

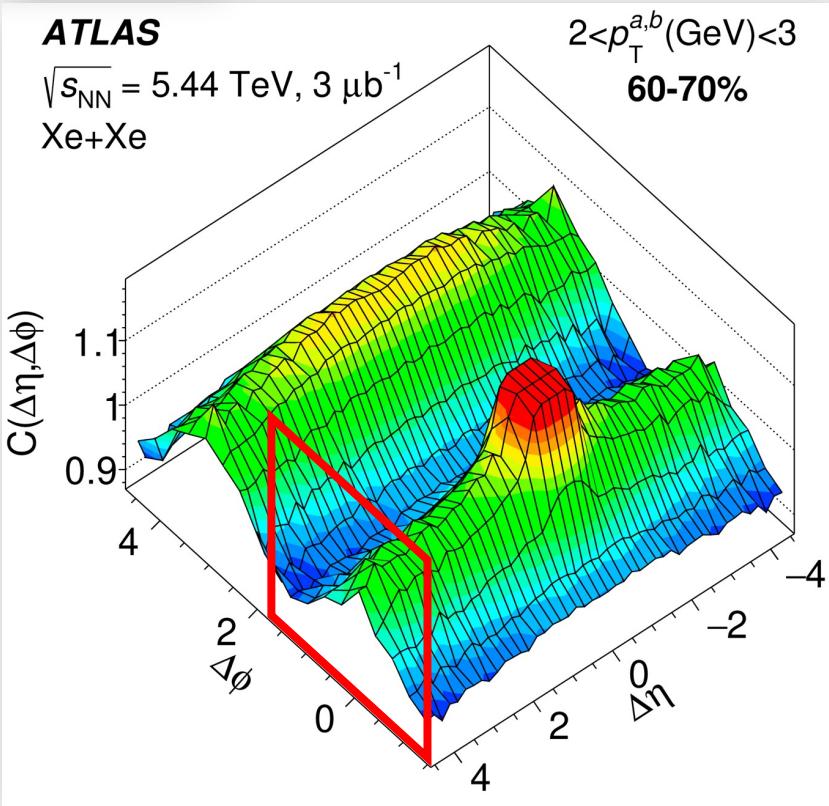
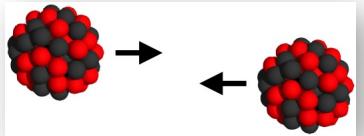


Measurement of the Sensitivity of Two-Particle Correlations in pp Collisions to the Presence of Hard Scatterings

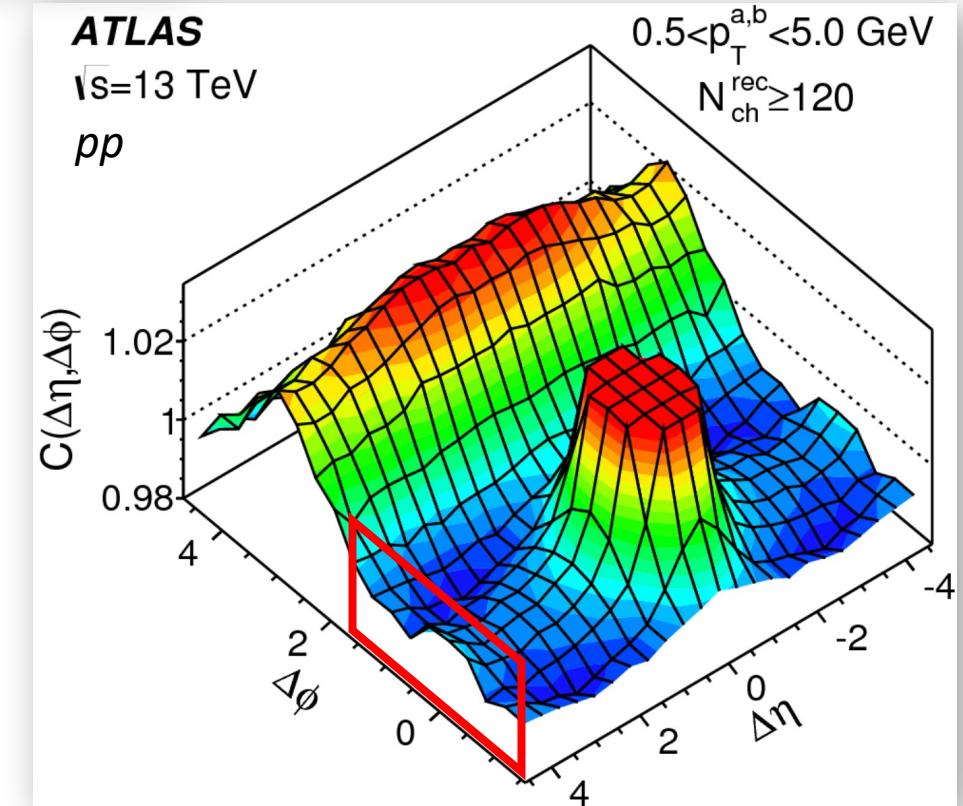
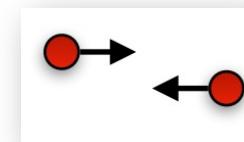
Pengqi Yin, Columbia University, For the ATLAS Collaboration

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Ridge in small system



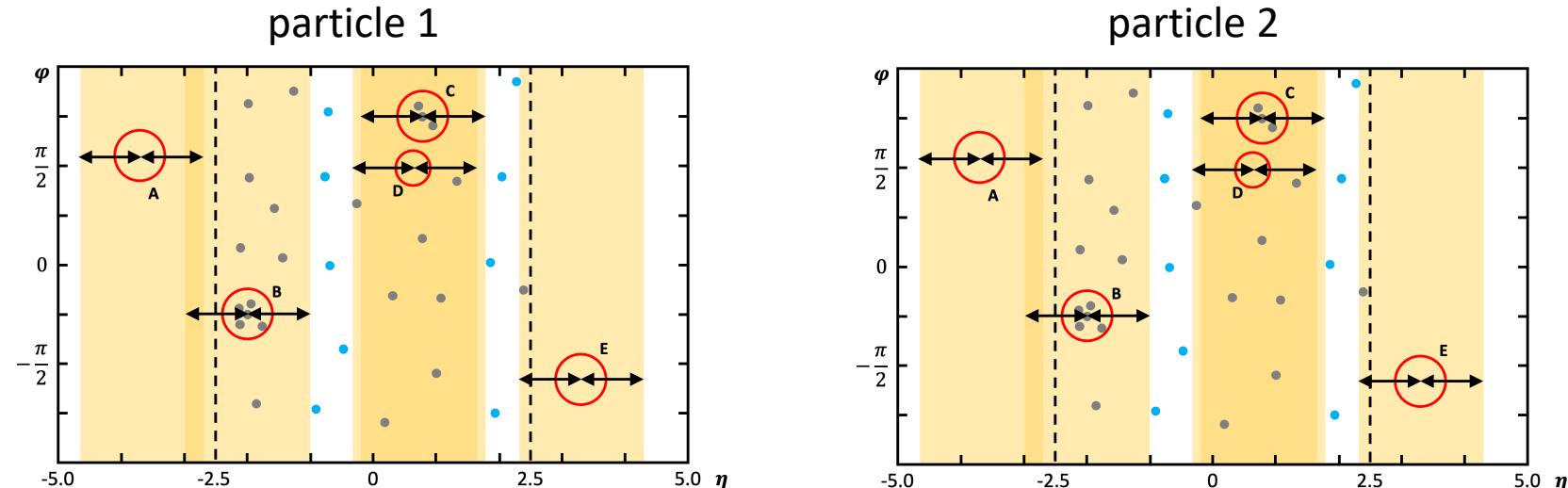
Collective flow



Arise from collective behavior?
Artifact of semi-hard processes?

