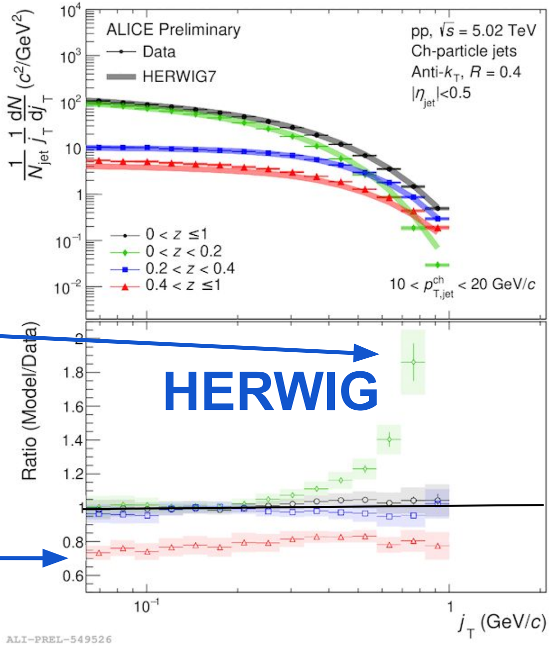

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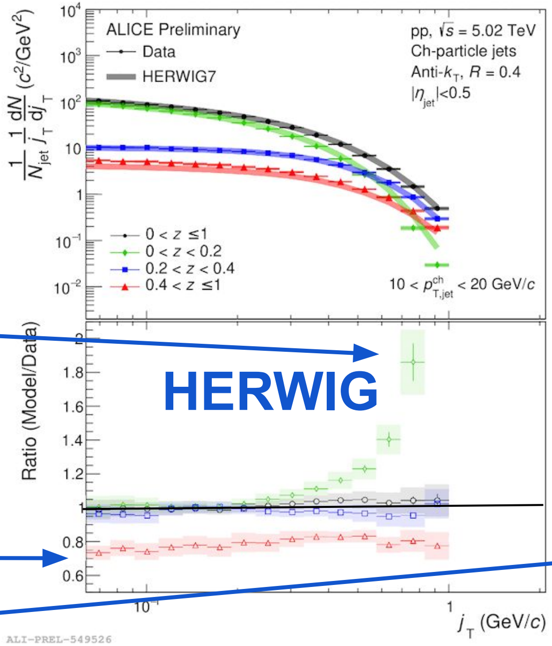

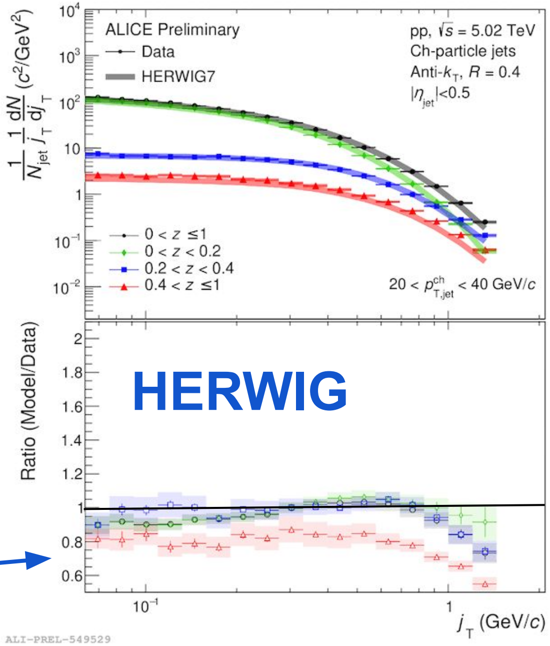

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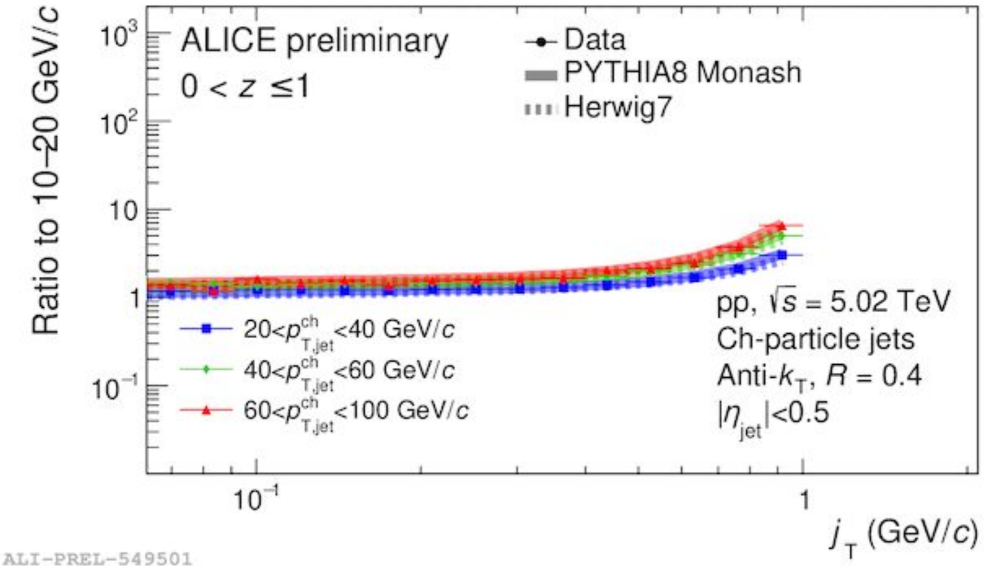
Jet fragmentation: p_T dependence

Ratio to 10-20 GeV/c

Inclusive *z*

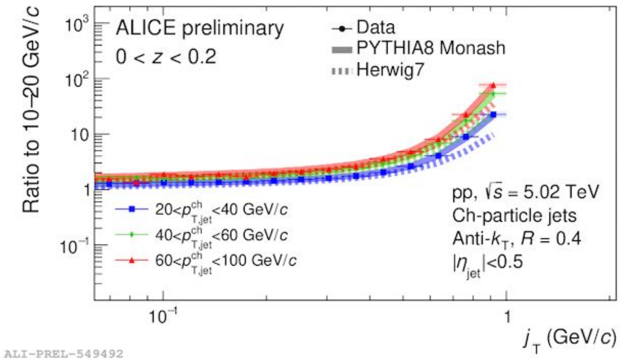


Small dependence on $p_{T,jet}$, decreases with $p_{T,jet}$

Jet fragmentation: p_T dependence

Ratio to 10-20 GeV/c

Low *z*



Models predict $p_{T,jet}$ dependence in all *z* regions

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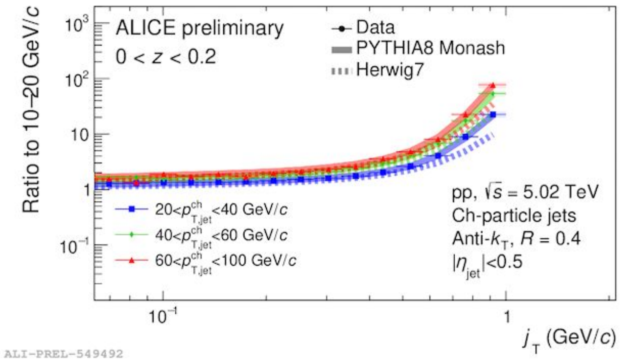
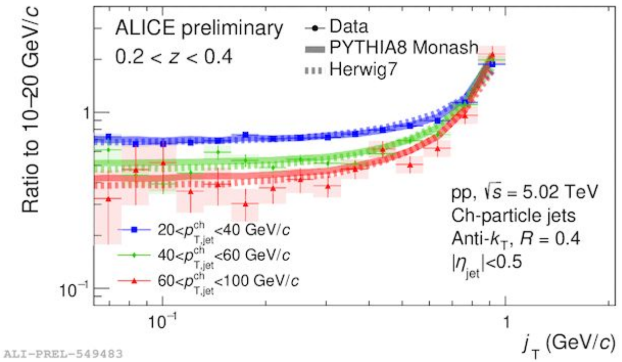


Mid *z*



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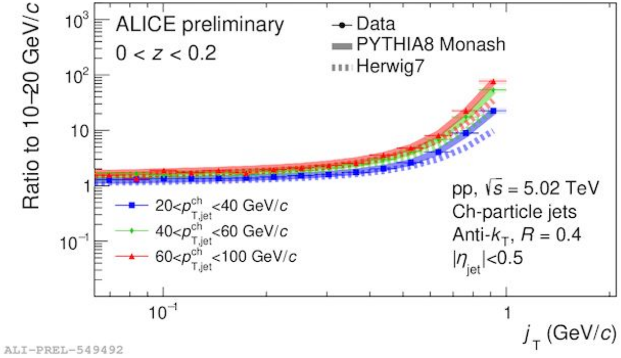

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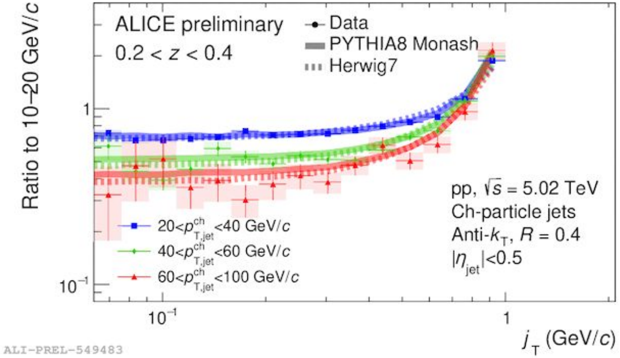

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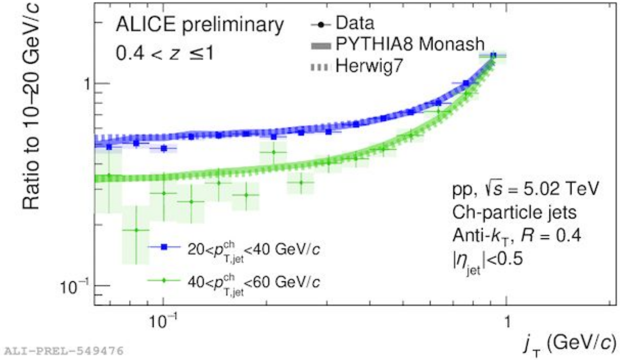
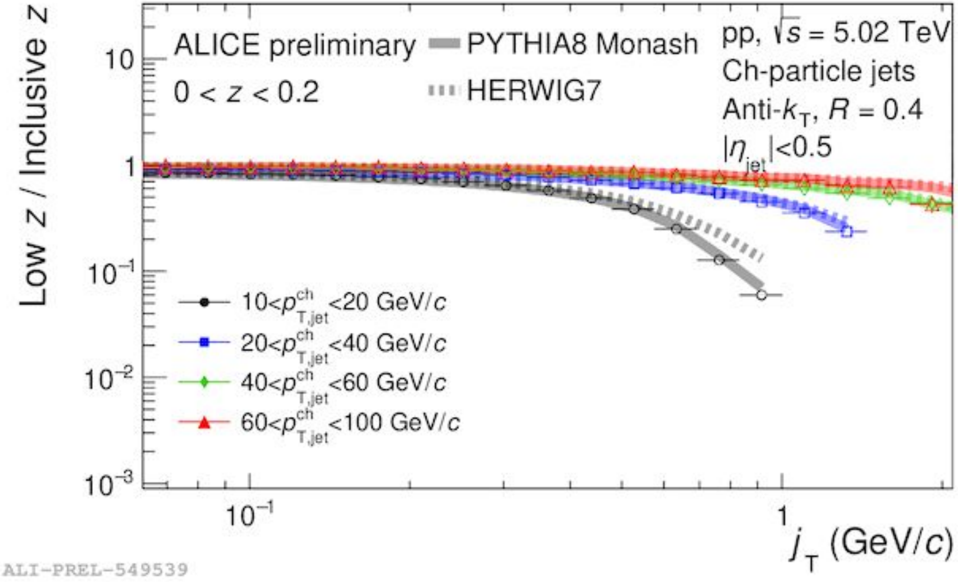


Models predict $p_{T,jet}$ dependence in all *z* regions

Jet fragmentation: Ratio to inclusive

Models qualitatively explain *z* dependence

Low *z* / Inclusive *z*



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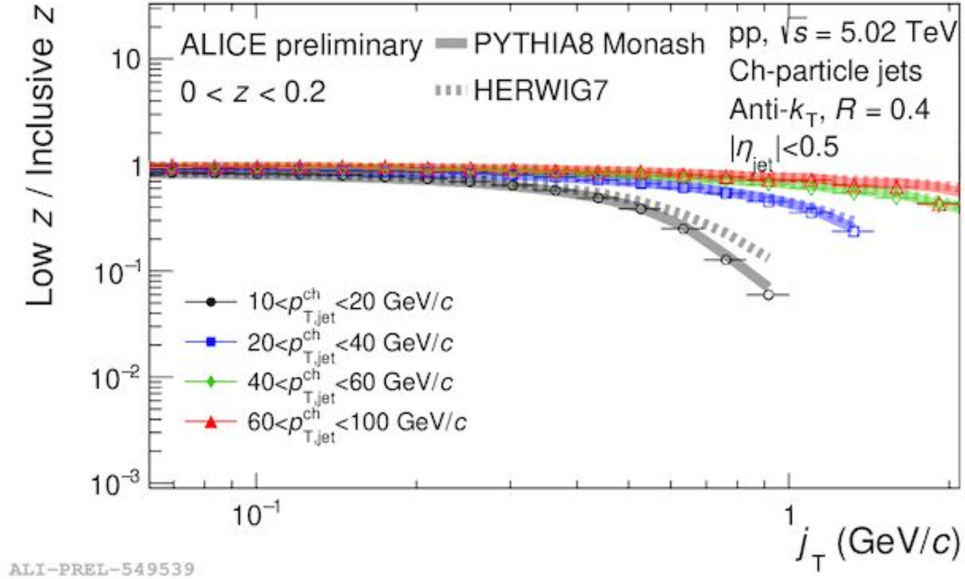

