Multiplicity dependent J/ψ-Jet fragmentation properties in proton-proton collisions

Qiuru Bai

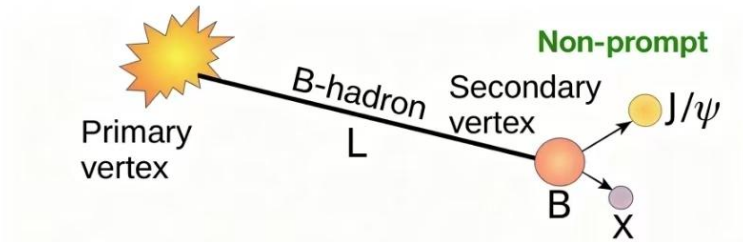
Central China Normal University

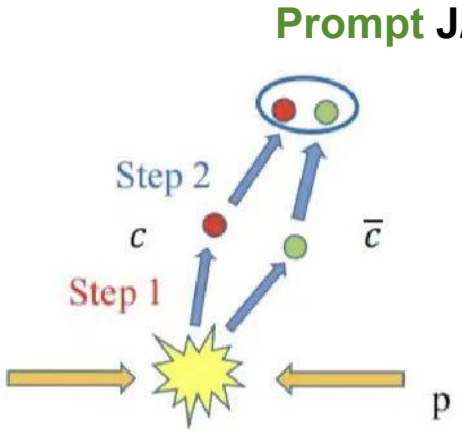
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Introduction

- Quarkonia: bound states of heavy quark and antiquark pairs.
- J/ψ： a bound state of a charm quark and an anti-charm quark
- Prompt J/ψ
  - Direct production in initial collisions
- Non-prompt J/ψ
  - Produced via B-hadron decays through weak interactions.





- Separating prompt and non-prompt J/ψ production allows us to probe charm-quark and bottom-quark physics independently.

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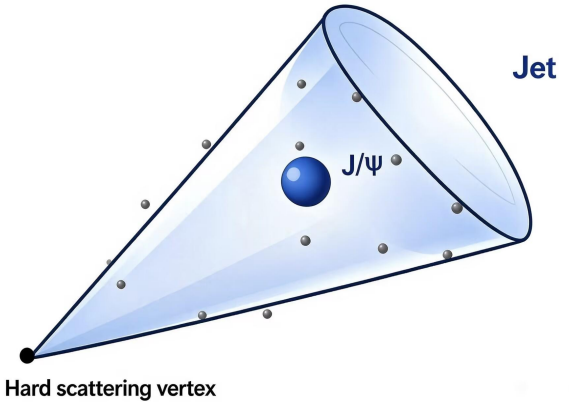
Motivation: J/ψ-jet

- Compared with inclusive quarkonium production, J/ψ-in-jet measurements retain information about the surrounding hadronic activity associated with the quarkonium.

- **A key observable in J/ψ-in-jet studies is the momentum fraction,**

$$z = \frac{P_T^{J/\psi}}{P_T^{jet}}$$

  - Large z: J/ψ carries most of the jet momentum.
  - Small z: J/ψ is accompanied by more hadronic activity inside the jet



- We study the momentum fraction distribution of J/ψ-in-jets in pp collisions using PYTHIA based on ALICE Run 3 kinematics.

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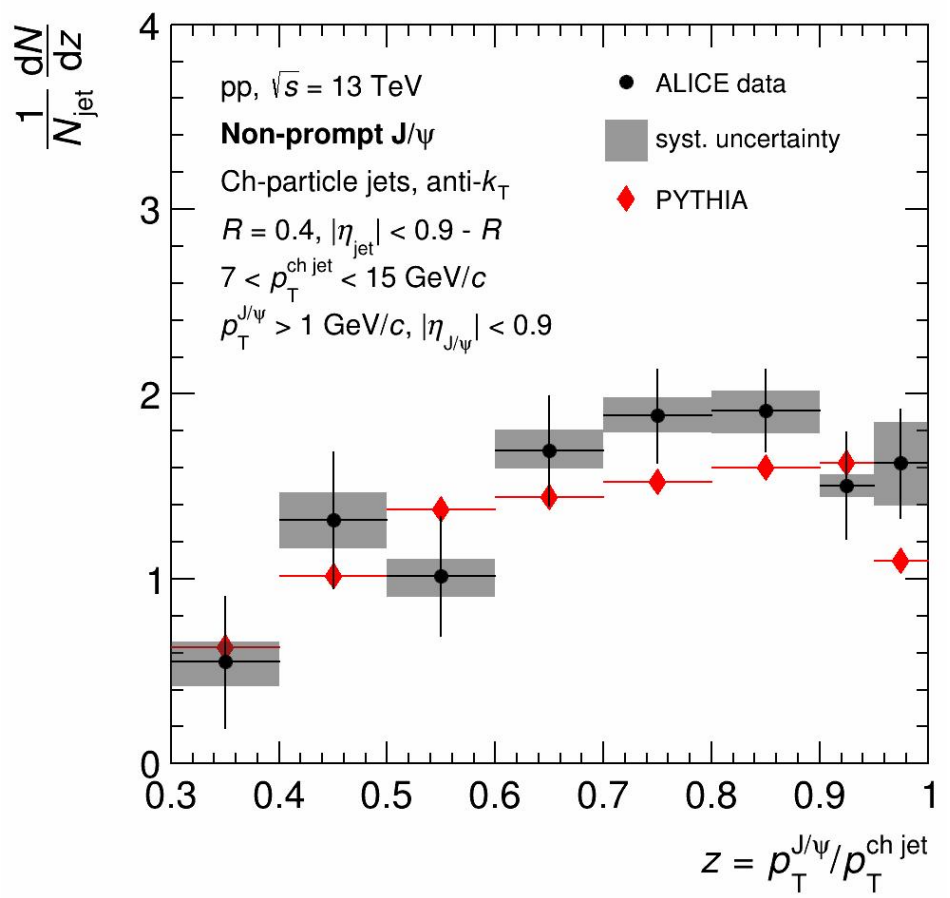
PYTHIA model configuration