Method

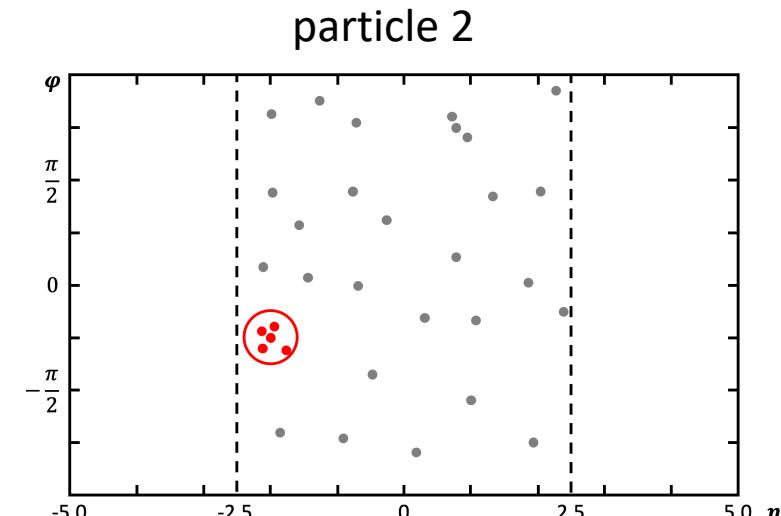
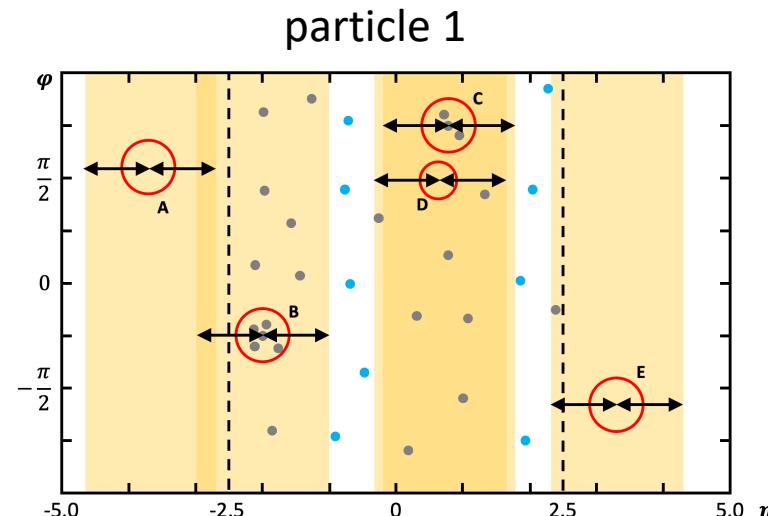
- Jets are reconstructed using particle-flow algorithm ([Eur. Phys. J. C 77 \(2017\) 466](#))
 - $p_T > 15 \text{ GeV}$, $|\eta| < 4.5$
 - Excluding particles within $|\Delta\eta| < 1$ of jets
- Measure 2PC
 - between two tracks not associated with jets
 - $h^{UE}-h^{UE}$



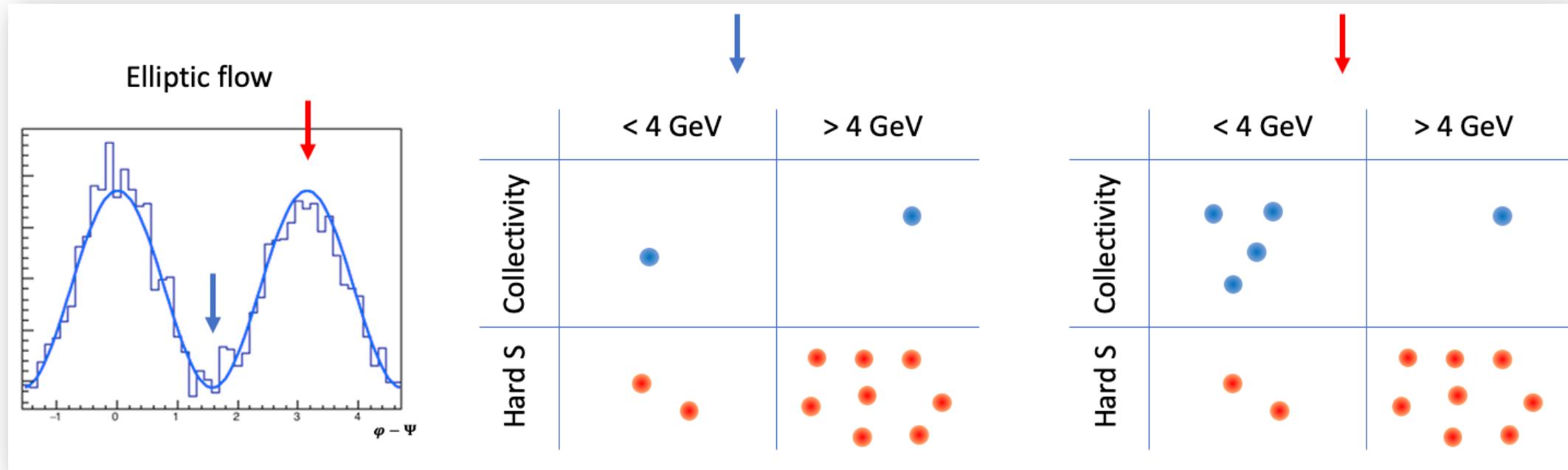
Method

ATLAS, arXiv:2303.17357, Submitted to PRL

- Jets are reconstructed using particle-flow algorithm ([Eur. Phys. J. C 77 \(2017\) 466](#))
 - $p_T > 15 \text{ GeV}$, $|\eta| < 4.5$
 - Excluding particles within $|\Delta\eta| < 1$ of jets
- Measure 2PC
 - between two tracks not associated with jets
 - $h^{UE}-h^{UE}$: (requiring the presence or absence of jets)
 - between tracks that are constituents of jets and tracks from the UE
 - $h^{UE}-h^J$



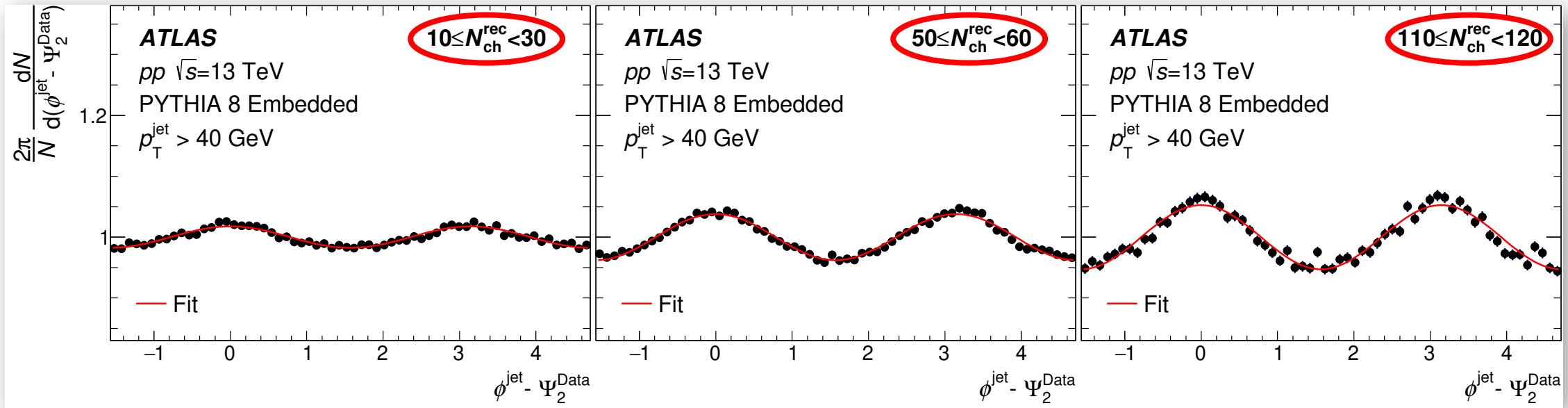
Problem



- From previous studies, we know there is a global modulation due to elliptic flow. **Not fluctuation!**
 - Particles from this flow mainly have low p_T .
 - Around 0 and π , more particles due to the modulation.
 - When a jet appear around 0 or π , reconstruction will catch more of these UE particles.
- The modulation provides a bias on jet p_T