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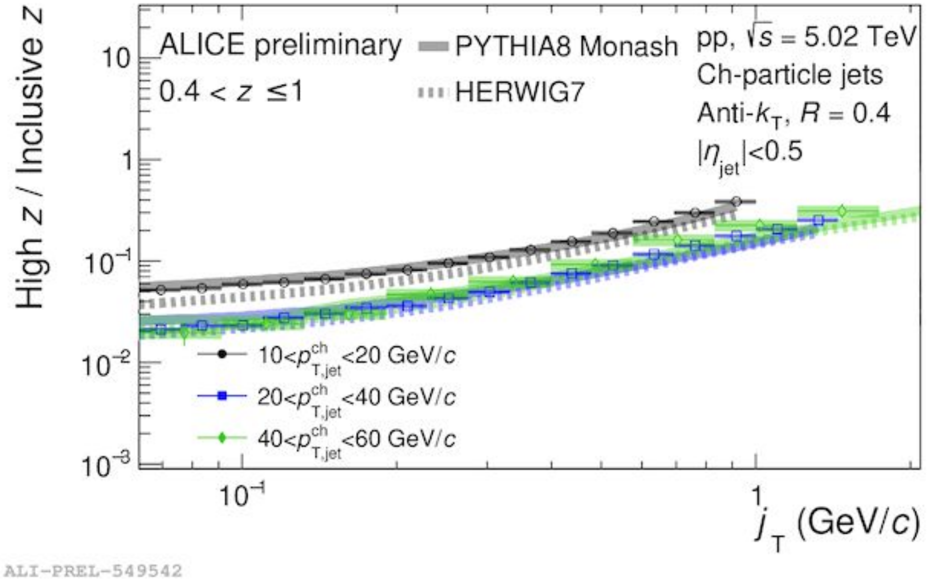
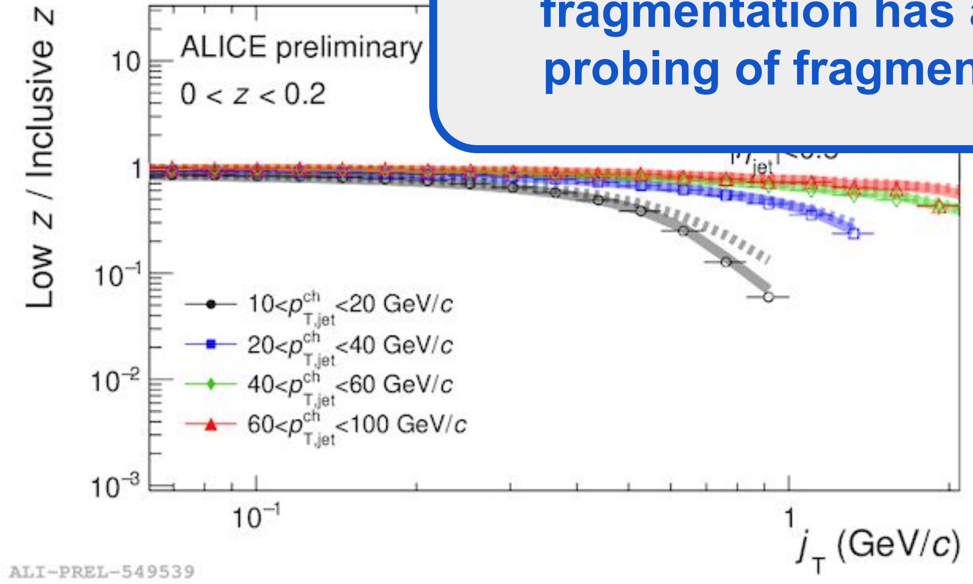
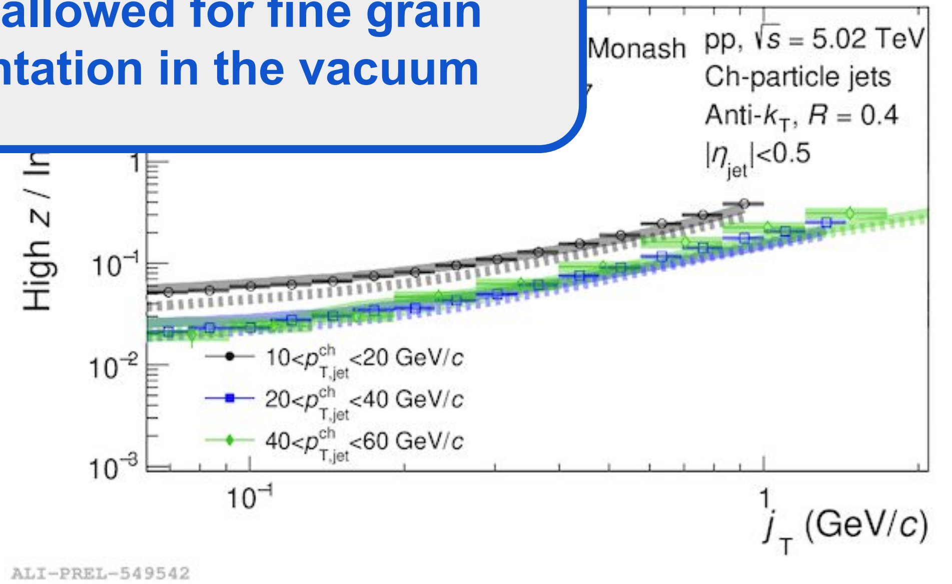


Models qualitatively explain z dependence

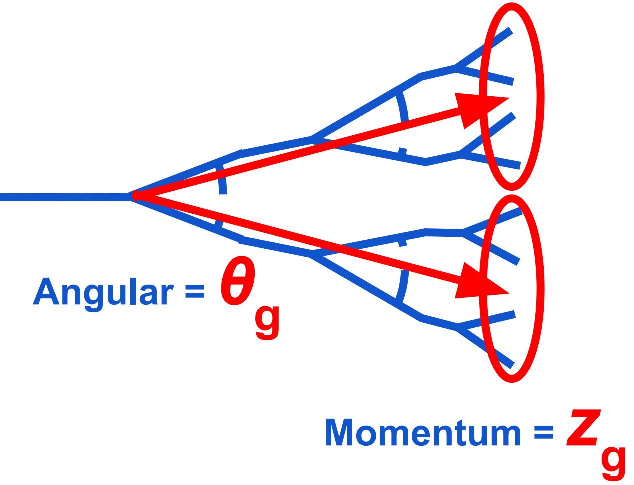
Low z / Inclusive z ... **High z / Inclusive z**





Multi-dimensional study of jet fragmentation has allowed for fine grain probing of fragmentation in the vacuum

Study correlation of Soft Drop θ_g and z_g



z_{cut} = 0.2, β = 0

Soft Drop: arXiv:1402.2657

Substructure correlations

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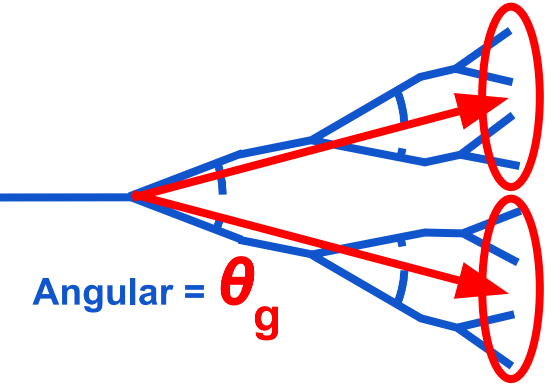

Angular = θ_g

Momentum = z_g

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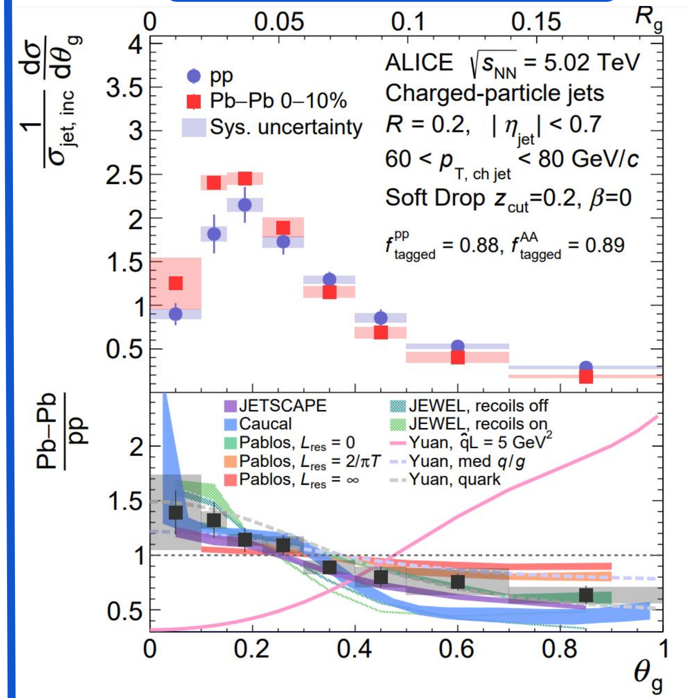
Previous ALICE measurement



Jet narrowing:

Previous ALICE result: arXiv:2107.12984

Substructure correlations

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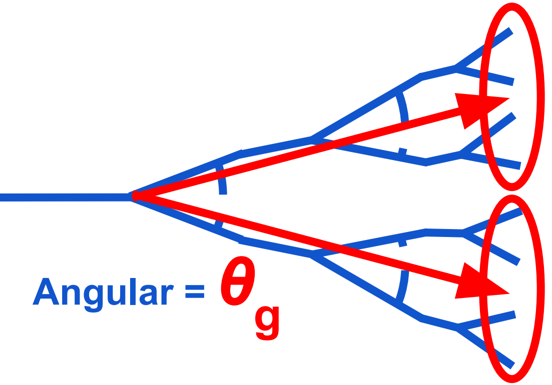

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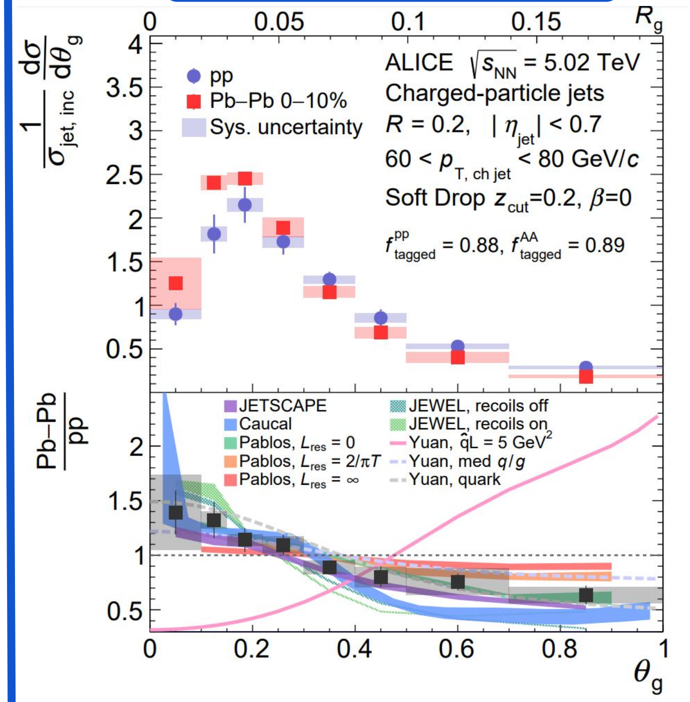

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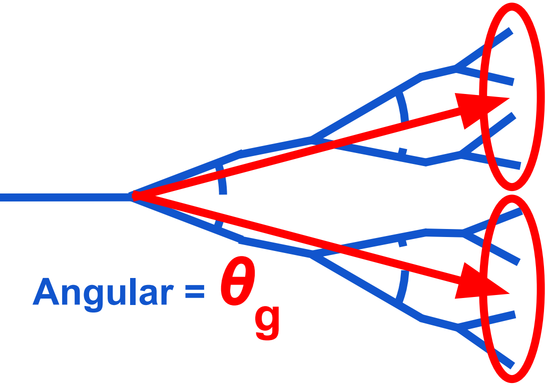

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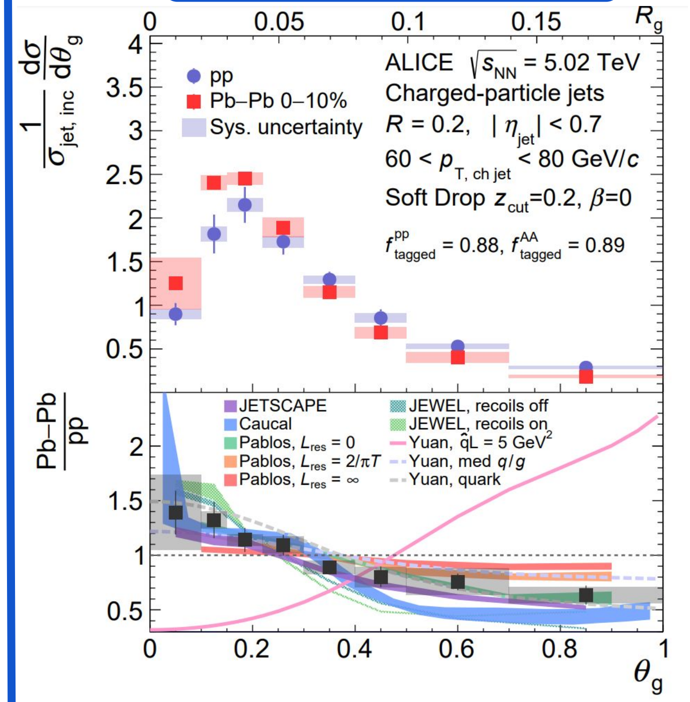