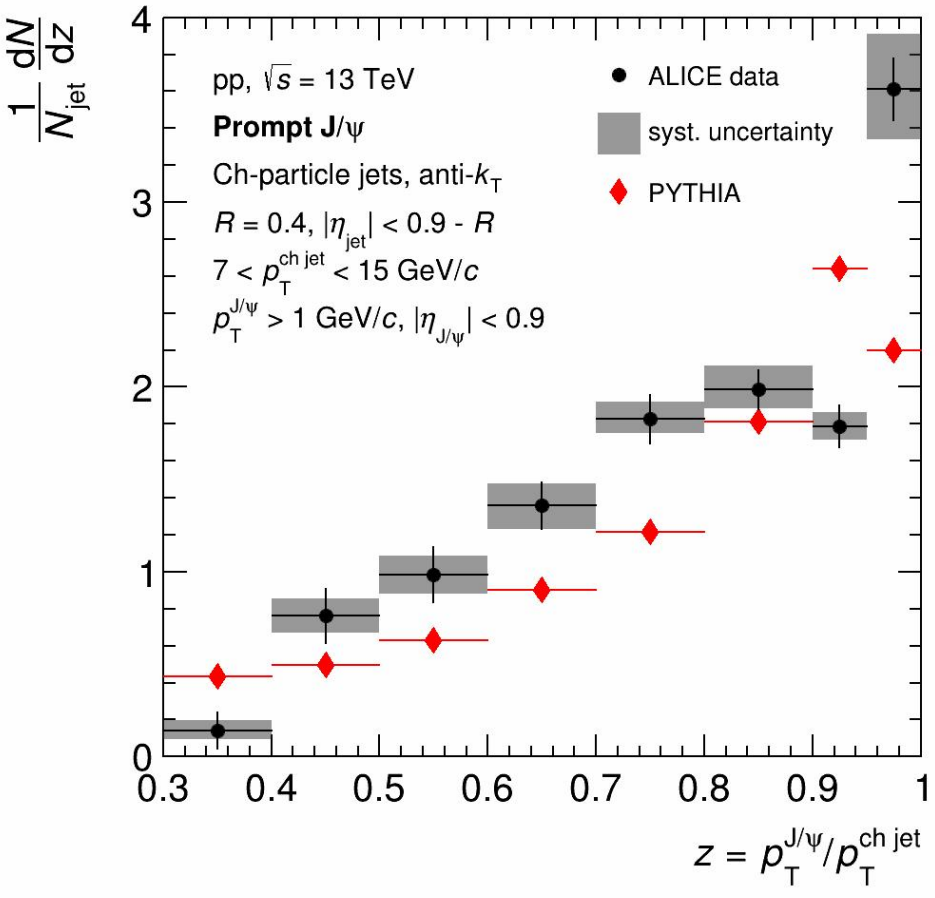
Generator	Sample	PYTHIA 8
Collision system	Collision type	pp collisions
Physics process	HardQCD:all	on
	Charmonium:all	on
Particle decay	443:mayDecay	off
Default switches	PartonLevel:MPI	on
	ColourReconnection:reconnect	on
Track selection	Final-state particle pseudorapidity	$\lvert\eta_{track}\rvert < 0.9$
Jet reconstruction	Algorithm	anti-k_T
	Radius parameter R	0.4
	Jet pseudorapidity range	$\lvert\eta_{jet}\rvert < 0.9 - R$
J/ψ selection	Transverse momentum	$p_T^{J/\psi} > 1$ GeV /c
	Pseudorapidity	$\lvert\eta_{J/\psi}\rvert < 0.9$

arXiv:2203.11601 [hep-ph].