Problem

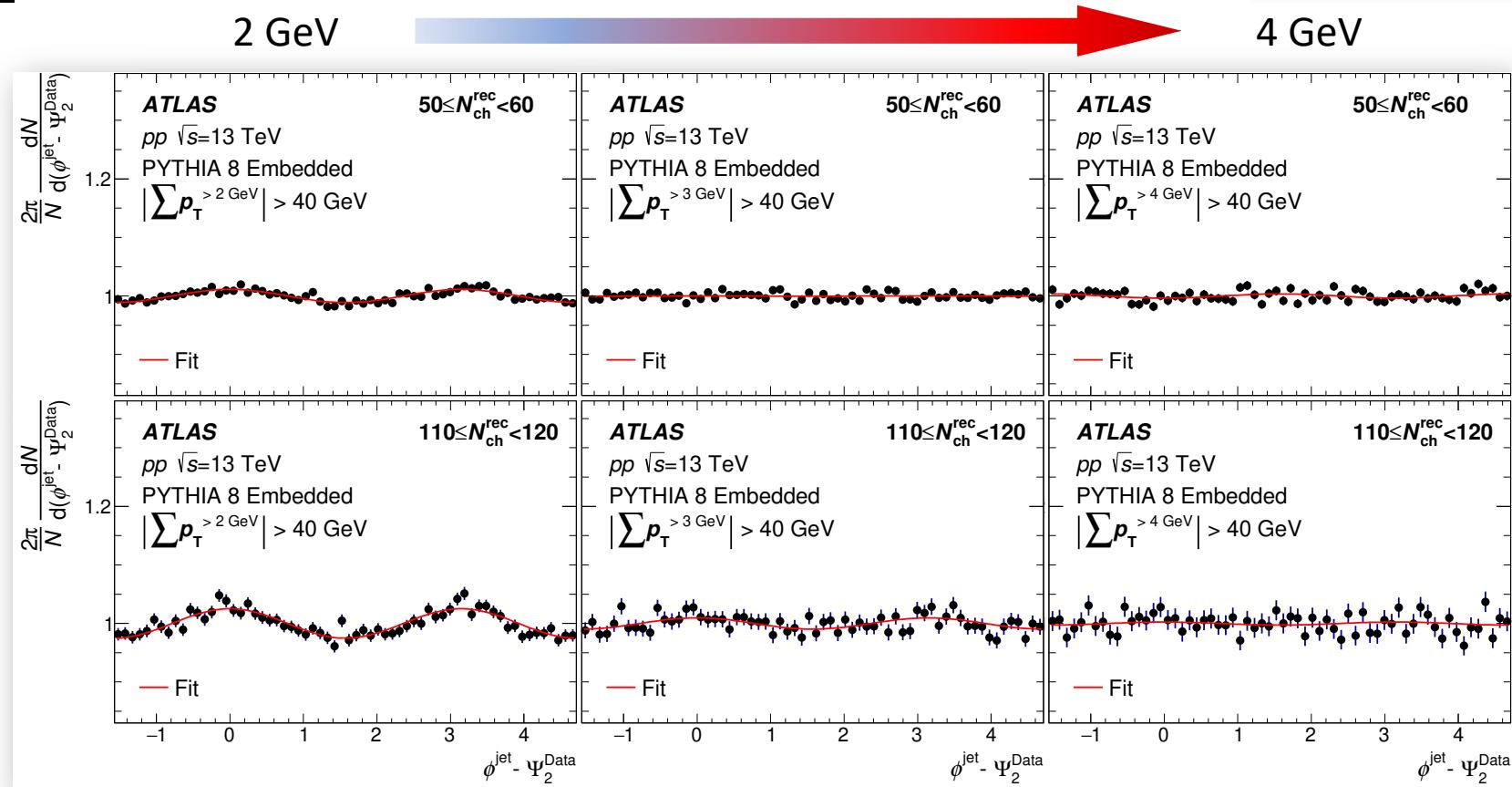
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- The UE bias was studied by overlaying PYTHIA8 event onto pp minimum-bias data
 - PYTHIA8 with MPI off and ISR on
- A strong modulation of jet yield vs $\phi^{\text{jet}} - \Psi_2^{\text{Data}}$ is observed
 - Event plane angle Ψ_2^{Data} is measured in the pp data before overlay
 - ϕ^{jet} is reconstructed taking particles from data and PYTHIA together, after overlay

Problem

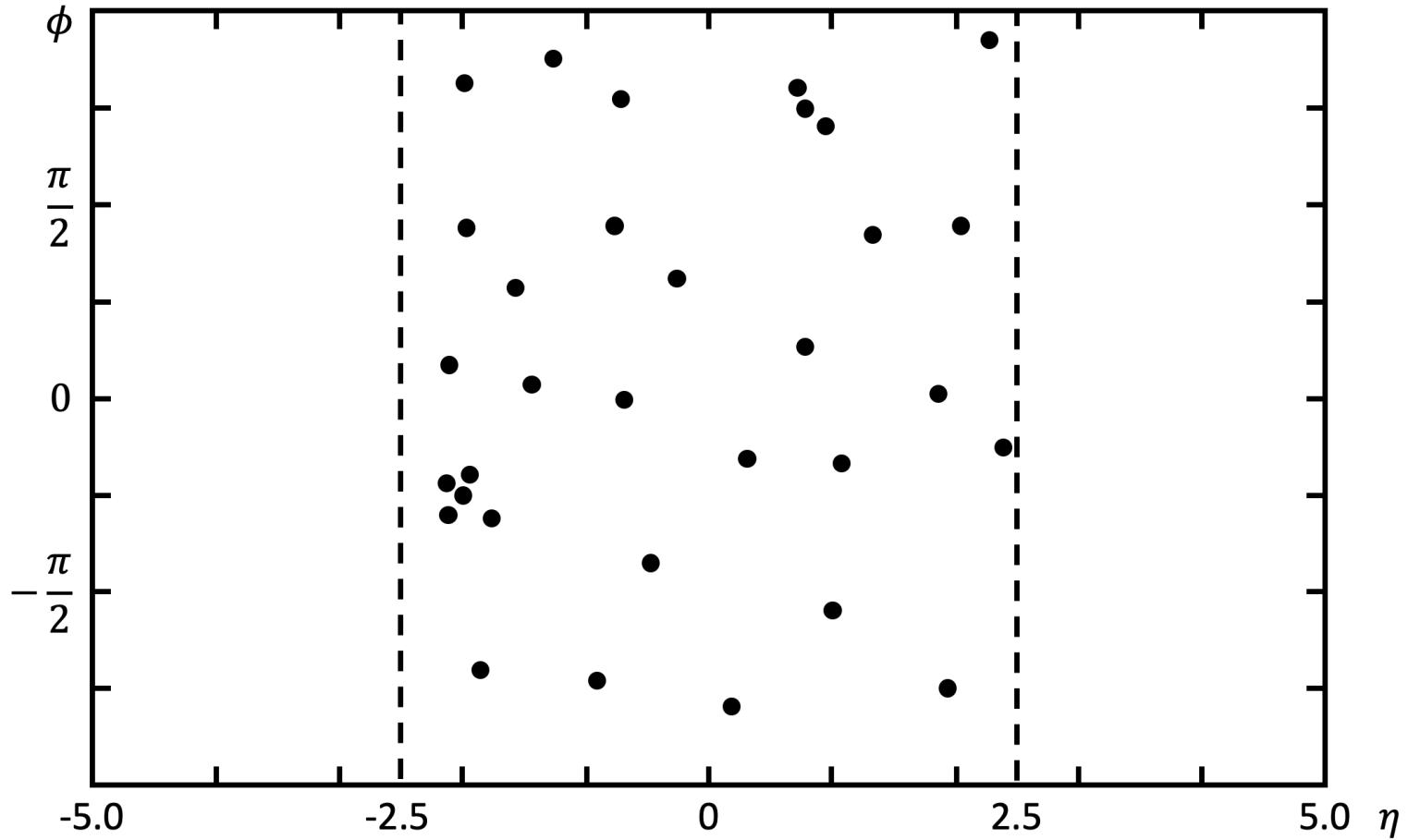
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- After trying a number of grooming and correction methods, the best suppression of UE bias was obtained by introducing a minimum p_T on jet constituents
- The jet p_T is redefined by summing constituents above 4 GeV: $p_T^G = \left| \sum_{\text{constituents}} p_T^{> 4 \text{ GeV}} \right|$