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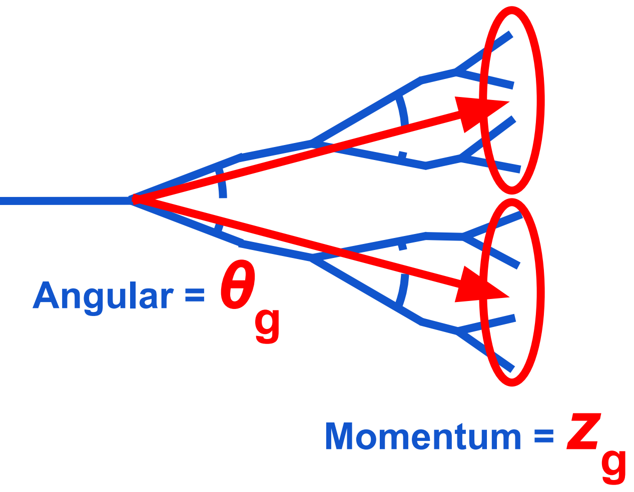

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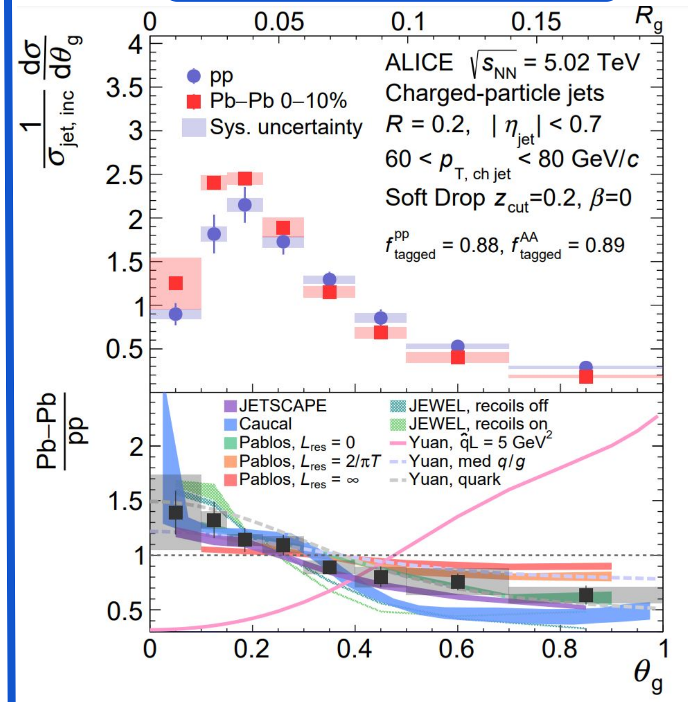

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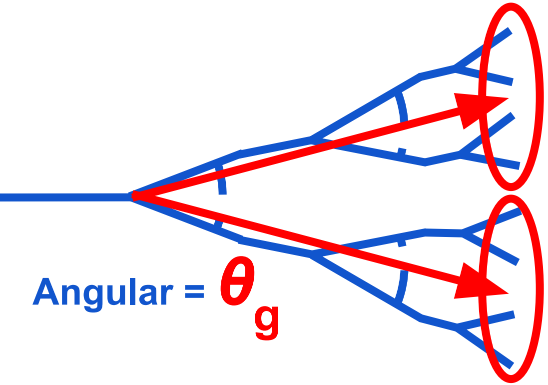

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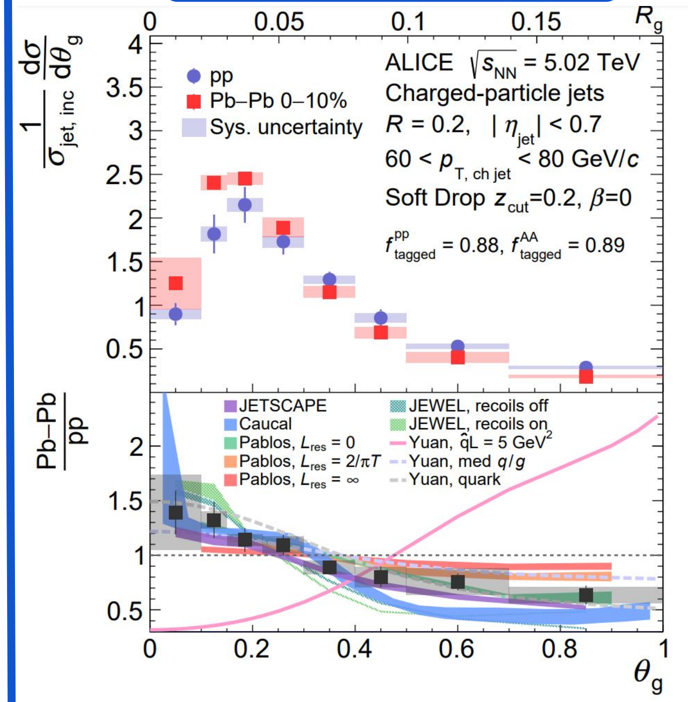

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Unravel with multidimensional analysis!

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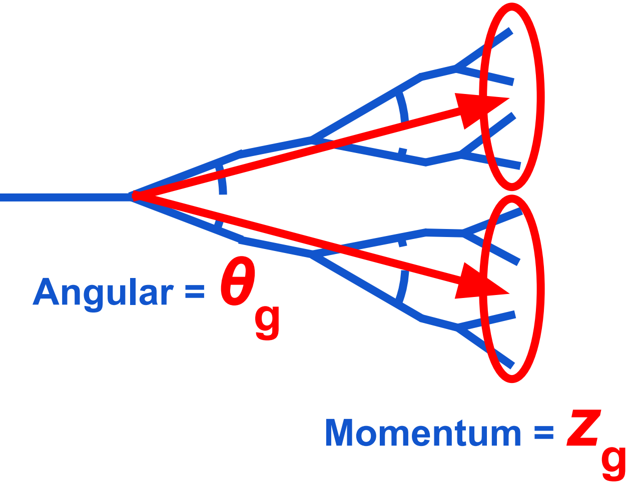

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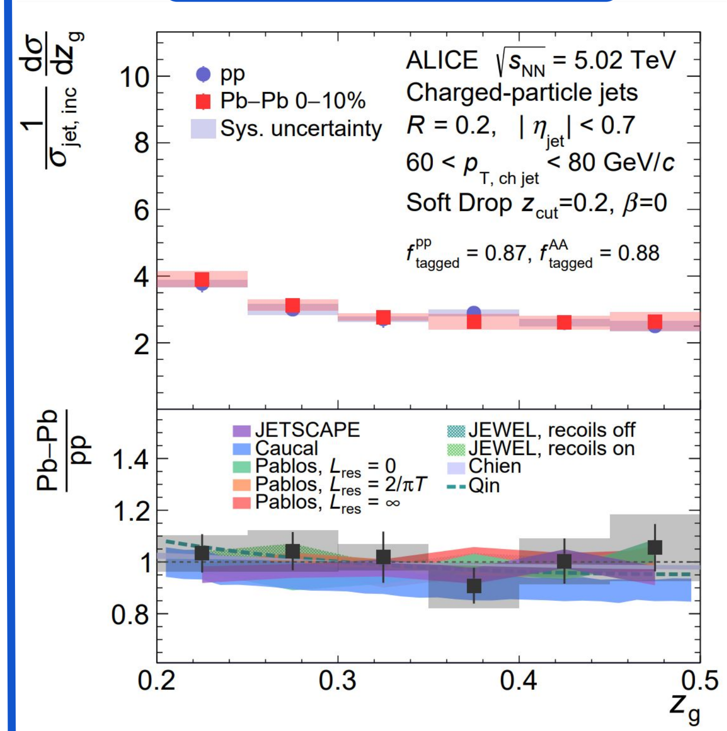

No modification found

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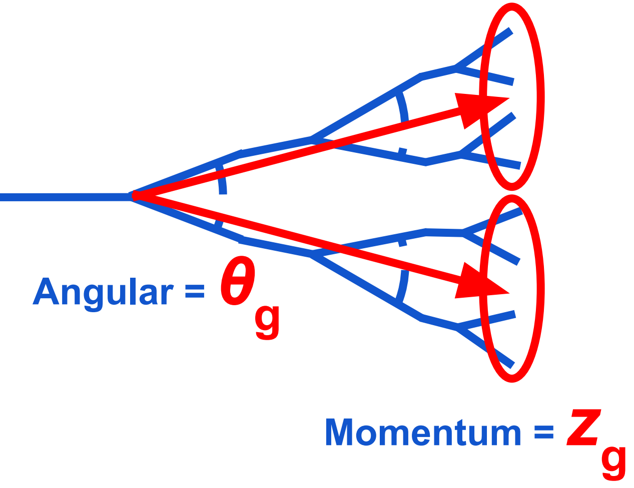

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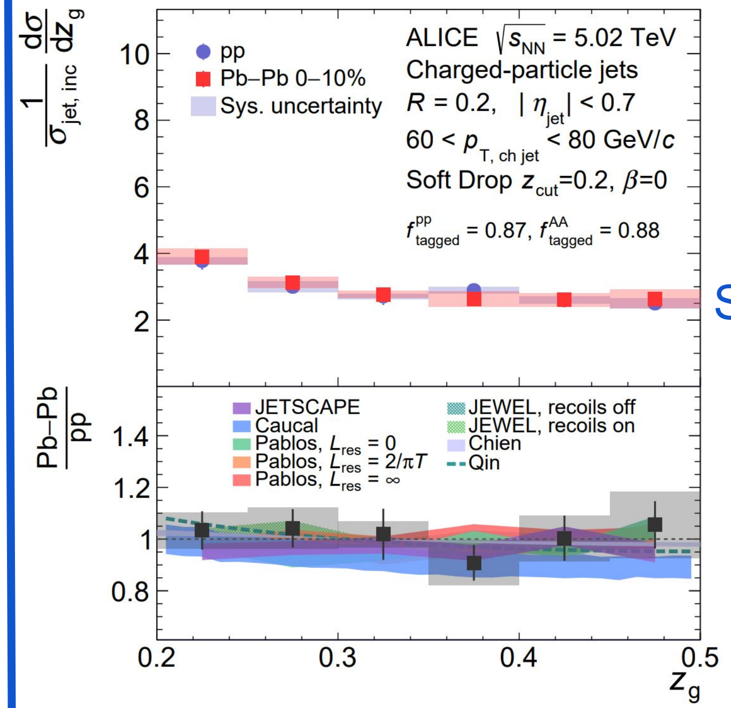

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Still room for modification in a more differential measurement?

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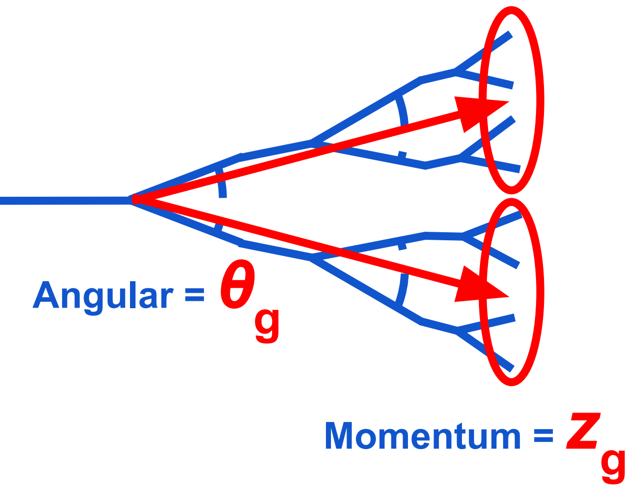
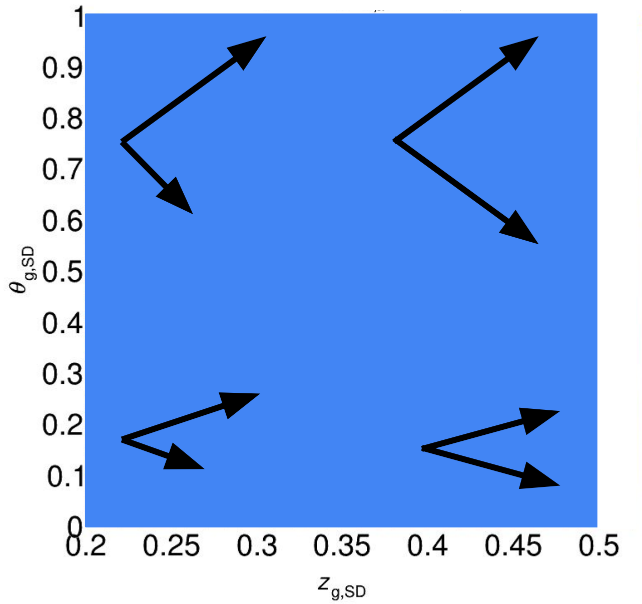
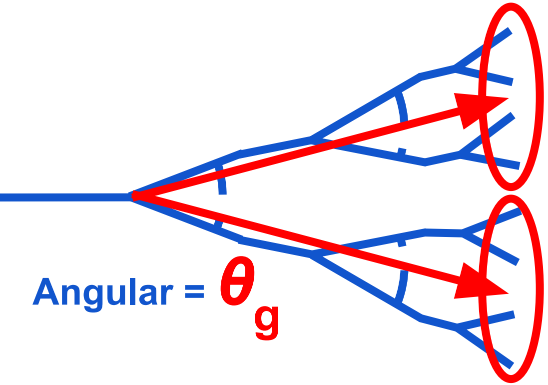