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Simulation Framework Validation

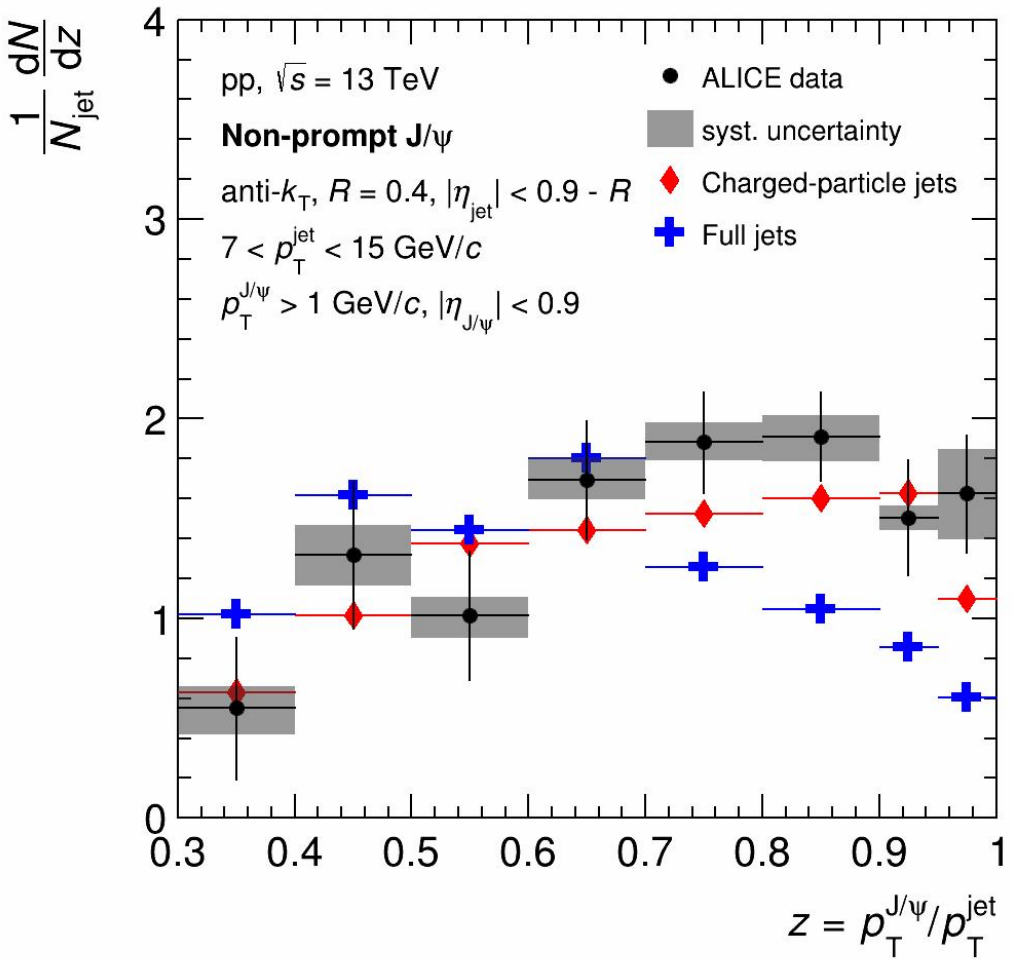


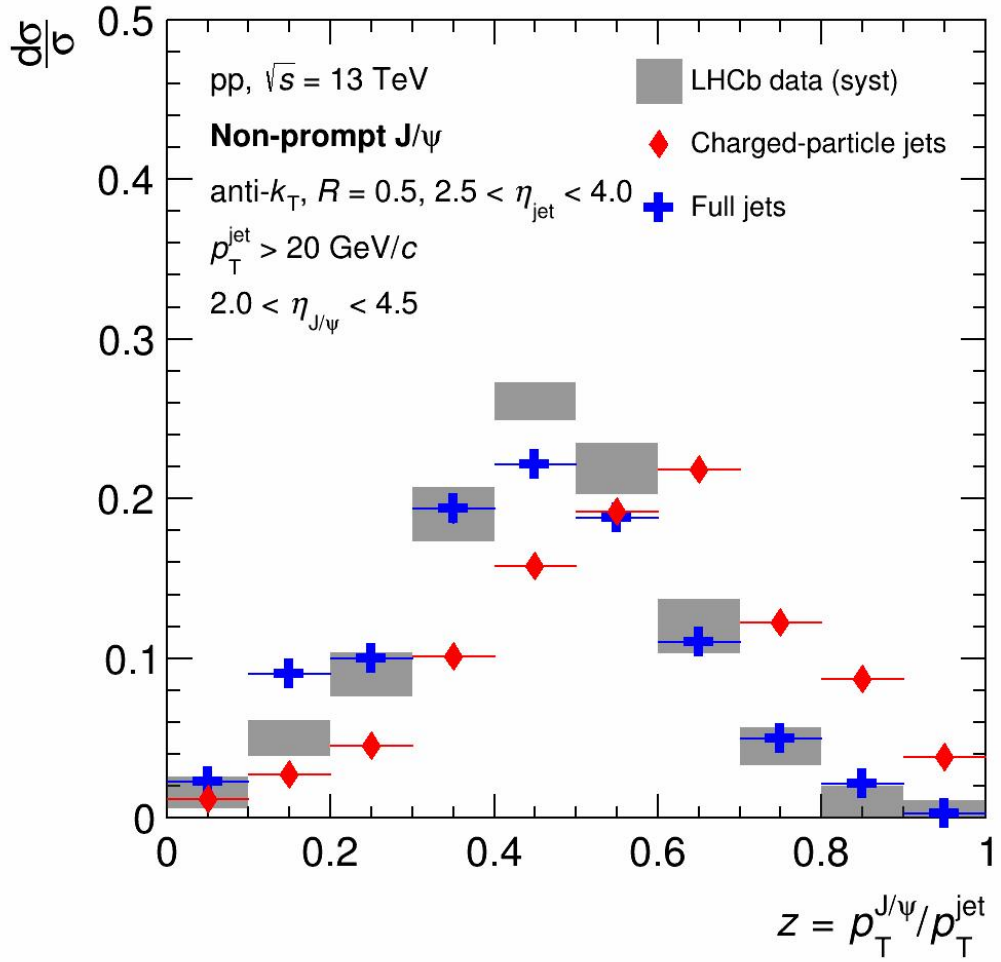


PYTHIA reasonably describes the momentum fraction distributions of both prompt and non-prompt J/ψ measured by ALICE.

ALICE, arXiv:2602.22889v1 [hep-ex], 2026.

J/ψ –jet fragmentations: Charged Vs Full Jets