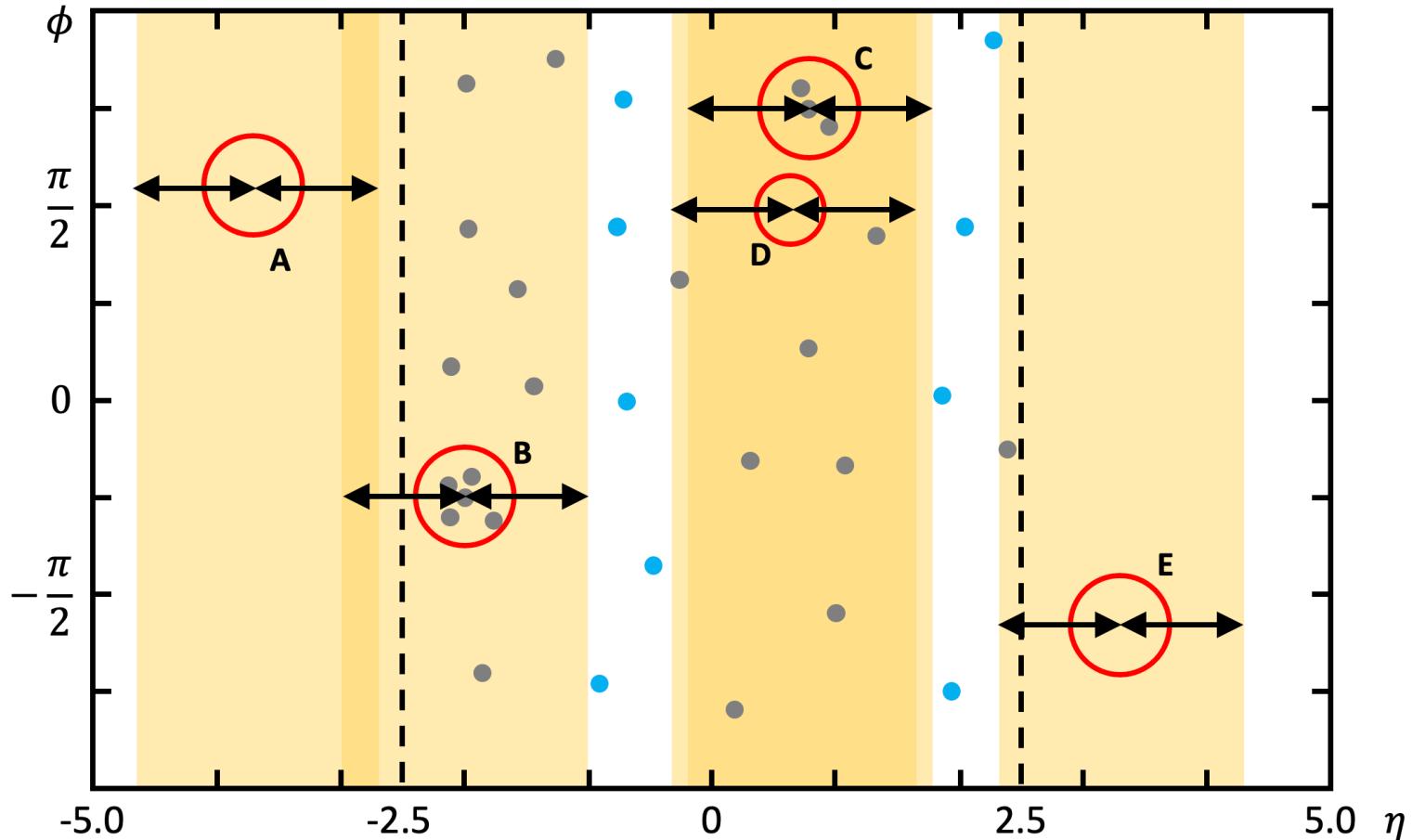
Selections

- $h-h$
- $h^{UE}-h^{UE}$ AllEvents
- $h^{UE}-h^{UE}$ NoJets
- $h^{UE}-h^{UE}$ WithJets
- $h^{UE}-h^J$



Selections

- $h-h$
 - $h^{UE}-h^{UE}$ AllEvents
 - $h^{UE}-h^{UE}$ NoJets
 - $h^{UE}-h^{UE}$ WithJets
 - $h^{UE}-h^J$
- Tracks within $\Delta\eta = \pm 1$ from the jet axis of any jets with $p_T^G > 15$ GeV are dropped.
- NoJets: Events do not have a single jet with $p_T^G > 15$ GeV
- WithJets: Events with at least one jet with $p_T^G > 15$ GeV

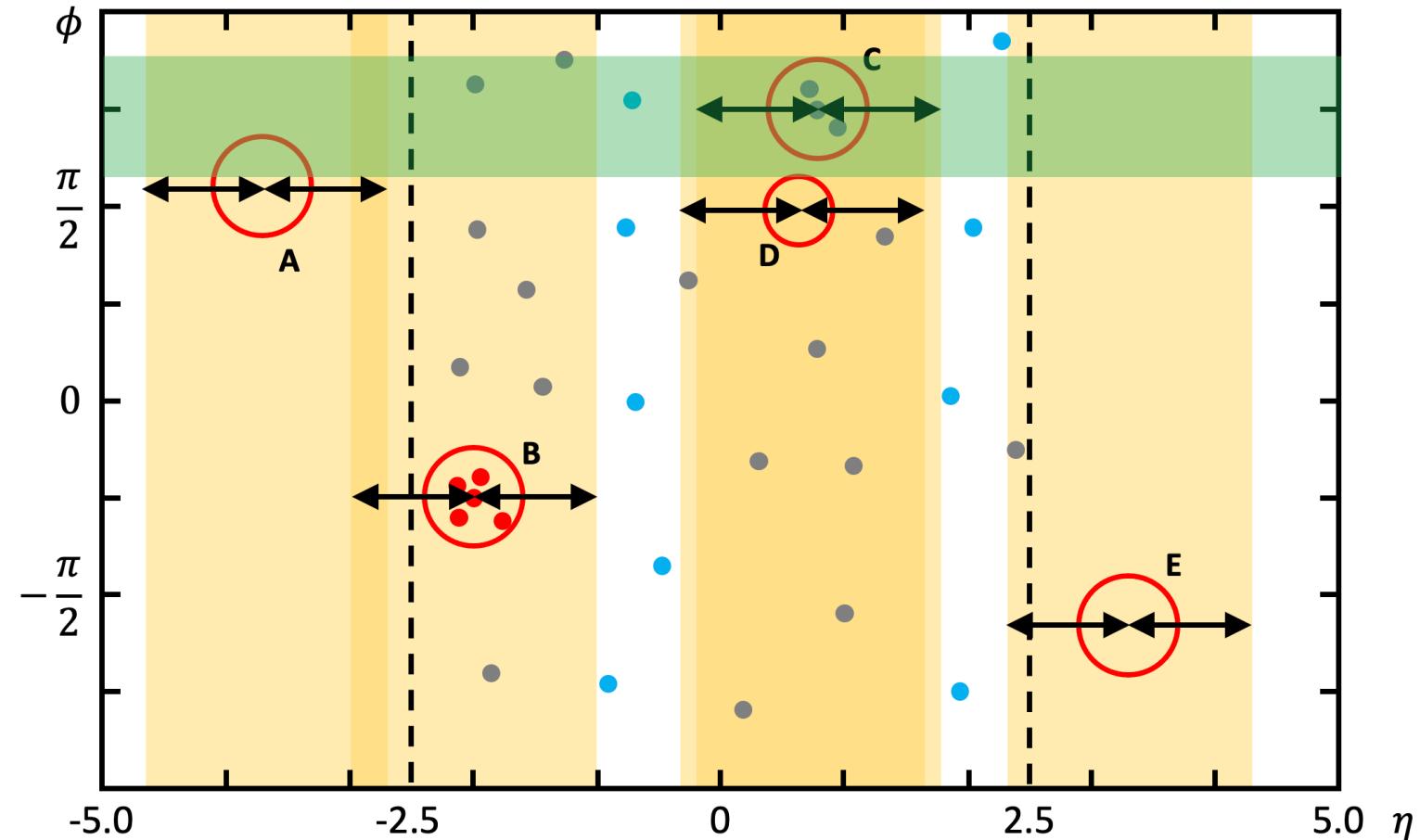


Selections

- $h-h$
- $h^{UE}-h^{UE}$ AllEvents
- $h^{UE}-h^{UE}$ NoJets
- $h^{UE}-h^{UE}$ WithJets
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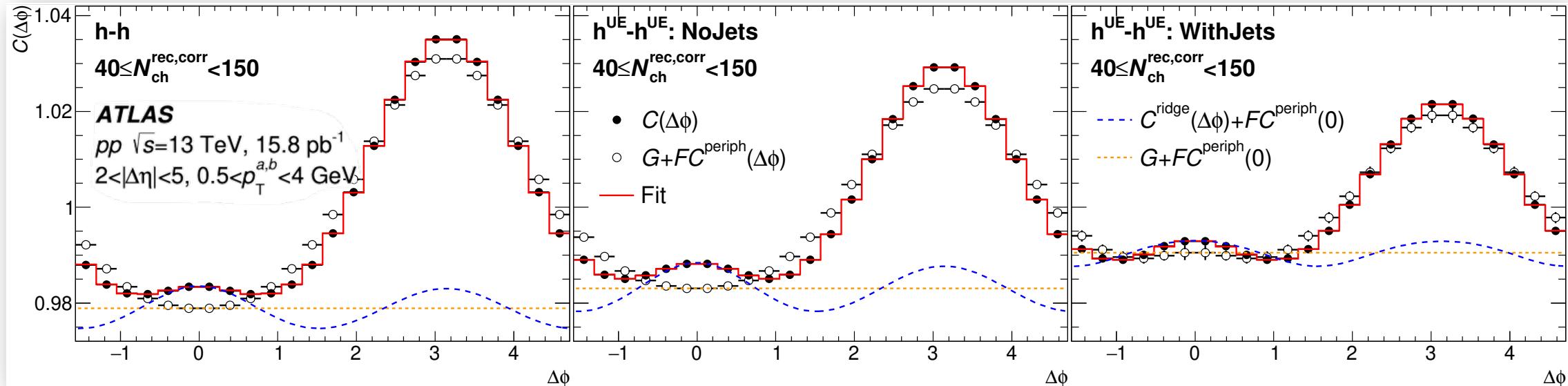
➤ Jet particles:

- Jet $p_T^G > 40$ GeV, $|\eta| < 2.1$
- Require balance jet with $p_T^G > 15$ GeV and $|\Delta\phi| > 5\pi/6$ to reduce non-flow effects in 2PC
- Apply isolation to remove potential distortion of 2PC



Two-particle Correlations

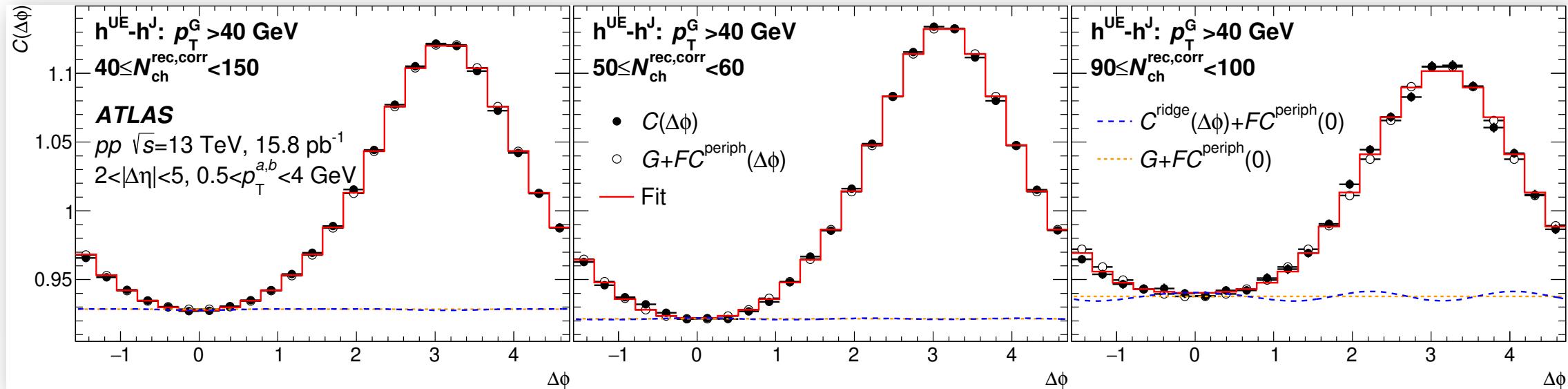
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- 2PC for $h-h$ (left), $h^{UE}-h^{UE}$ NoJets (middle), $h^{UE}-h^{UE}$ WithJets (right)
- Charged particle multiplicity is measured excluding jet constituents
 - Ensure the event activity is not biased by the presence of jets
 - Only reflects the soft multiplicity in the event
- Template-fit is used to extract v_2
- Near-side ridges are observed in $h^{UE}-h^{UE}$

Two-particle Correlations

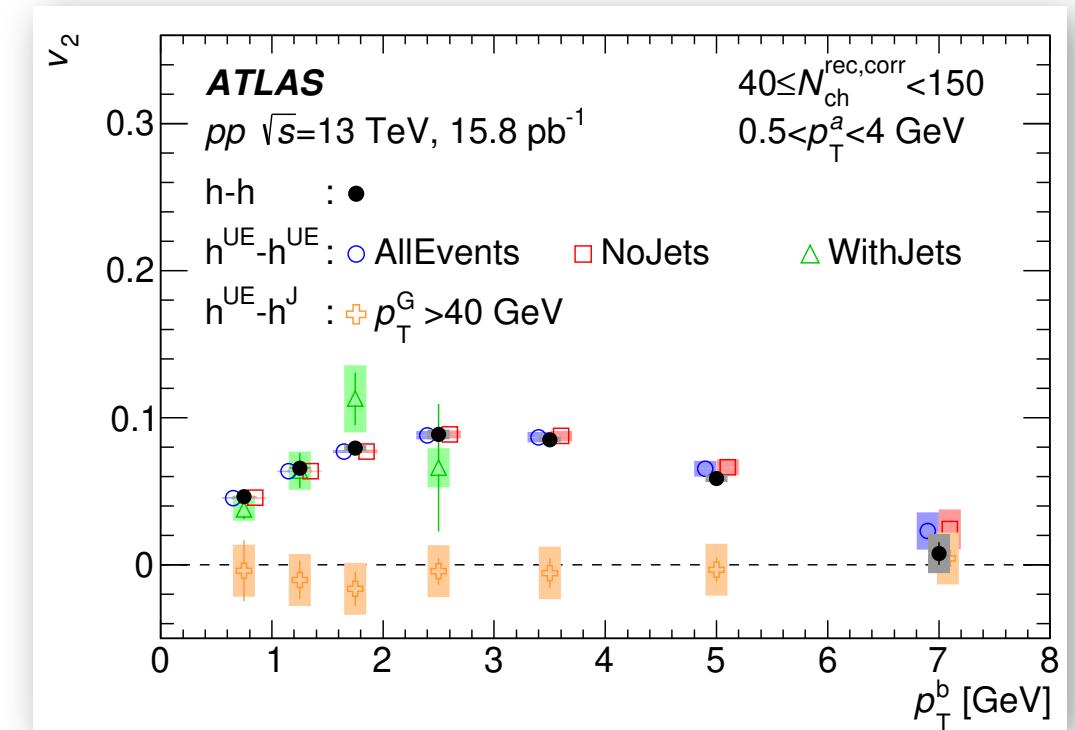
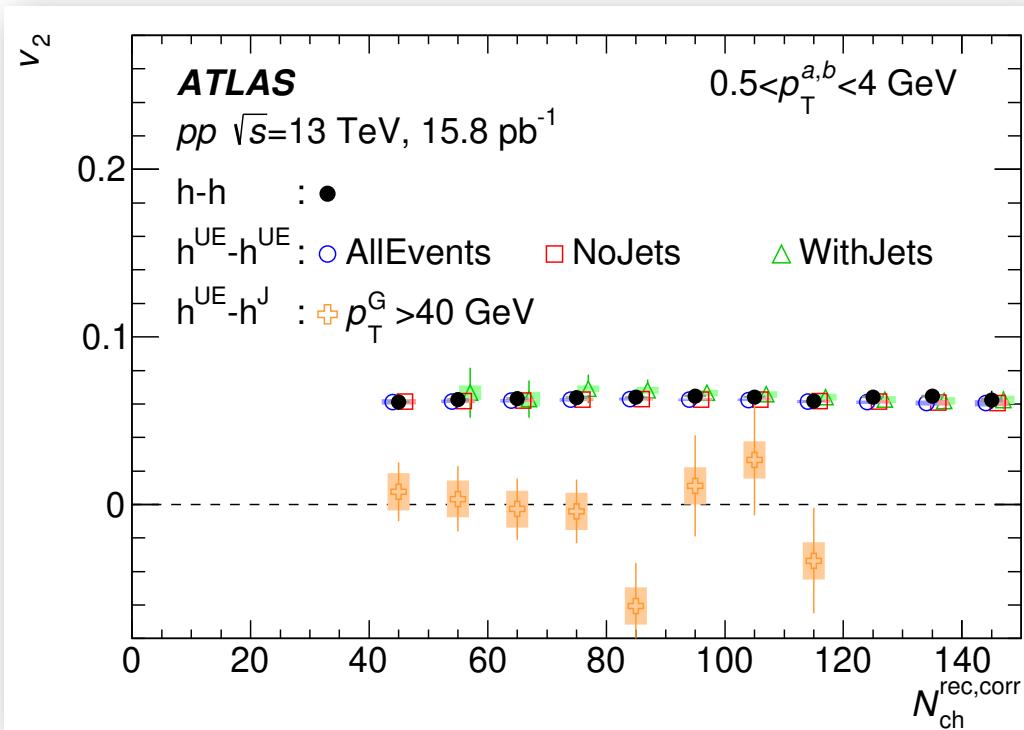
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- $h^{\text{UE}} - h^{\text{J}}$ 2PC for different multiplicity bins
- No ridge is observed in the 2PC for any multiplicity interval