z_{cut} = 0.2, β = 0

Soft Drop: arXiv:1402.2657



Study correlation of Soft Drop θ_g and z_g



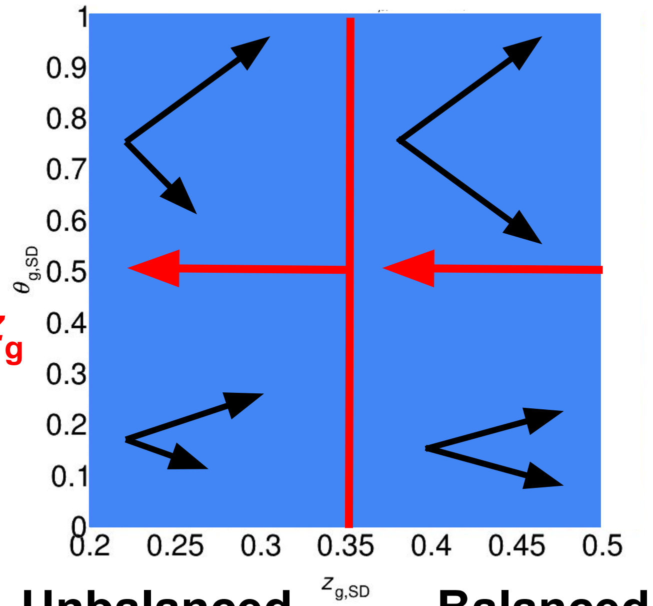
Angular = θ_g

Momentum = z_g

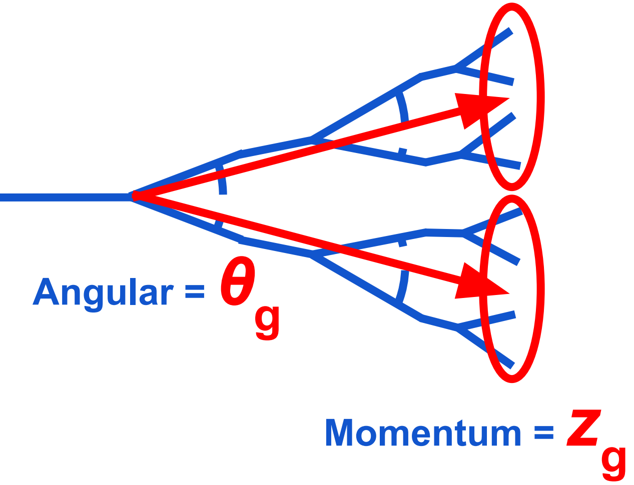
z_{cut} = 0.2, β = 0

Soft Drop: arXiv:1402.2657

Project θ_g for large and small z_g

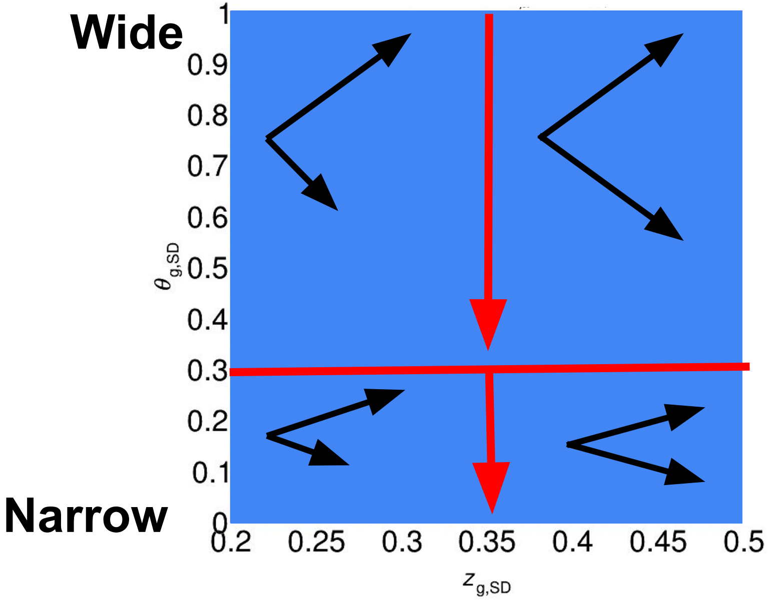


Study correlation of
Soft Drop θ_g and z_g



$z_{cut} = 0.2$, $\beta = 0$

Soft Drop: arXiv:1402.2657



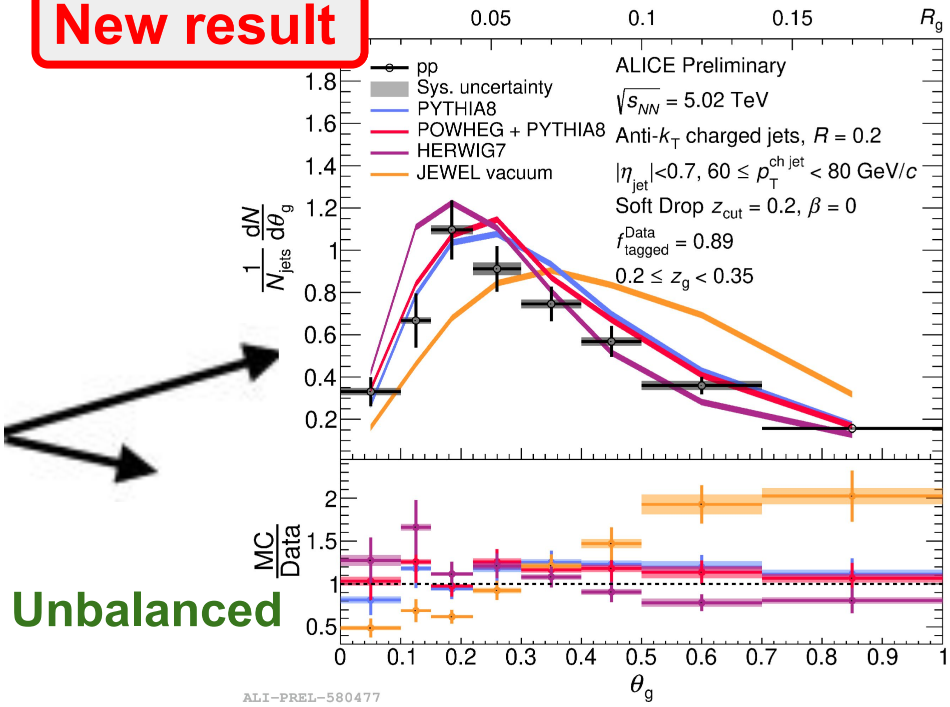
Project z_g
for large and small θ_g

Substructure correlations: pp

Reasonable agreement of data with PYTHIA, POWHEG , HERWIG

JEWEL vacuum predicts too wide of jets in pp

New result



Unbalanced

Substructure correlations: pp

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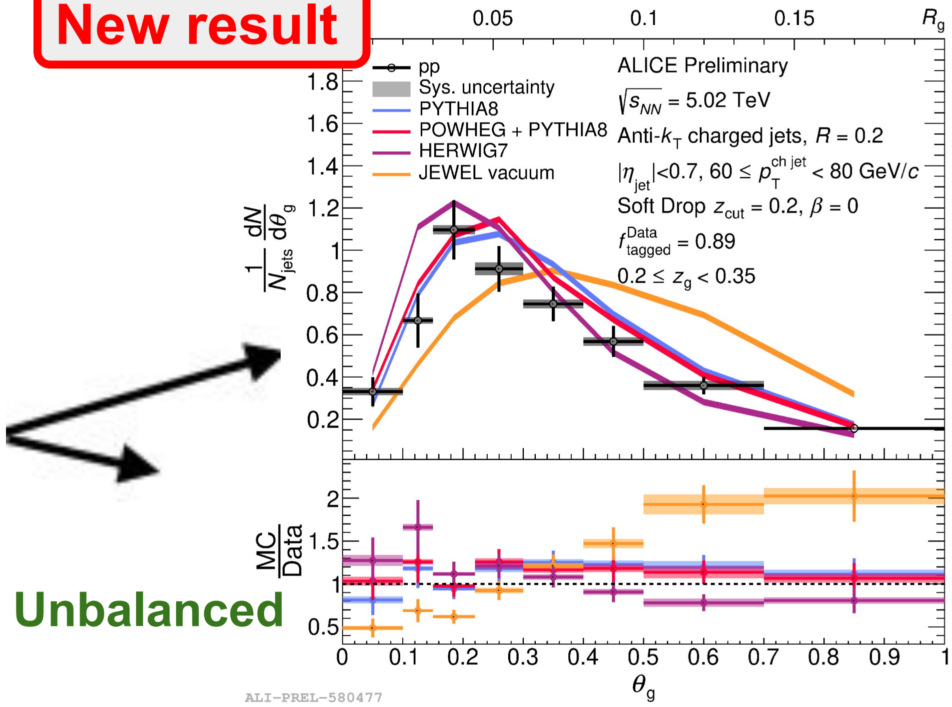
JEWEL vacuum predicts too wide of jets in pp