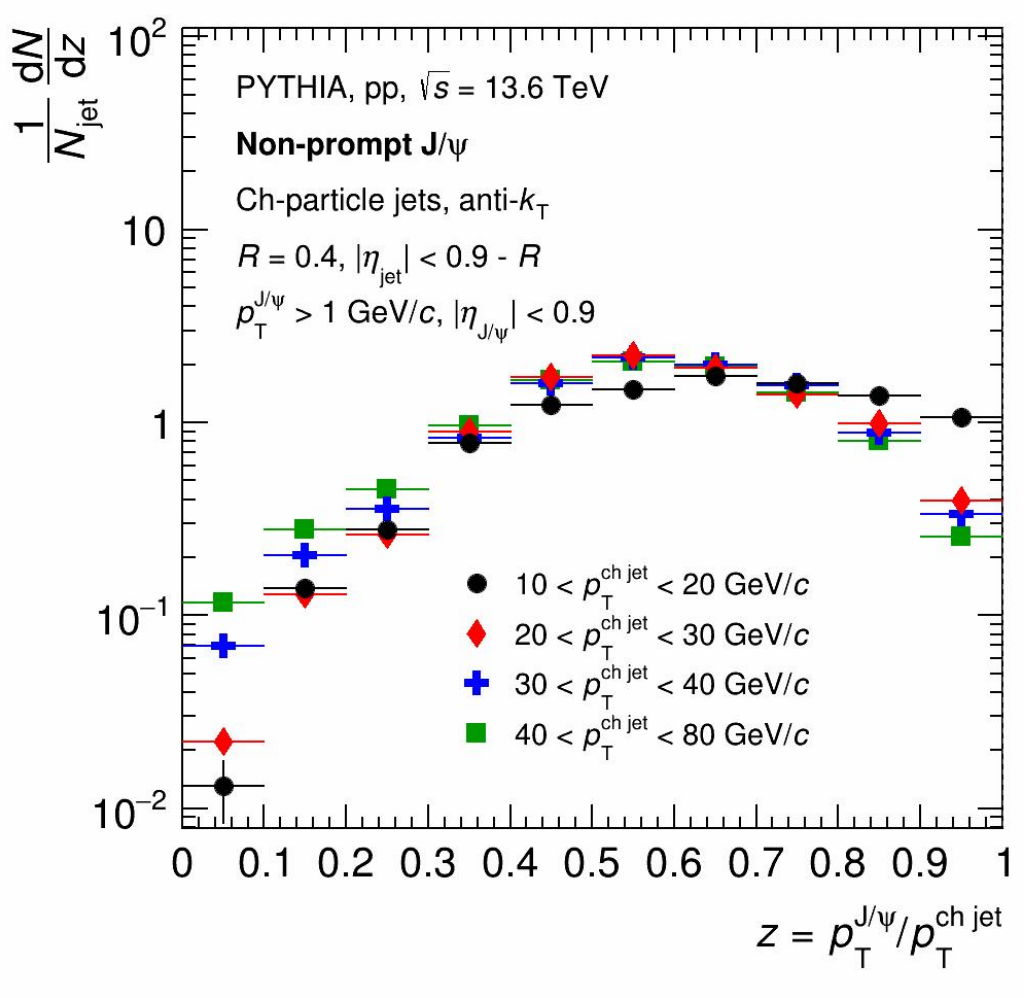


- When reconstructing jets includes also neutral component, the J/ψ- jet fragmentation shift to a lower z direction due to the jet energy scale changes.
- By using full jets instead of charged-particle jets, we can reproduce the LHCb measurements as well since they used full jet reconstruction.