Template-fit v_2

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- The v_2 values are observed to vary weakly with multiplicity
 - Rejecting particles associated with jet in the pp collisions has negligible impact
- $h^{\text{UE}} - h^J v_2$ consistent with zero within uncertainties
 - Both multiplicity dependent and p_T dependent
 - Ridge is not related to jets

Conclusions

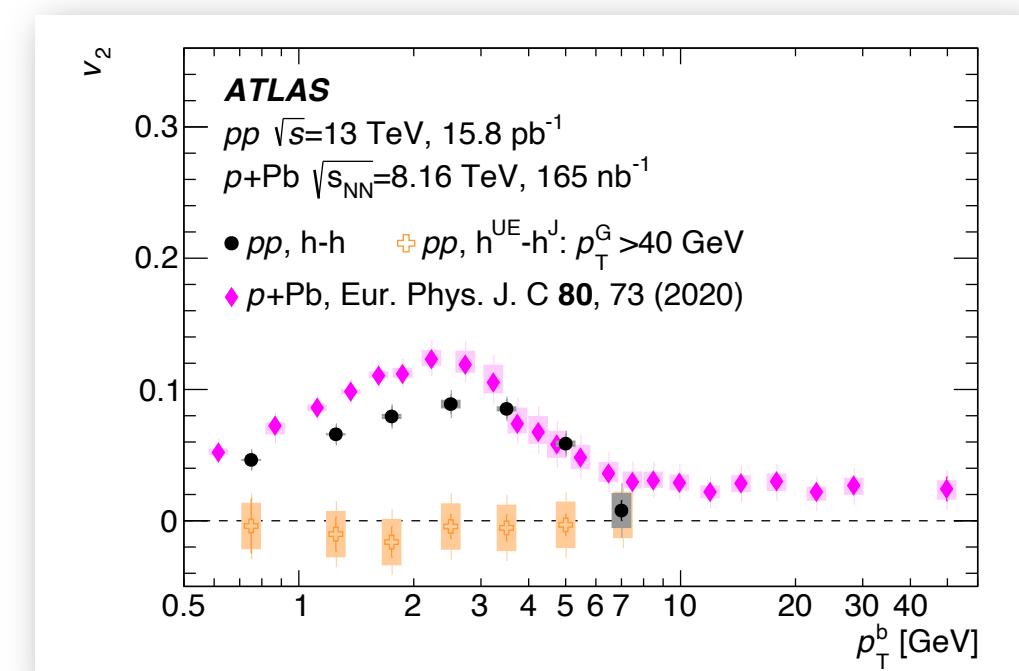
ATLAS, arXiv:2303.17357, Submitted to PRL

- In pp collision, jet p_T are biased by event modulation in the UE
 - The bias is suppressed by applying a p_T threshold to jet constituents
- Absence or presence of jets in pp collision does not impact ν_2
- h^{UE-h^J} 2PC ν_2 consistent with zero
 - Hard scattering and soft collectivity are unrelated

Conclusions

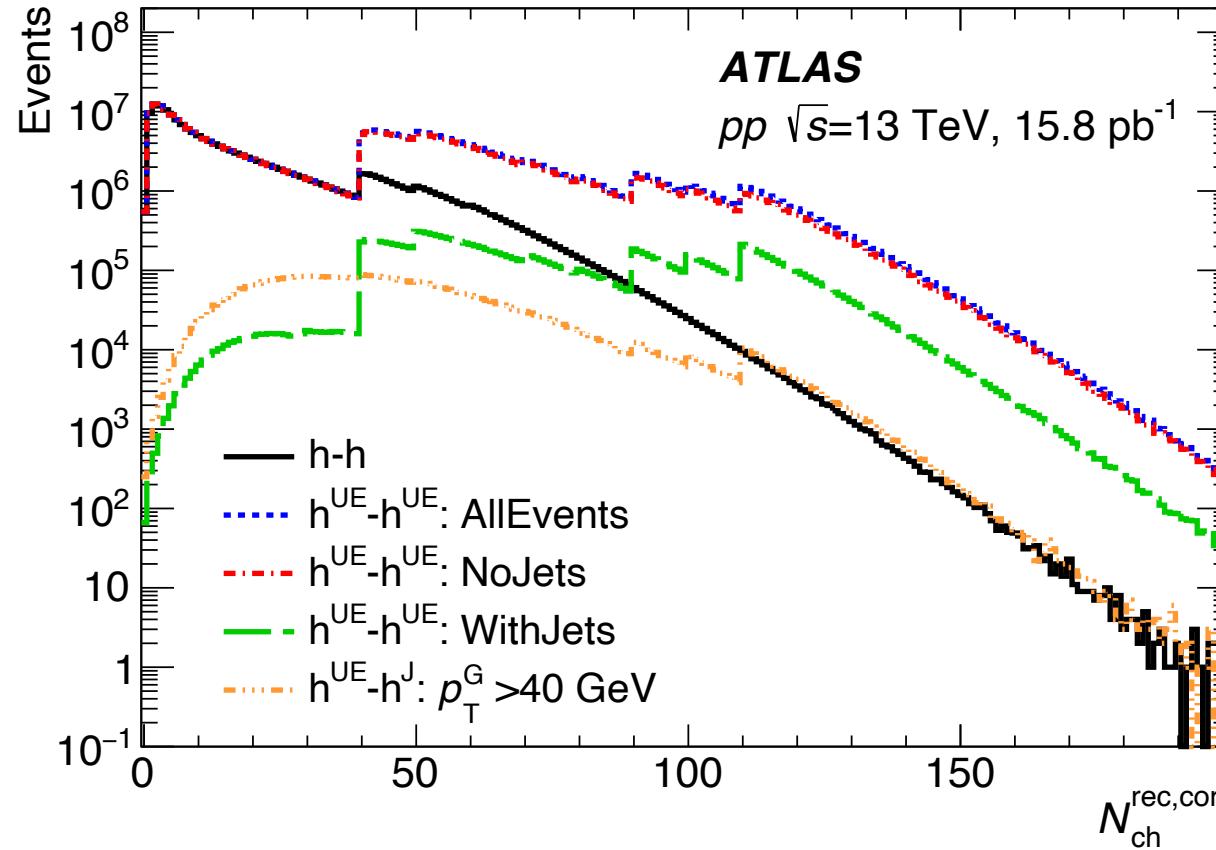
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- In pp collision, jet p_T are biased by event modulation in the UE
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- Absence or presence of jets in pp collision does not impact v_2
- h^{UE-h^J} 2PC v_2 consistent with zero
 - Hard scattering and soft collectivity are unrelated
- Previous analysis in p+Pb show correlations between jet particles and the UE
 - $\sim 0.02 v_2$ at $p_T > 8$ GeV region in p+Pb
 - Maybe due to physics-related factor
 - Different techniques used with different p_T range
- Further studies are needed to understand the difference