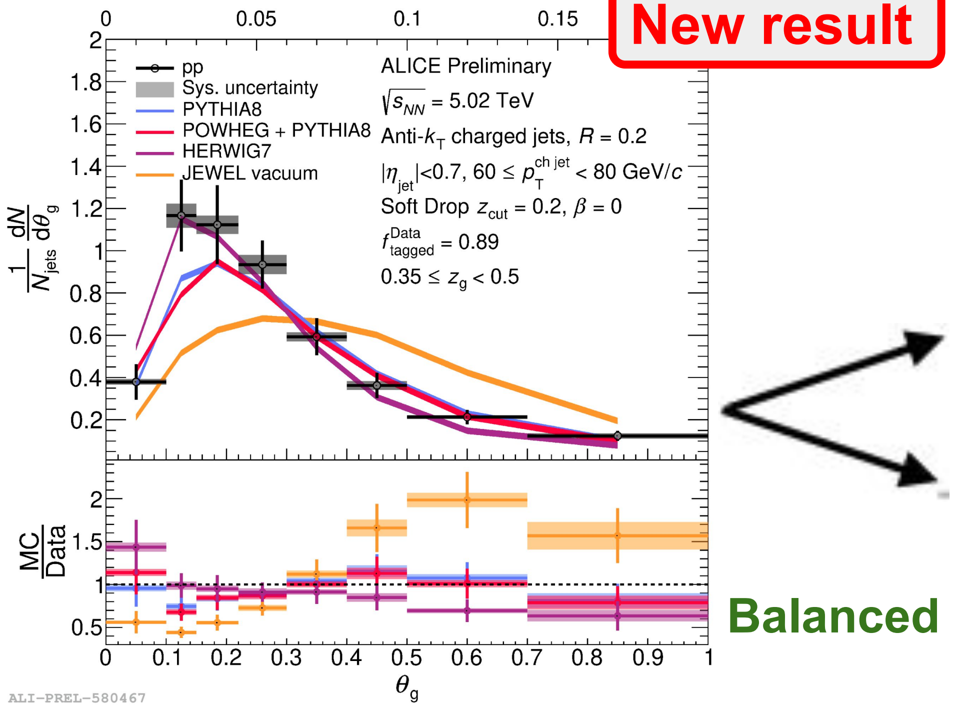
New result

Unbalanced



New result

Balanced

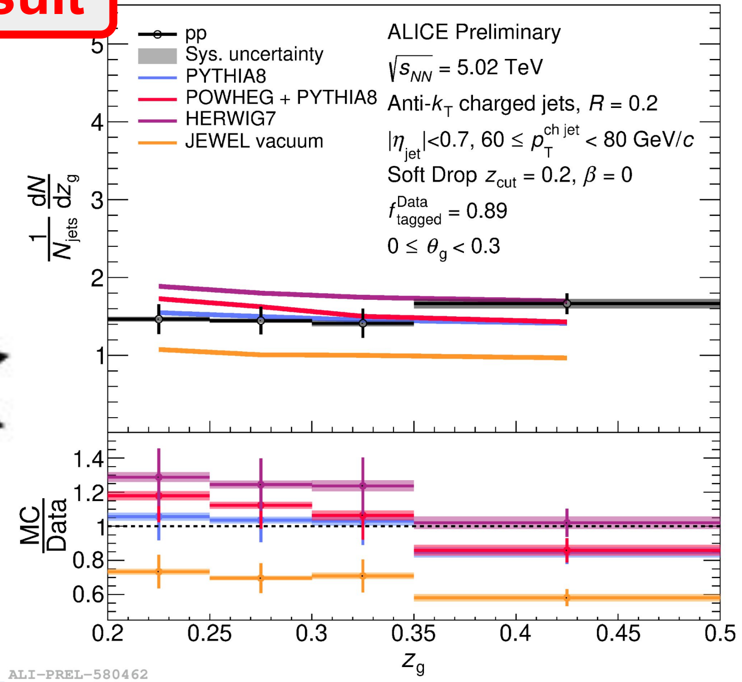


Substructure correlations: pp

Reasonable agreement of data with PYTHIA, POWHEG , HERWIG

Shape of z_g well described by models including JEWEL vacuum

New result



Narrow

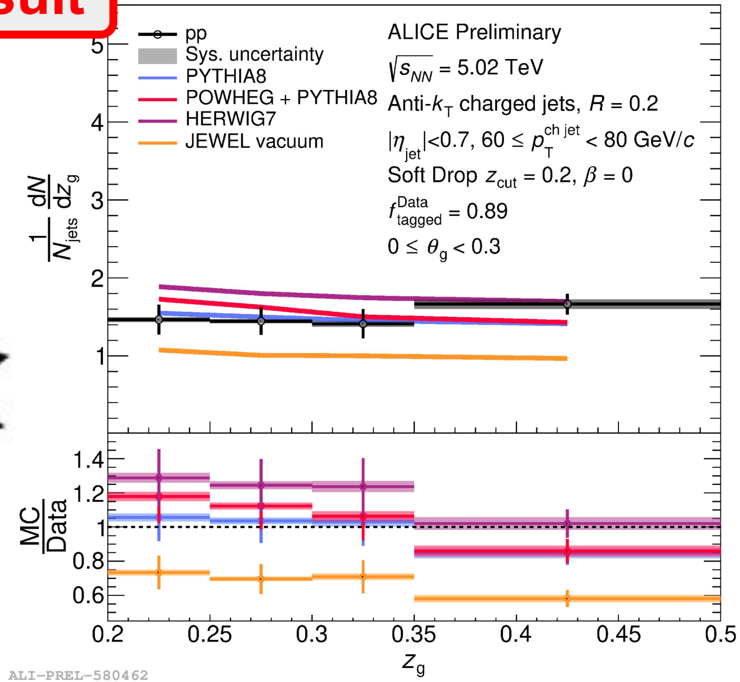
Substructure correlations: pp

Reasonable agreement of data with PYTHIA, POWHEG , HERWIG

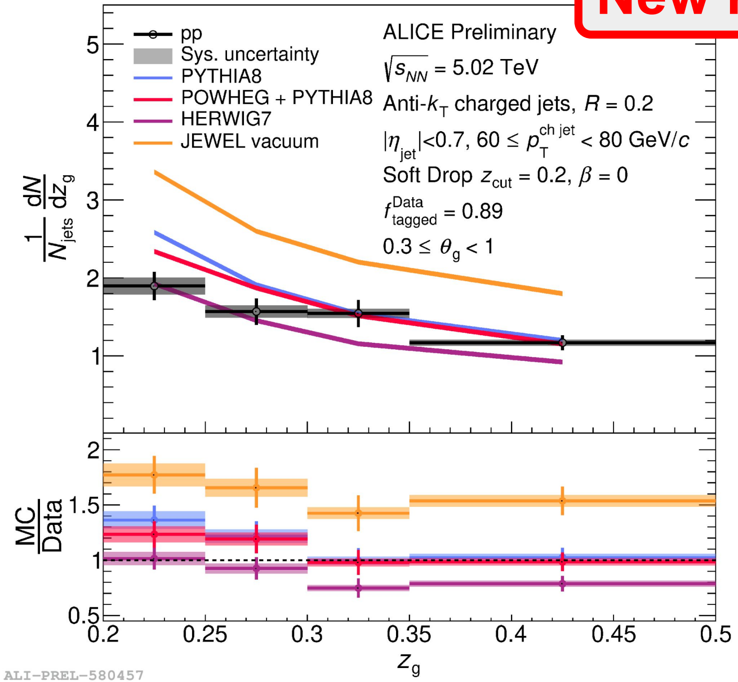
Shape of z_g well described by models including JEWEL vacuum

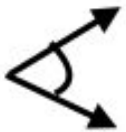
New result

Narrow



New result



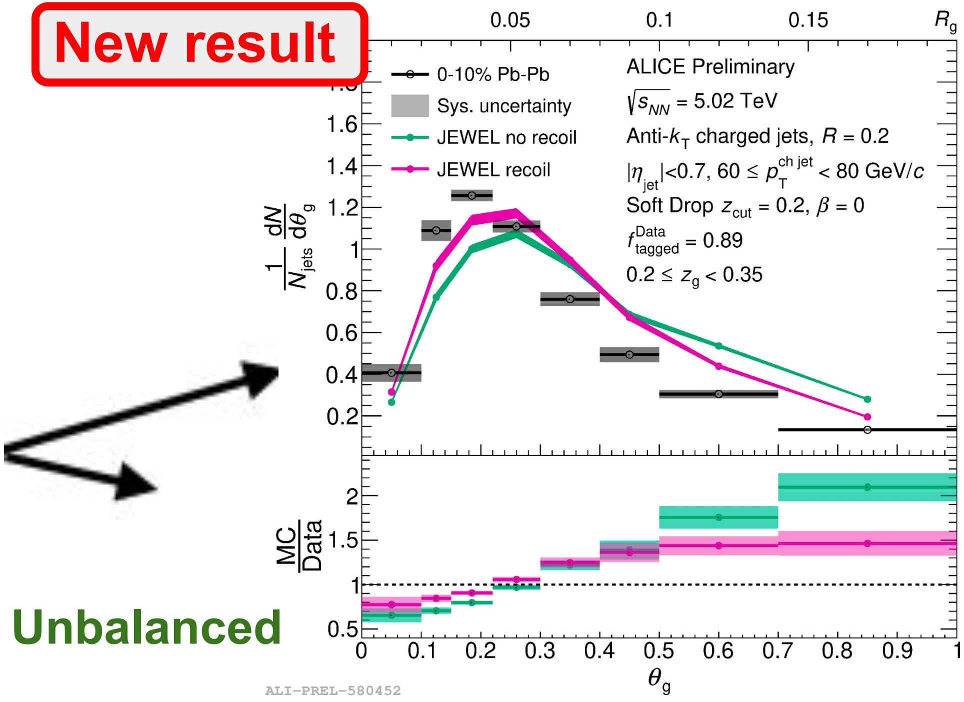


Wide

Substructure correlations: Pb-Pb

Jewel predicts too wide of jets in Pb-Pb

New result



Unbalanced

Substructure correlations: Pb-Pb

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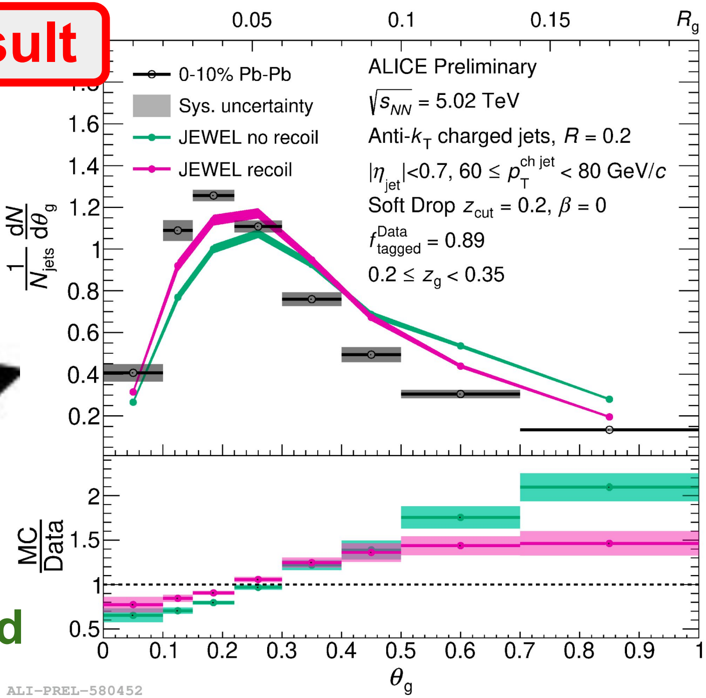
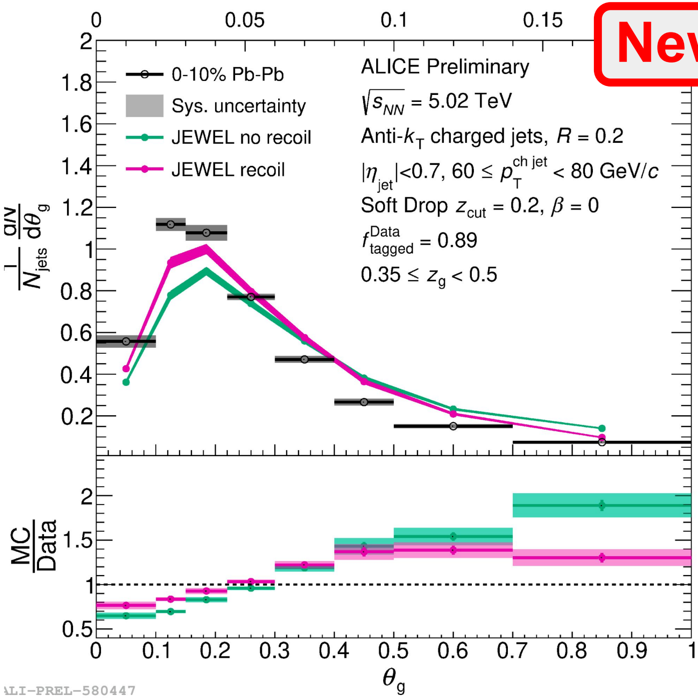
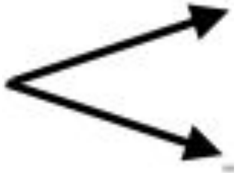
New result