LHCb, Phys. Rev. Lett. 118, 192001 (2017)

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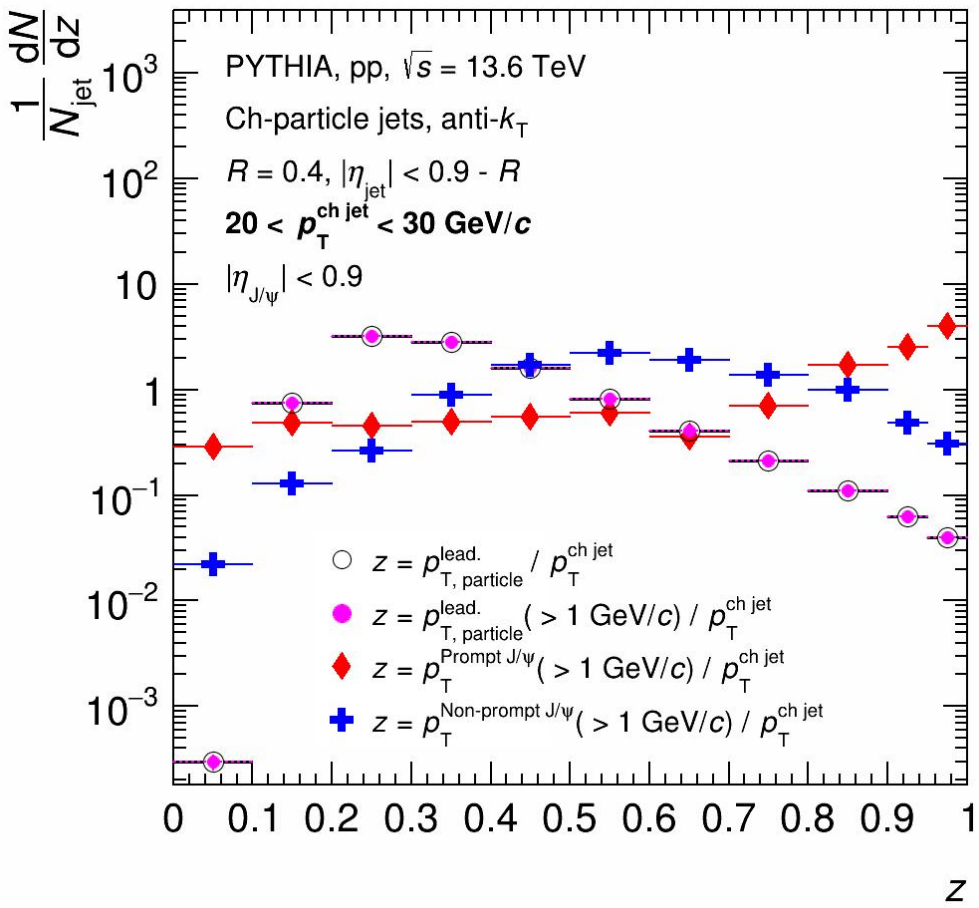
J/ψ Momentum Fraction: Jet Momentum dependence



- When increasing the jet p_T, J/ψ-jet FF shifts towards to left for z distribution
- While FF is biased in the lowest jet p_T bin due to the kinematical cuts applied on J/ψ selection