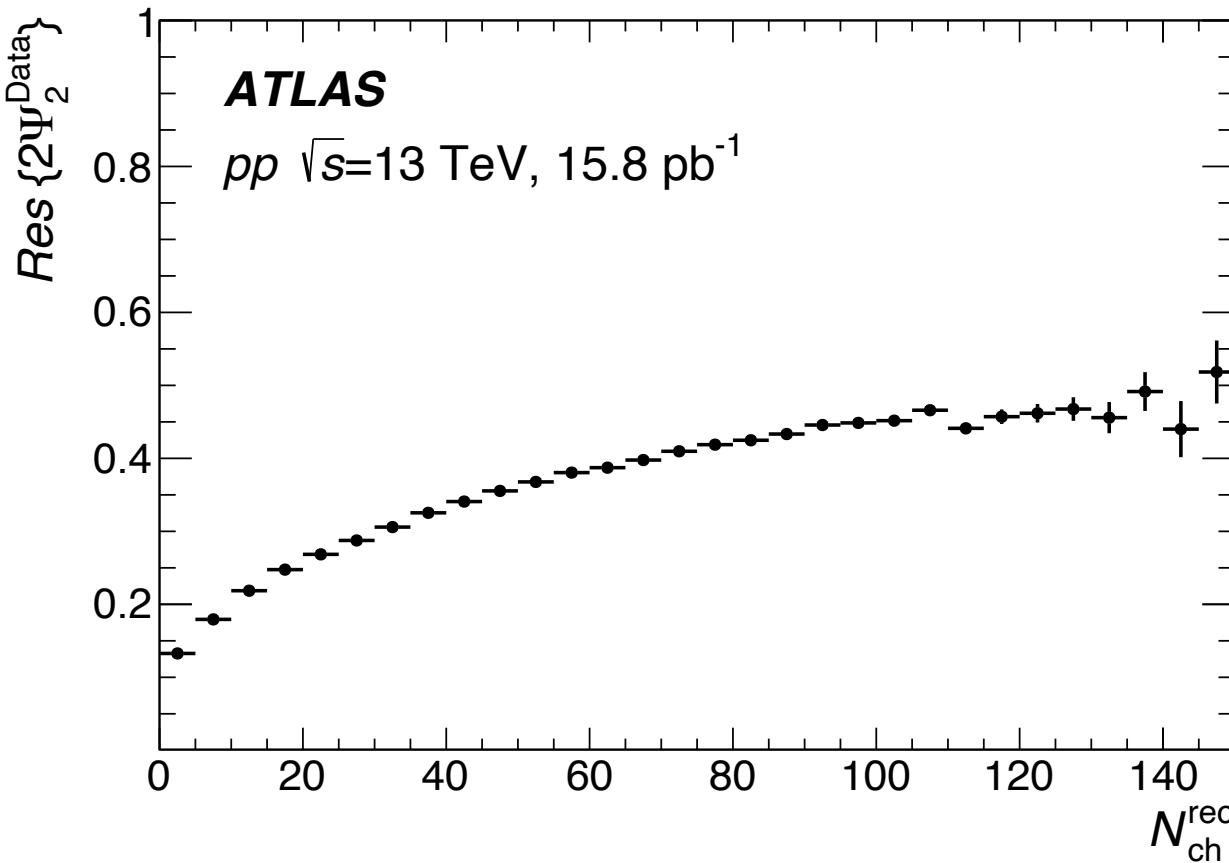


Backup

Multiplicity distribution

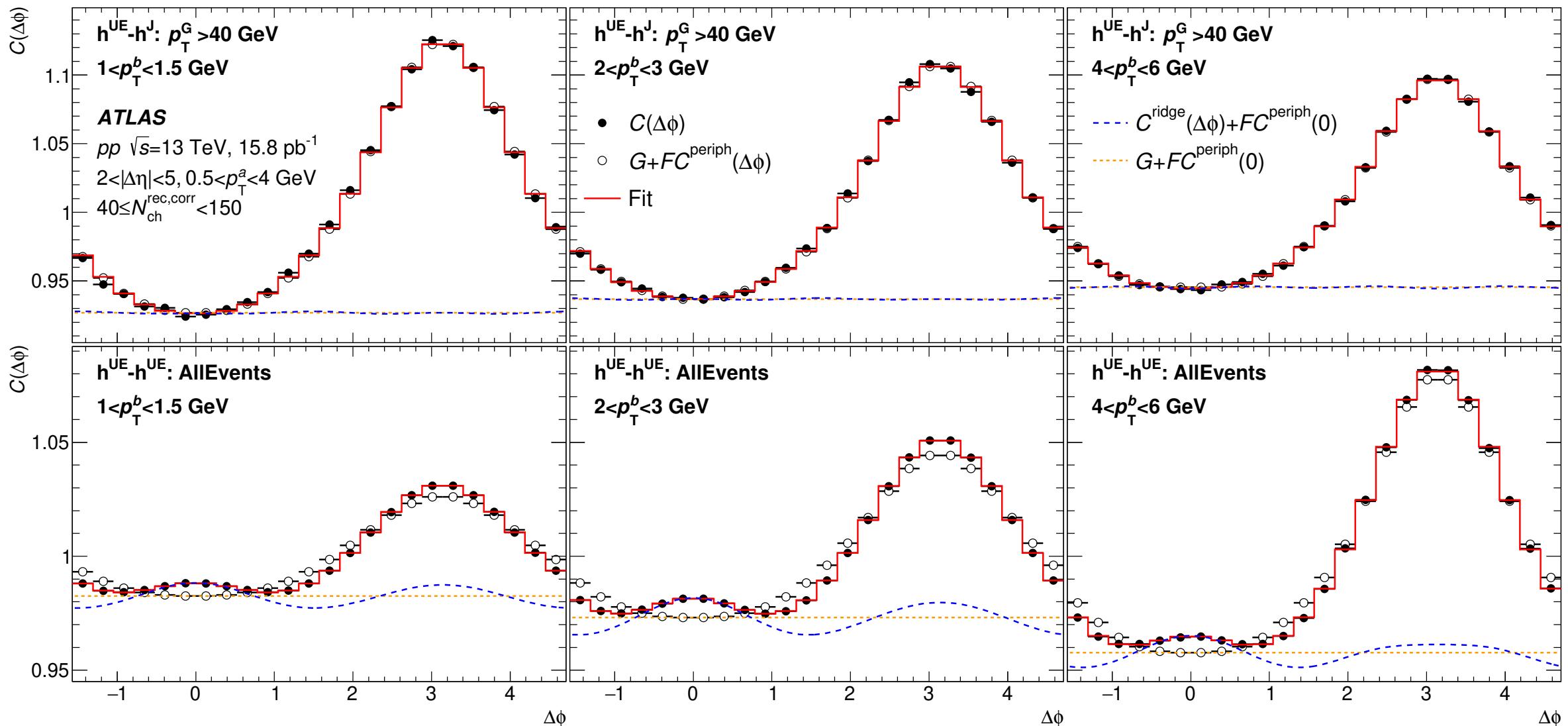


Event plane resolution

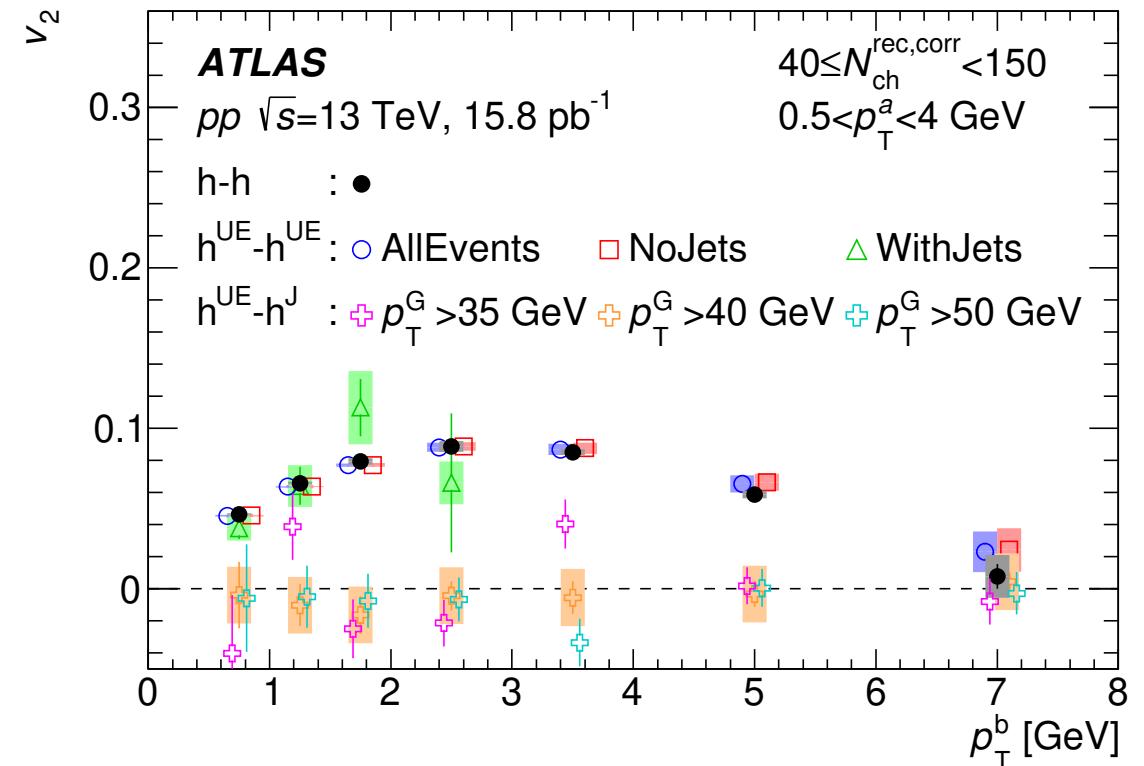
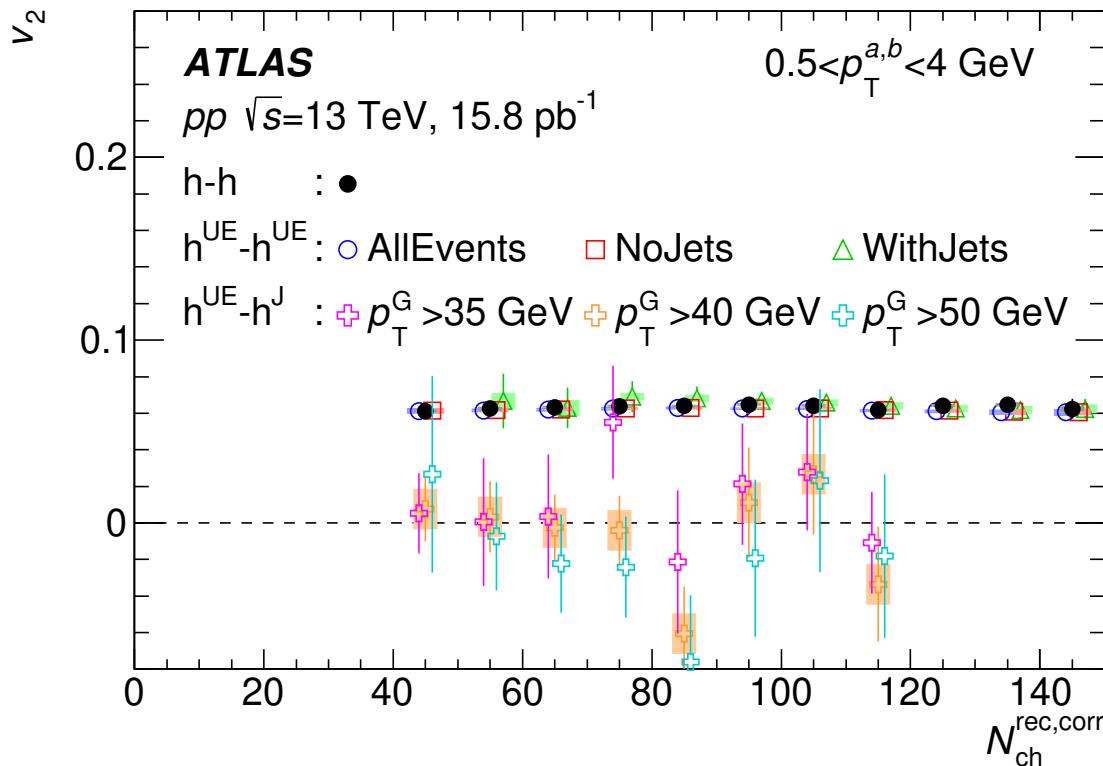