Unbalanced



New result

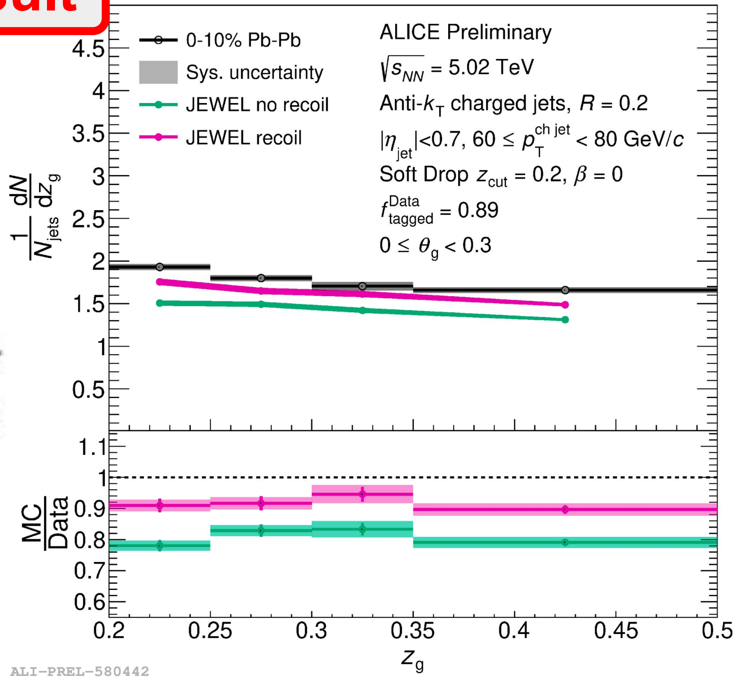


Balanced

Substructure correlations: Pb-Pb

Shape of z_g well described by Jewel

New result



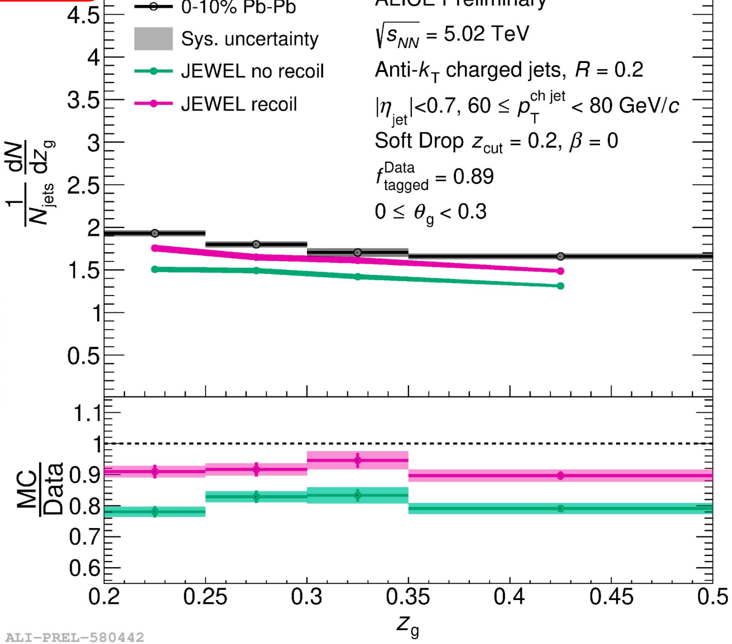
Narrow

Substructure correlations: Pb-Pb

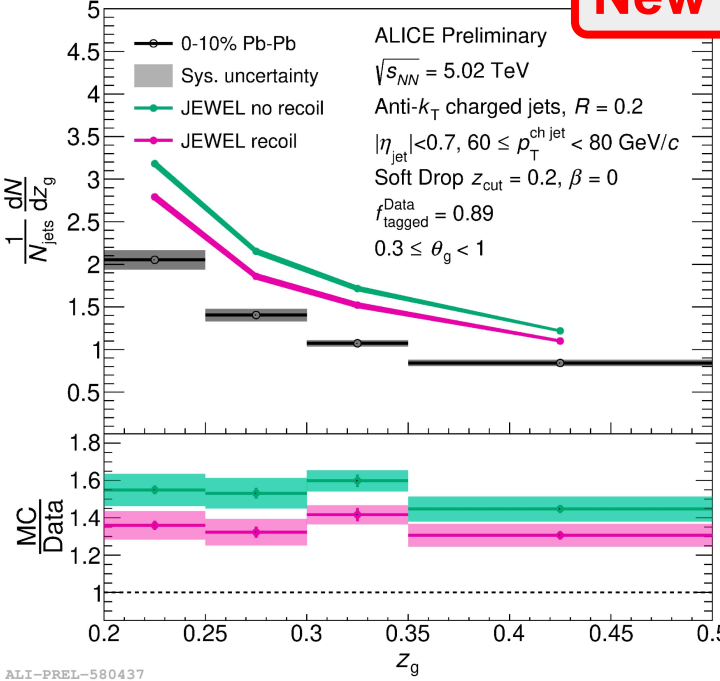
Shape of z_g well described by Jewel

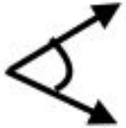
New result

Narrow



New result

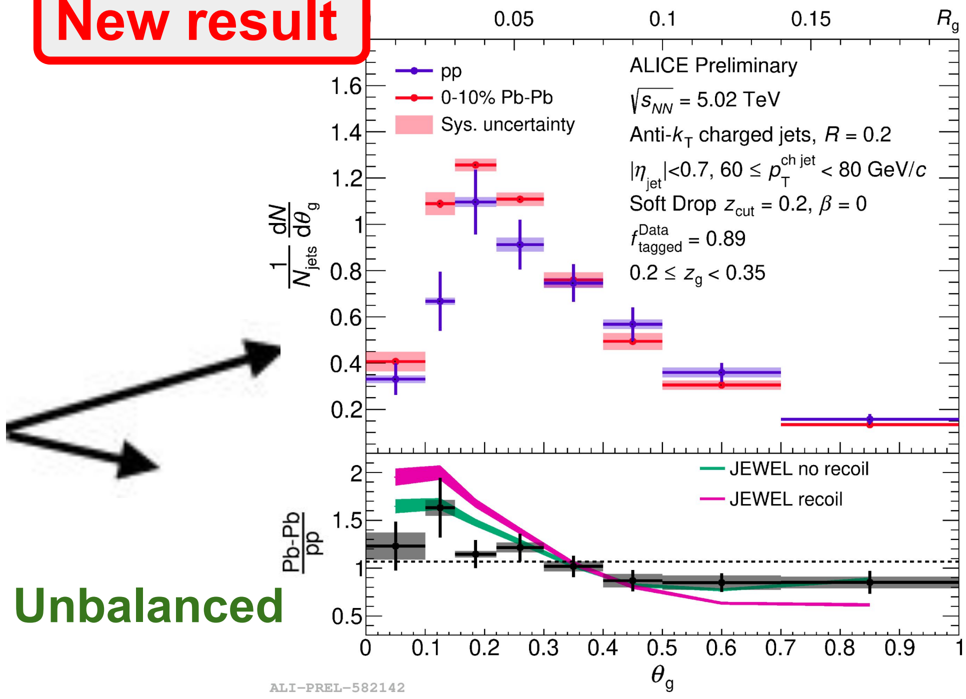




Wide

Jets narrower in Pb-Pb compared to pp

New result

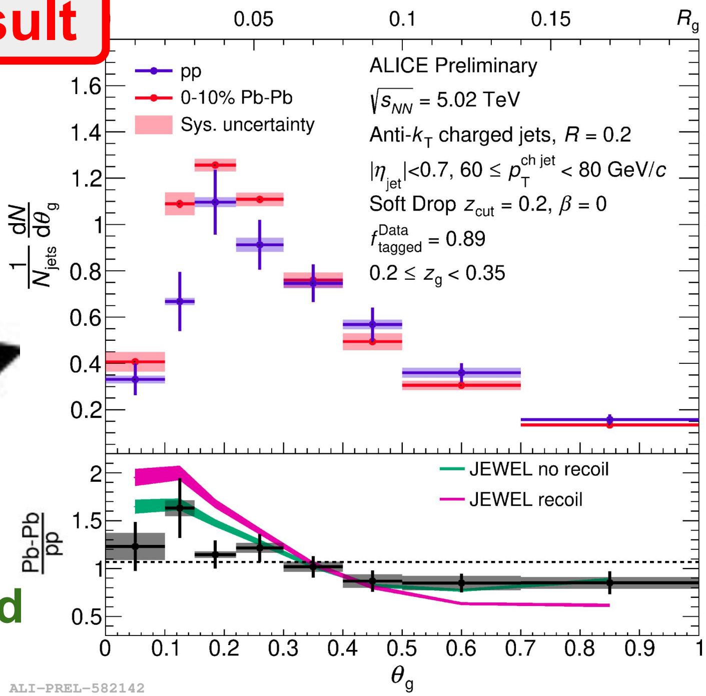


Unbalanced

Substructure correlations: θ_g

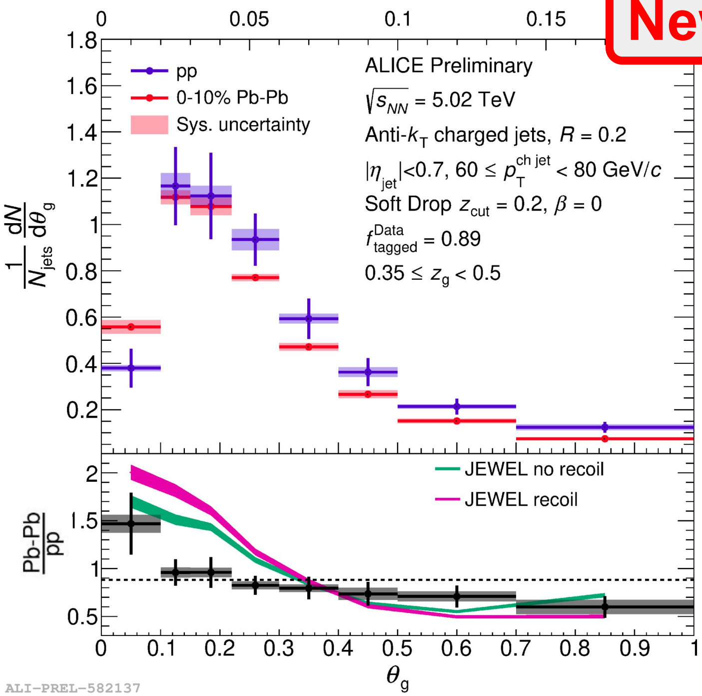
Jets narrower in Pb-Pb compared to pp

New result



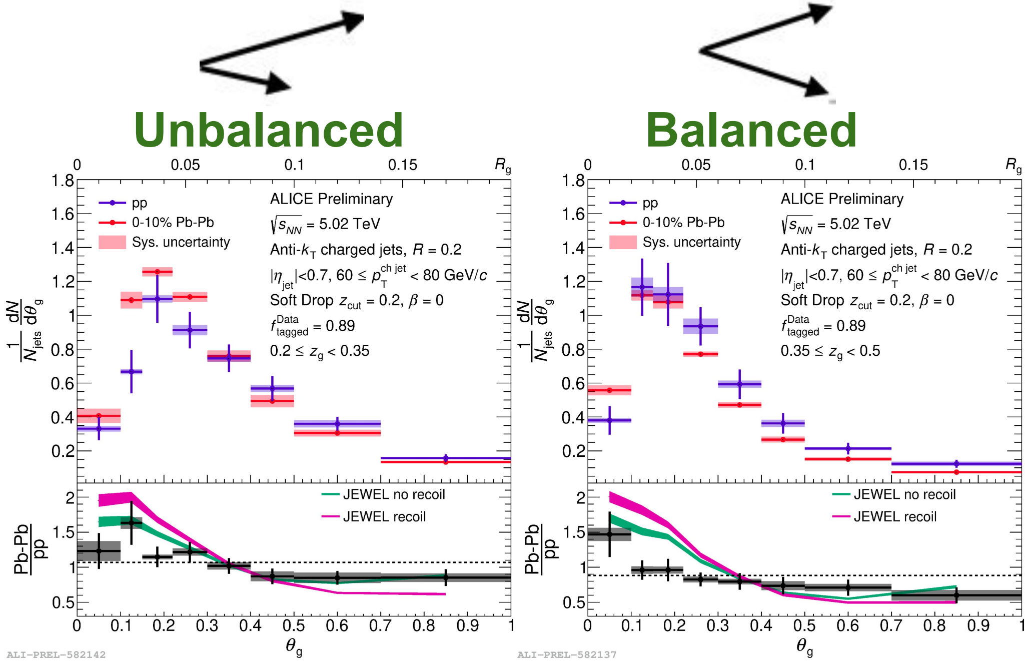
Unbalanced

New result



Balanced

Jets narrower in PbPb



Substructure correlations: θ_g

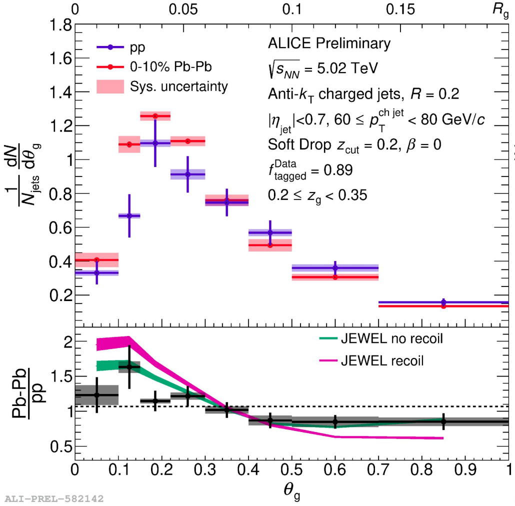
Jets narrower in PbPb

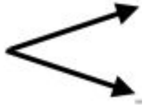
Jets being narrowed by QGP?

or

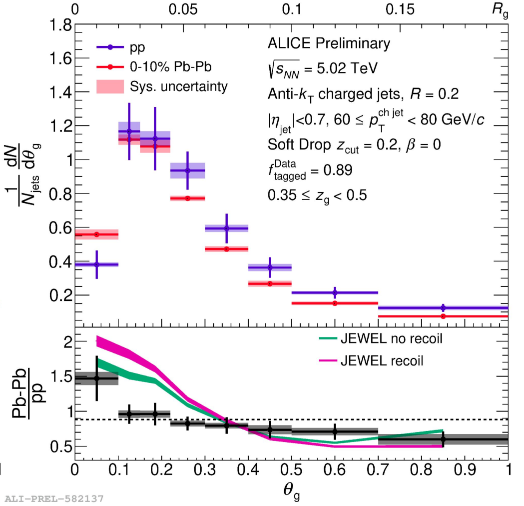
Wider jets less likely to survive QGP?

Unbalanced





Balanced



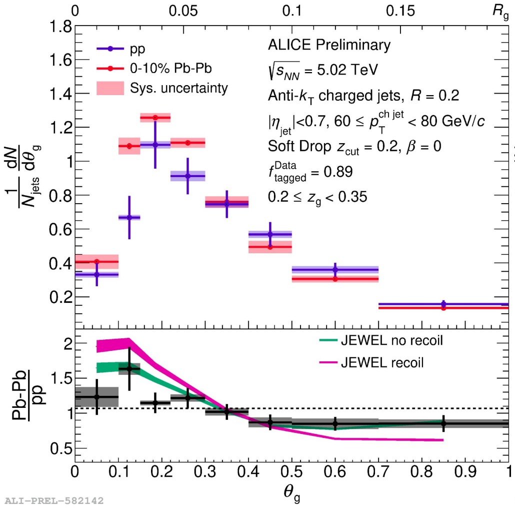
Substructure correlations: θ_g

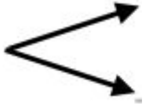
Jets narrower in PbPb

Jets being narrowed by QGP?
or
Wider jets less likely to survive QGP?