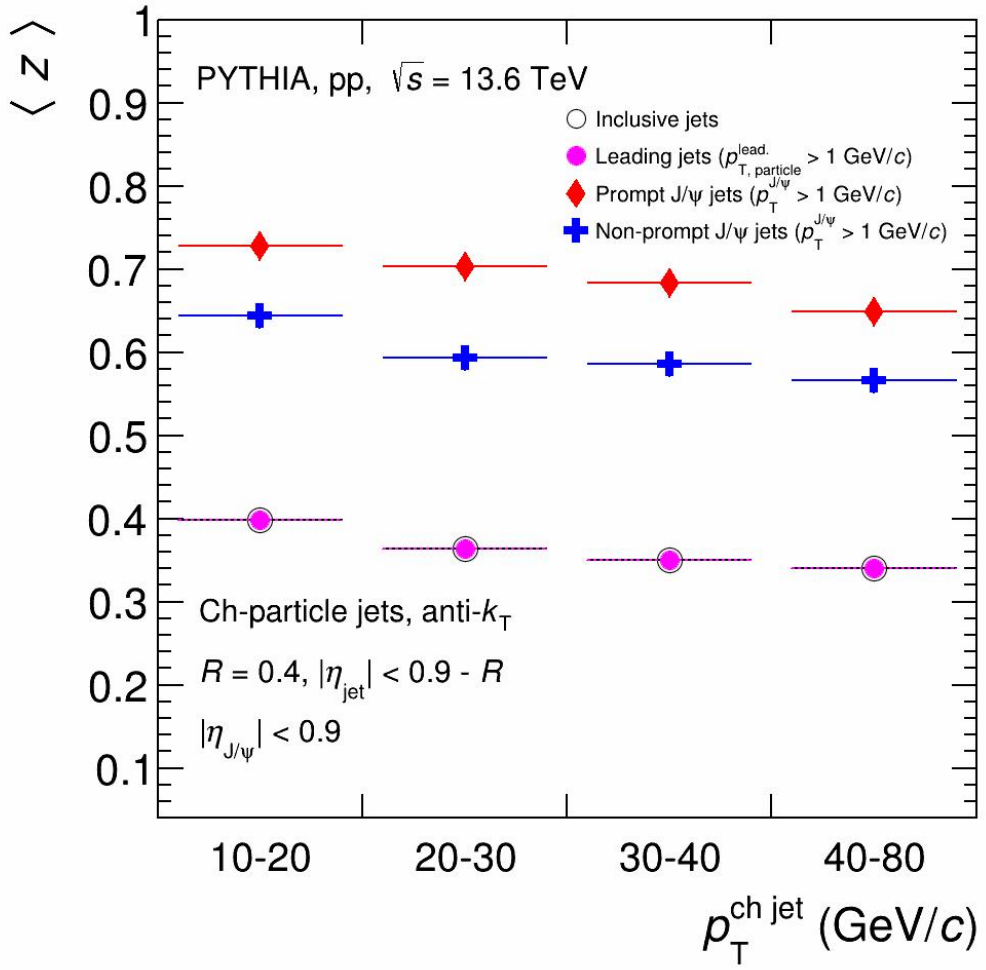
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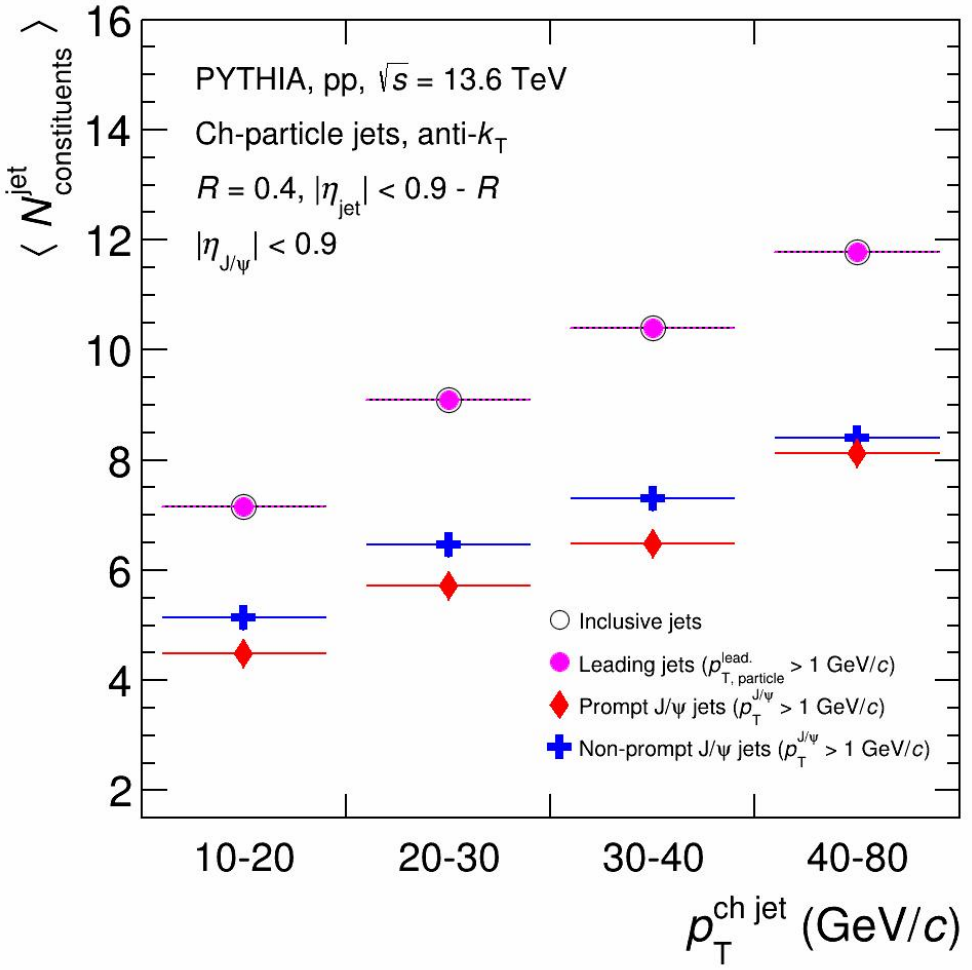
Mass/Flavor-Dependent Jet Fragmentation



- In jets with $20 < p_T^{ch\ jet} < 30$ GeV/c, the momentum fraction of leading particle cut ($p_T > 1$ GeV/c) is almost unaffected.
- Compared to different type of jets FF, a clear flavor and mass dependence is observed.