- Calculated using sub-event method with particle-flow objects 1 unit in eta away from $p_T^G > 15 \text{ GeV}$ jets

Two-particle Correlations with different p_T bins

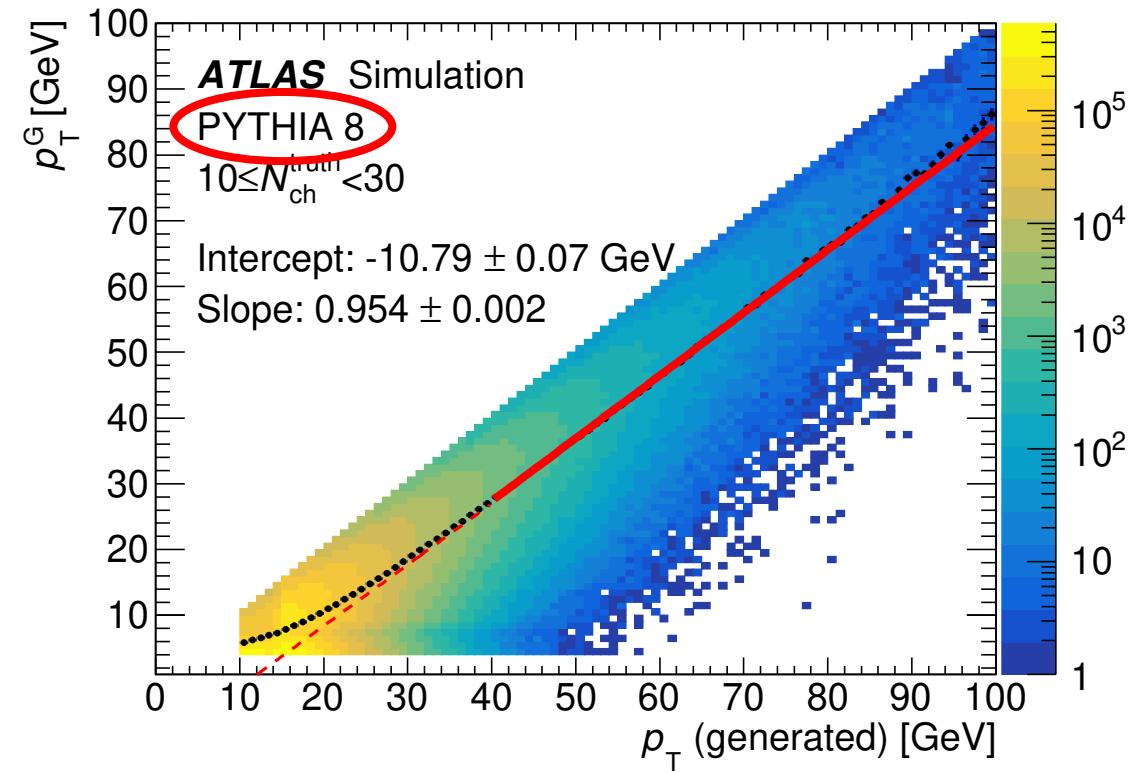
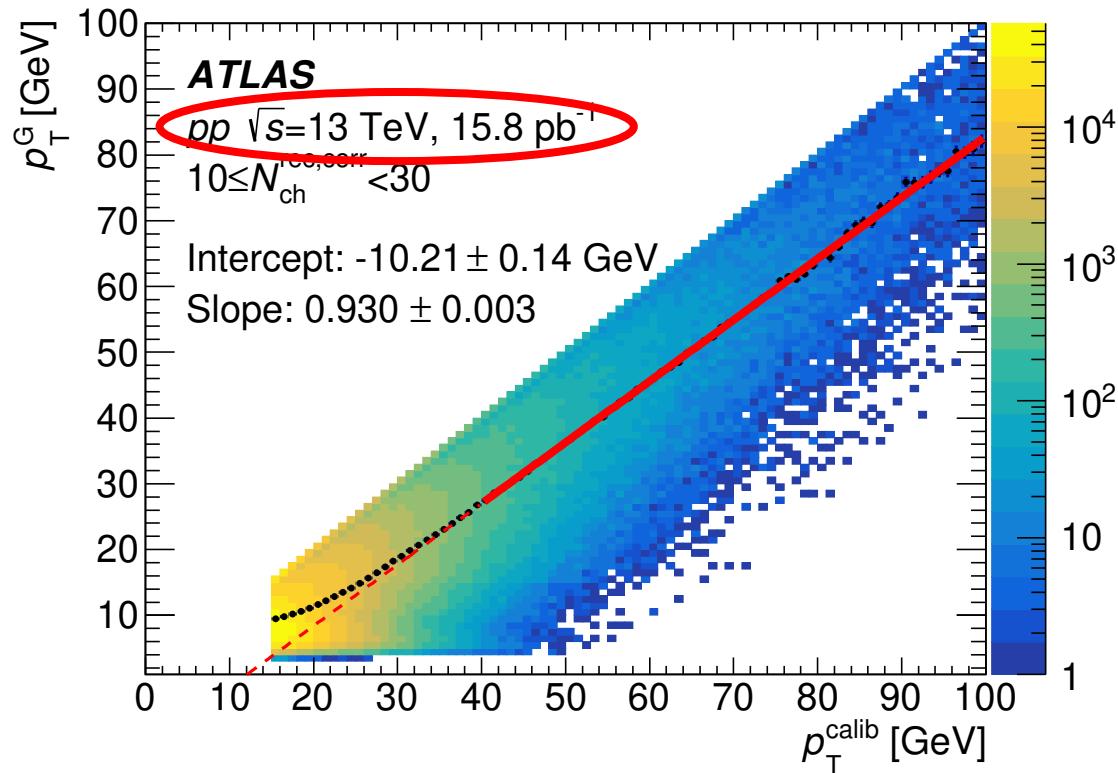


Crosscheck of p_T^G threshold



- $h^{\text{UE}} - h^{\text{J}}$ v_2 obtained using three different p_T^G threshold
 - $p_T^G > 35 \text{ GeV}$, $p_T^G > 40 \text{ GeV}$, $p_T^G > 50 \text{ GeV}$
- No p_T^G dependence observed
- Results are consistent with each other and consistent with zero

p_T^G vs original jet p_T



- Comparison of p_T^G to original jet p_T in data (left) and PYTHIA 8 (right)
- Low multiplicity events are used as UE bias is negligible
- Fits are consistent between data and MC