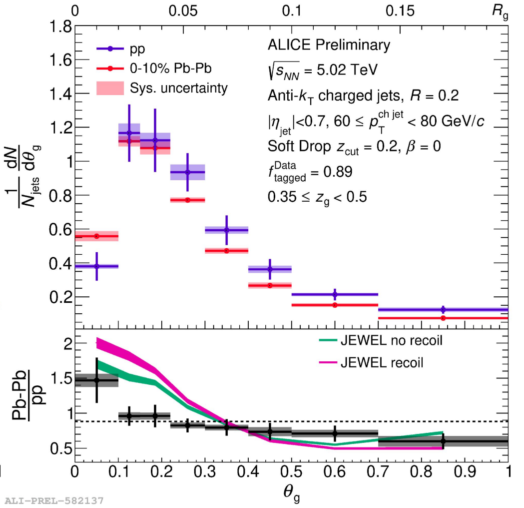
Survival bias independent of z_g

Unbalanced





Balanced



Jets narrower in PbPb

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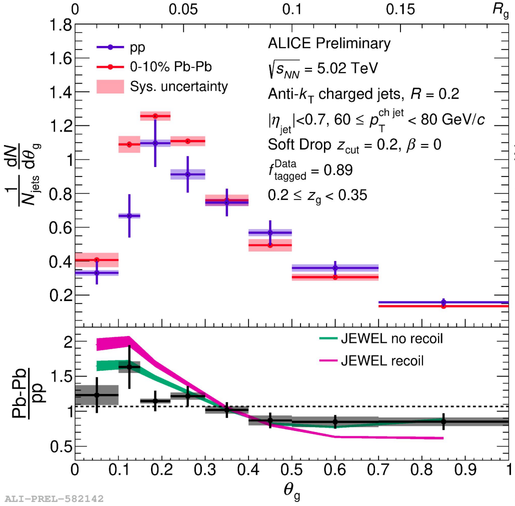
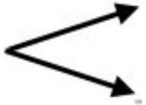
Survival bias independent of z_g

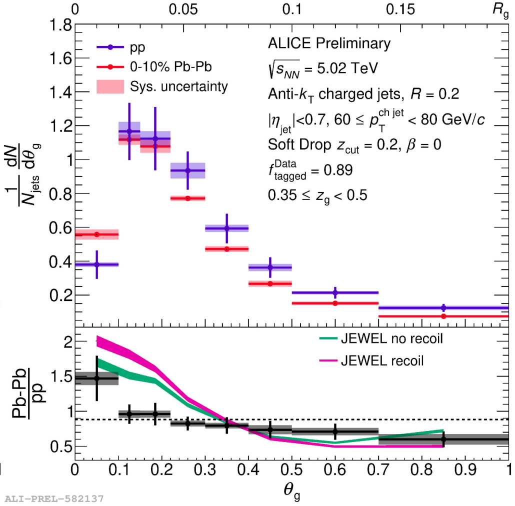
z_g independent of p_T: Unaffected by p_T migration

Unbalanced





Balanced



Substructure correlations: θ_g

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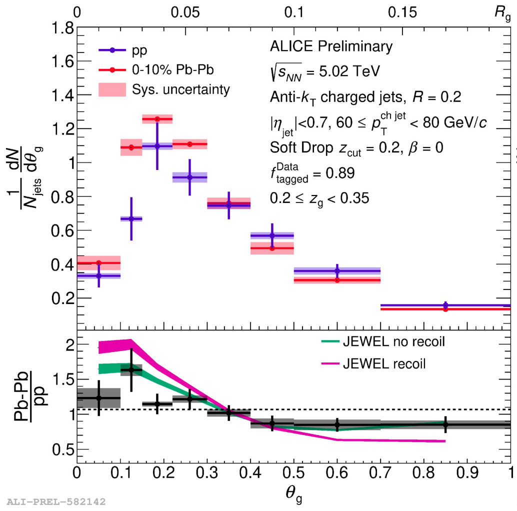
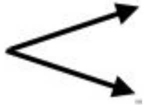
Survival bias independent of z_g

z_g independent of p_T: Unaffected by p_T migration

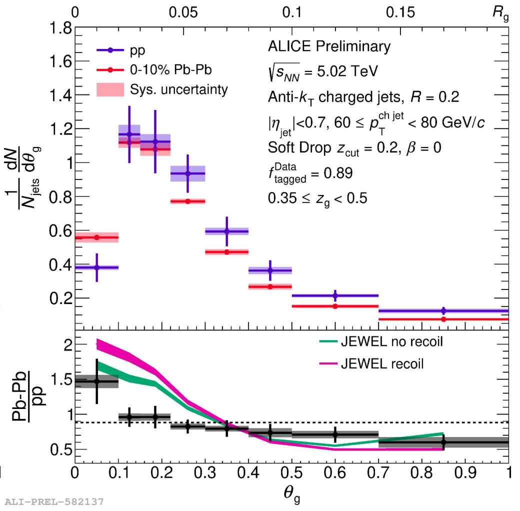
Any difference we see between z_g selections is independent of survival bias

Unbalanced





Balanced



Substructure correlations: θ_g

Jets narrower in PbPb

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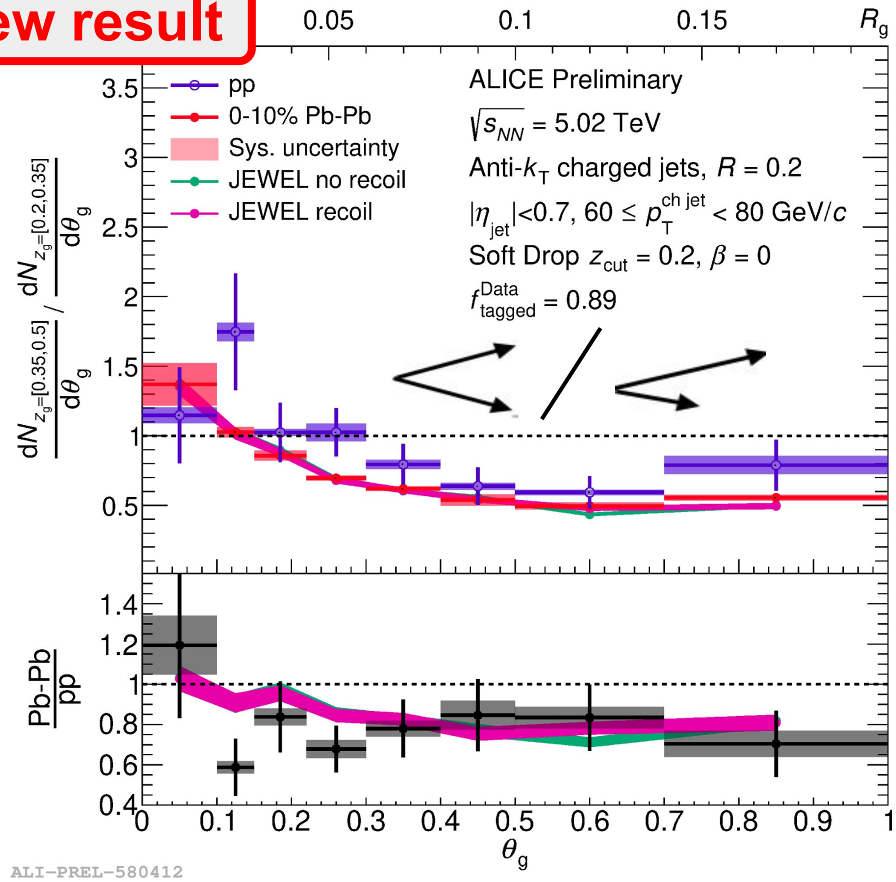
New result



Substructure correlations: θ_g

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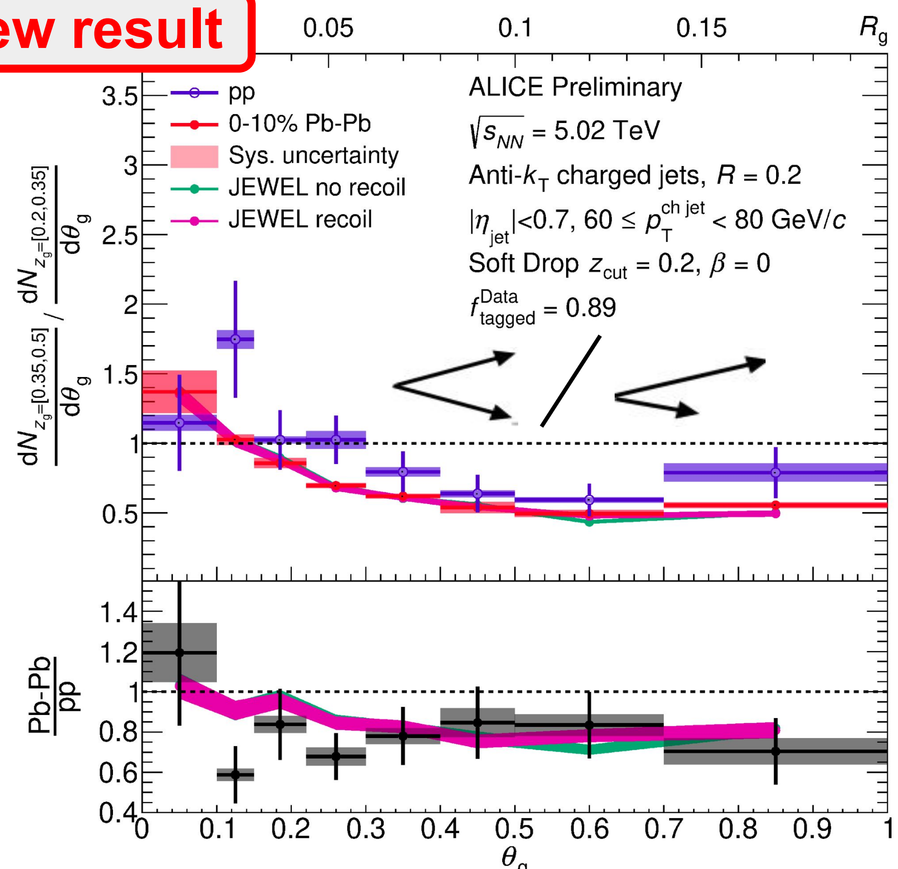
We see significantly more jet narrowing in balanced jets

New result



Substructure correlations: θ_g

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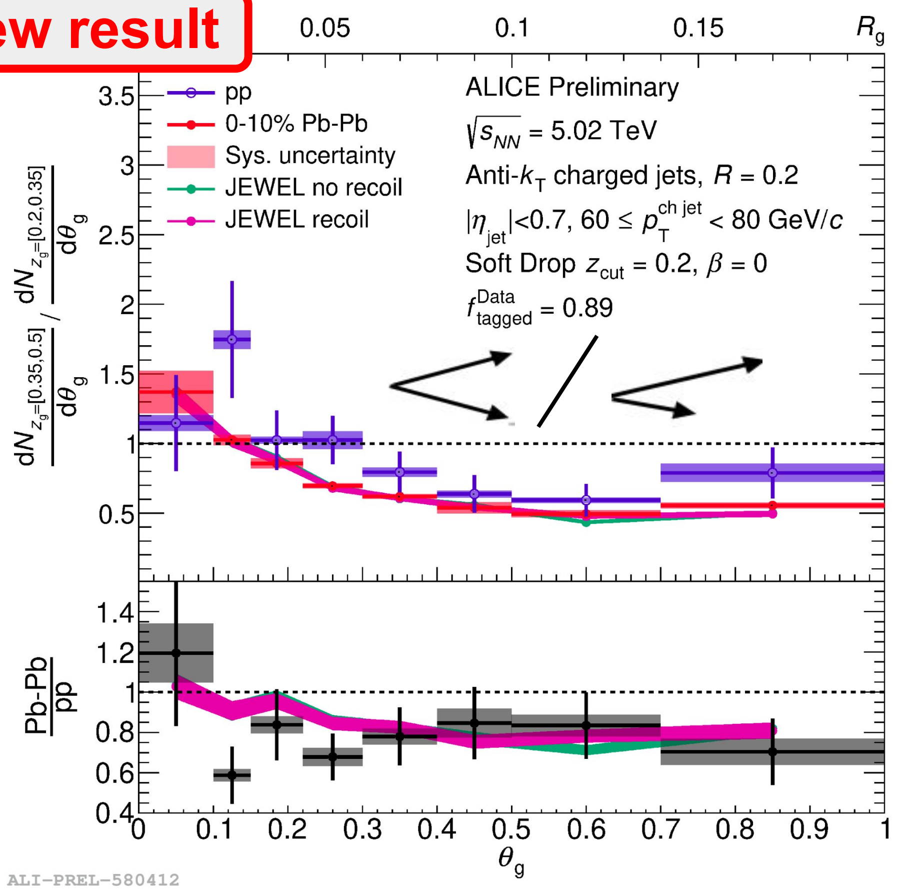
z_g independent of p_T: Unaffected by p_T migration