Mass/Flavor-Dependent Jet Fragmentation

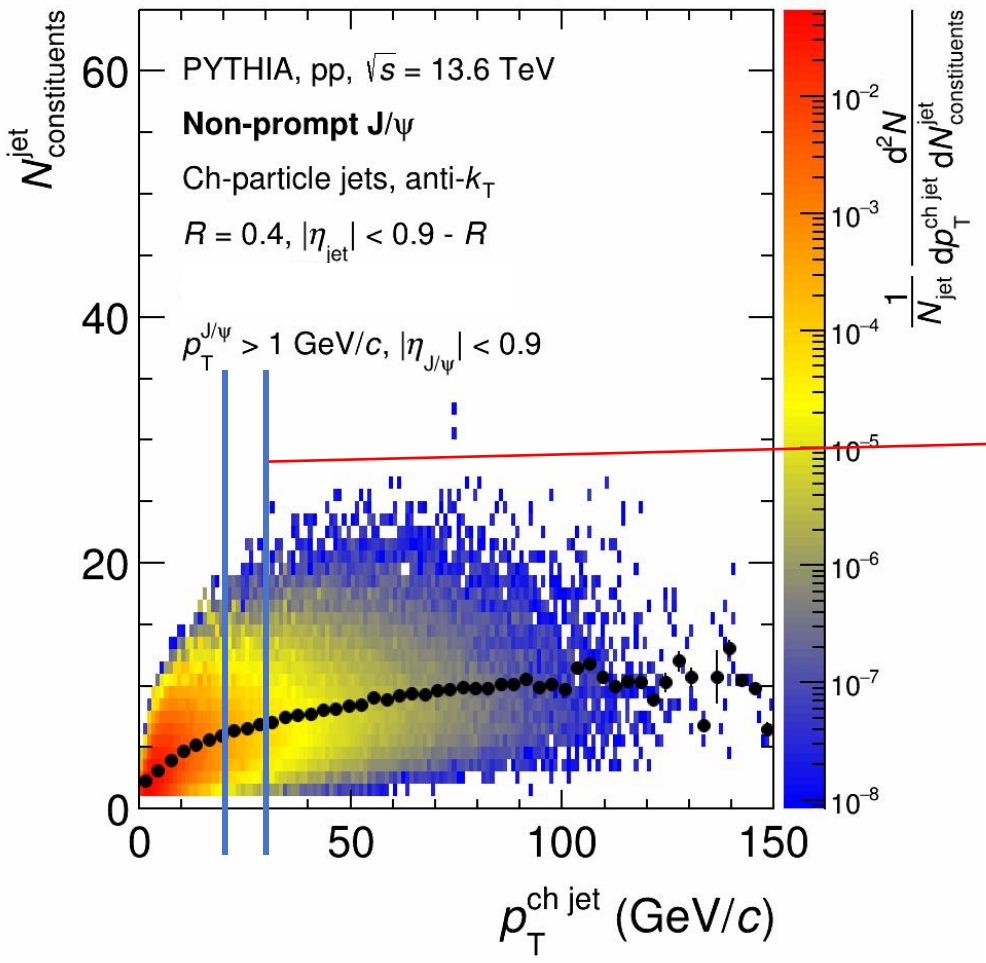


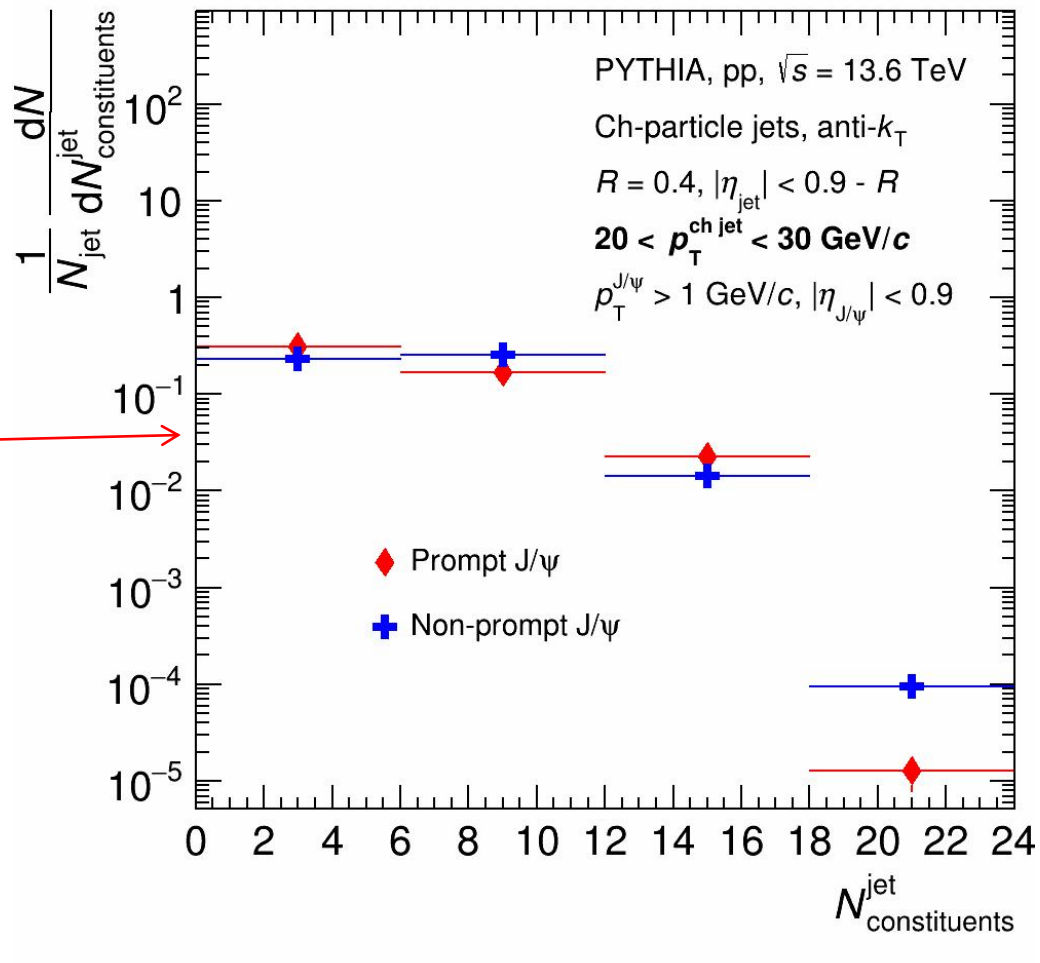


- As the $p_T^{ch\ jet}$ increases, $\langle N_{constituents} \rangle$ increases, while $\langle z \rangle$ decreases.
- $\langle z \rangle$ shifts toward higher z when going from light-flavor to heavy-flavor particles.