Any difference we see between z_g selections is independent of survival bias

We see significantly more jet narrowing in balanced jets

Not due to p_T migration from jet e-loss

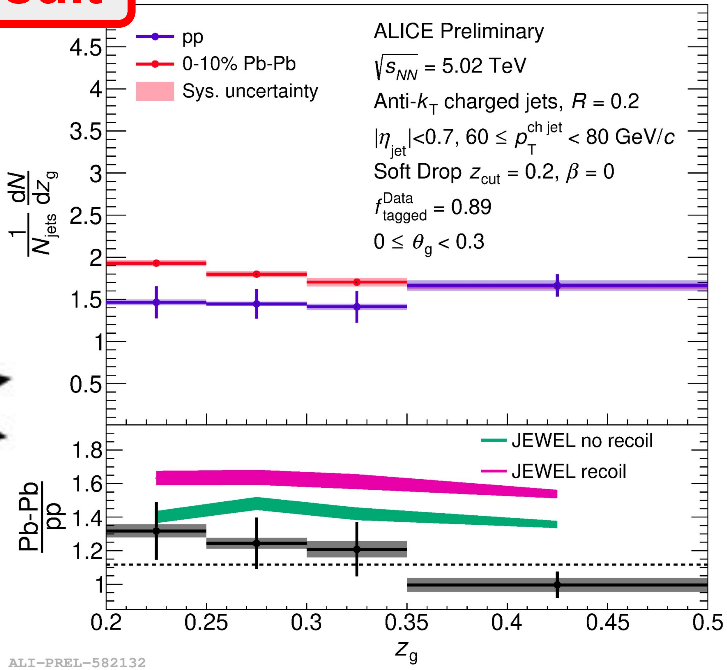
New result



Substructure correlations: z_g

No significant modification in narrow jets within uncertainties

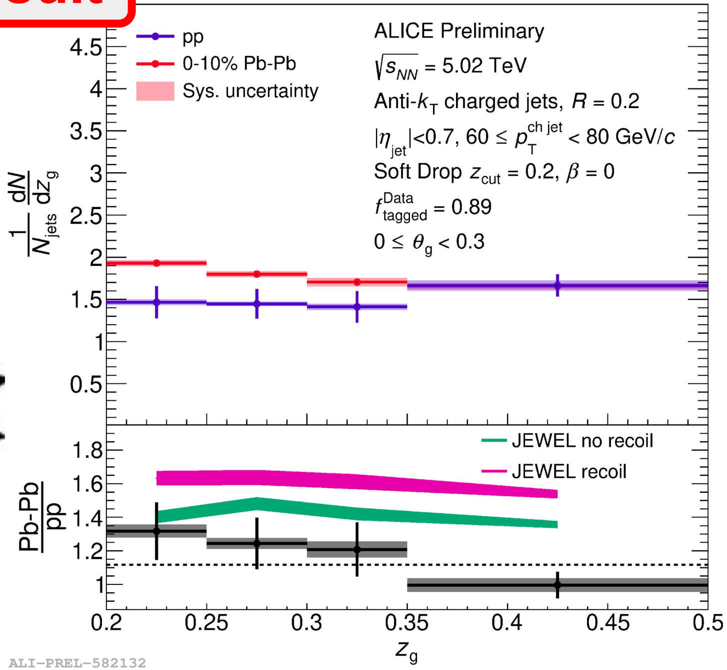
New result



Narrow

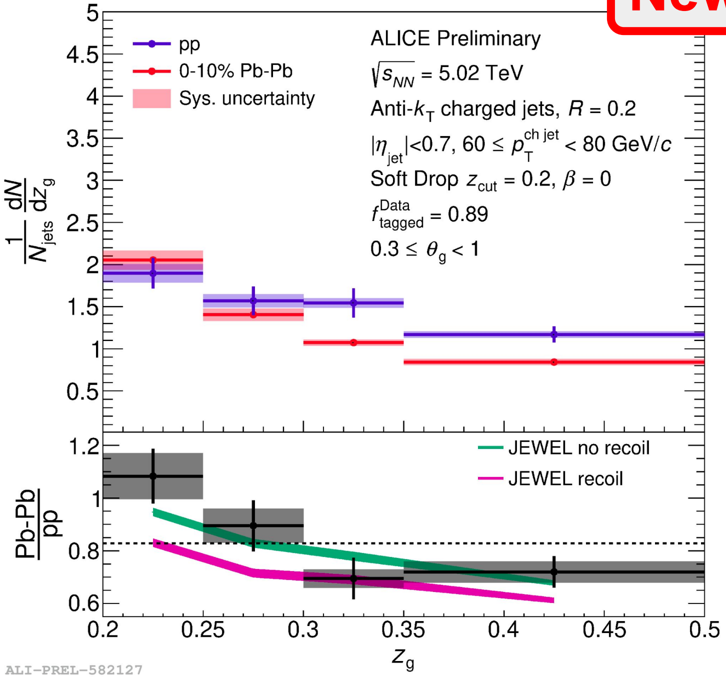
Wide jets show z_g modification

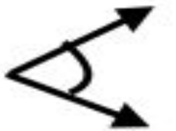
New result



Narrow

New result



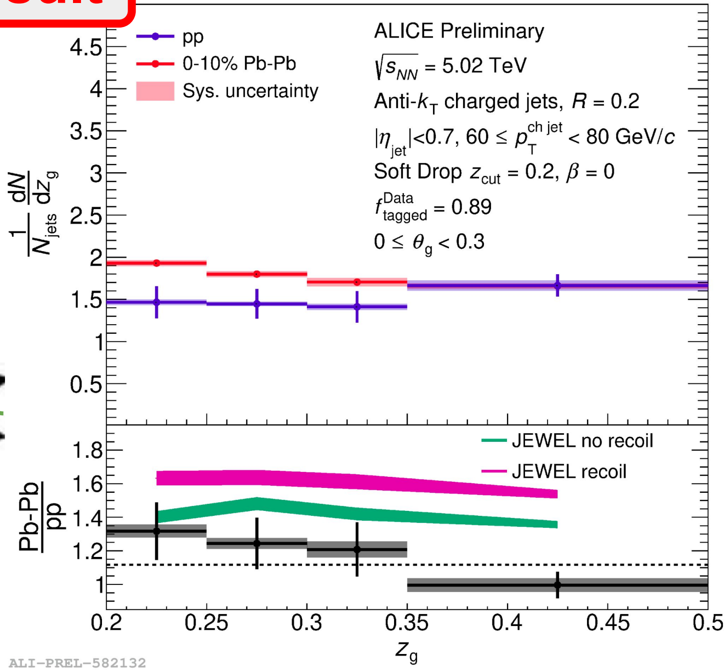


Wide

Wide jets show z_g modification

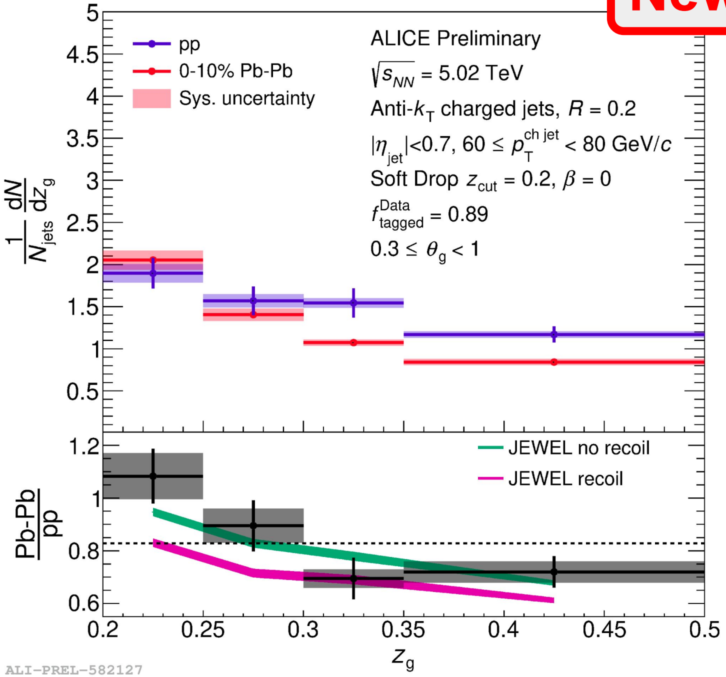
Wide jets more independent energy loss sources?

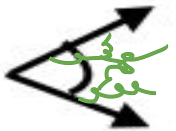
New result



Narrow

New result





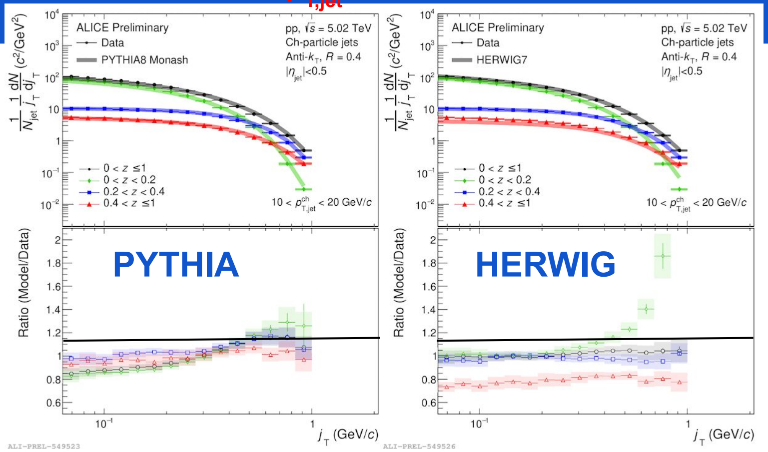
Wide

Conclusions

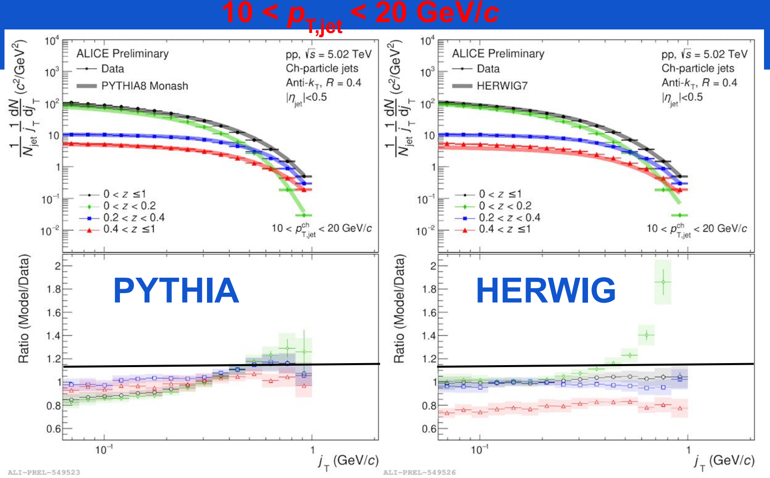
Jet fragmentation

j_T measured for various z

$10 < p_{T,jet} < 20$ GeV/c



Conclusions



Jet fragmentation

j_T measured for various z

Tension with models

Conclusions

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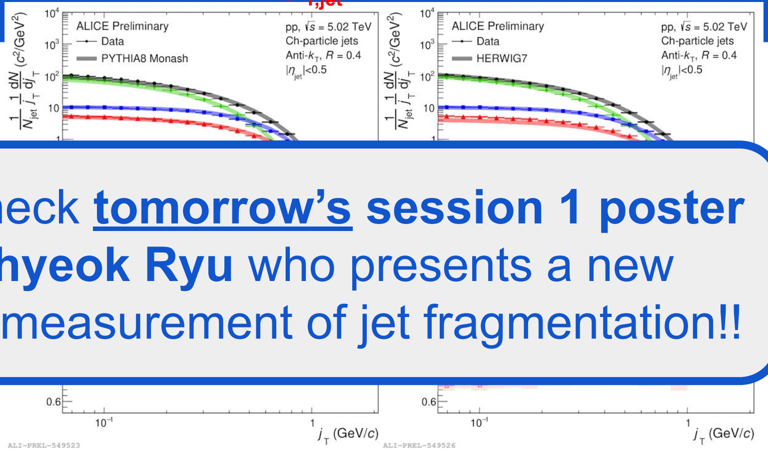

Jet fragmentation

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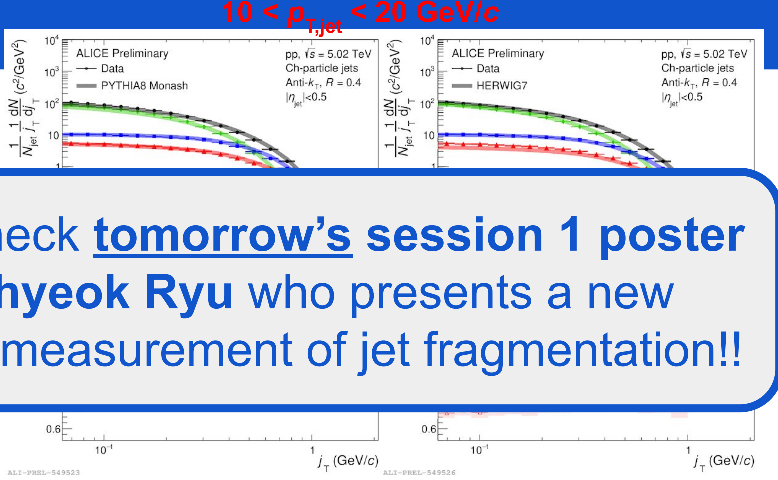
Also check **tomorrow's session 1 poster** by **Jaehyeok Ryu** who presents a new ALICE measurement of jet fragmentation!!

Conclusions



Jet fragmentation

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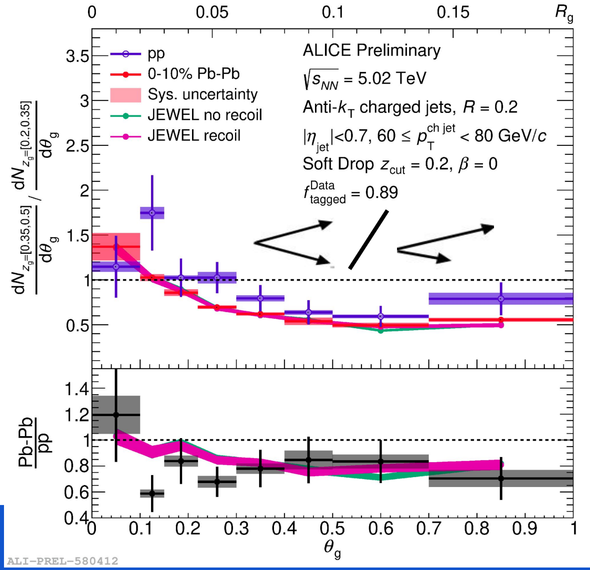
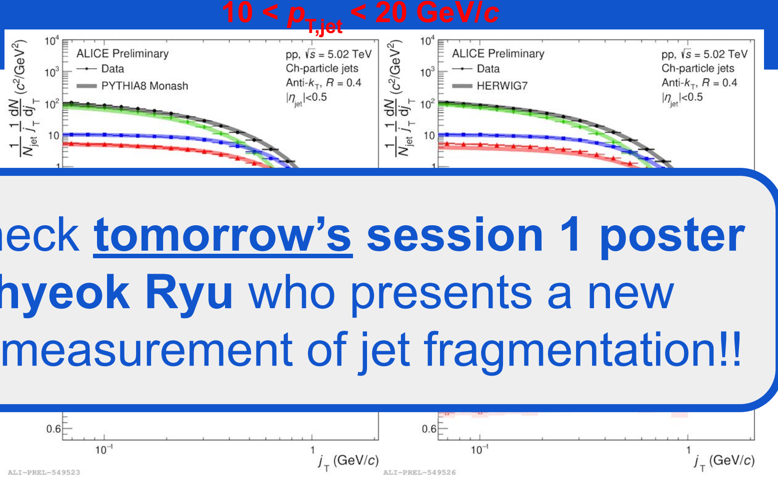
Correlation of Soft Drop θ_g and z_g

Stronger jet narrowing for balanced subjets

Not due to p_T migration from jet energy loss alone



Conclusions



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z_g modification in wide jets