- $\langle N_{constituents} \rangle$ shifts toward lower $N_{constituents}$ when going from light-flavor to heavy-flavor particles.

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Multiplicity-Dependent J/ψ Fragmentation



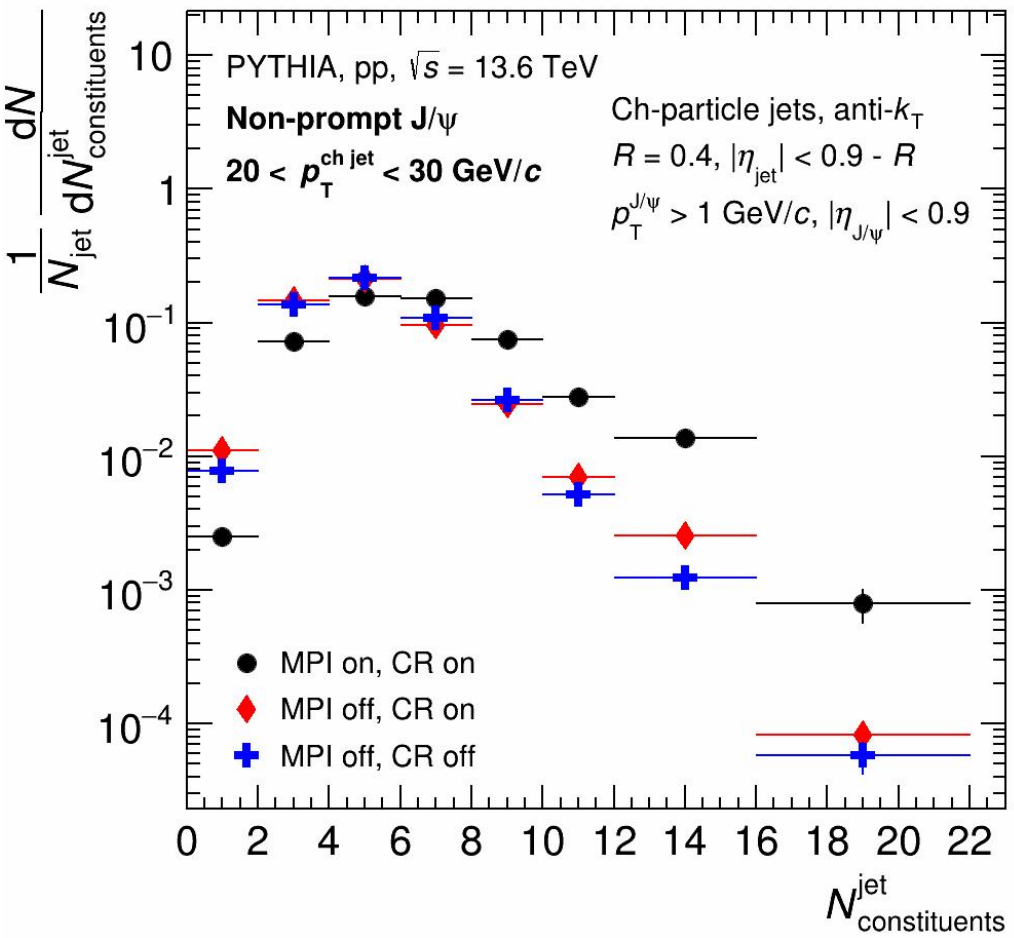


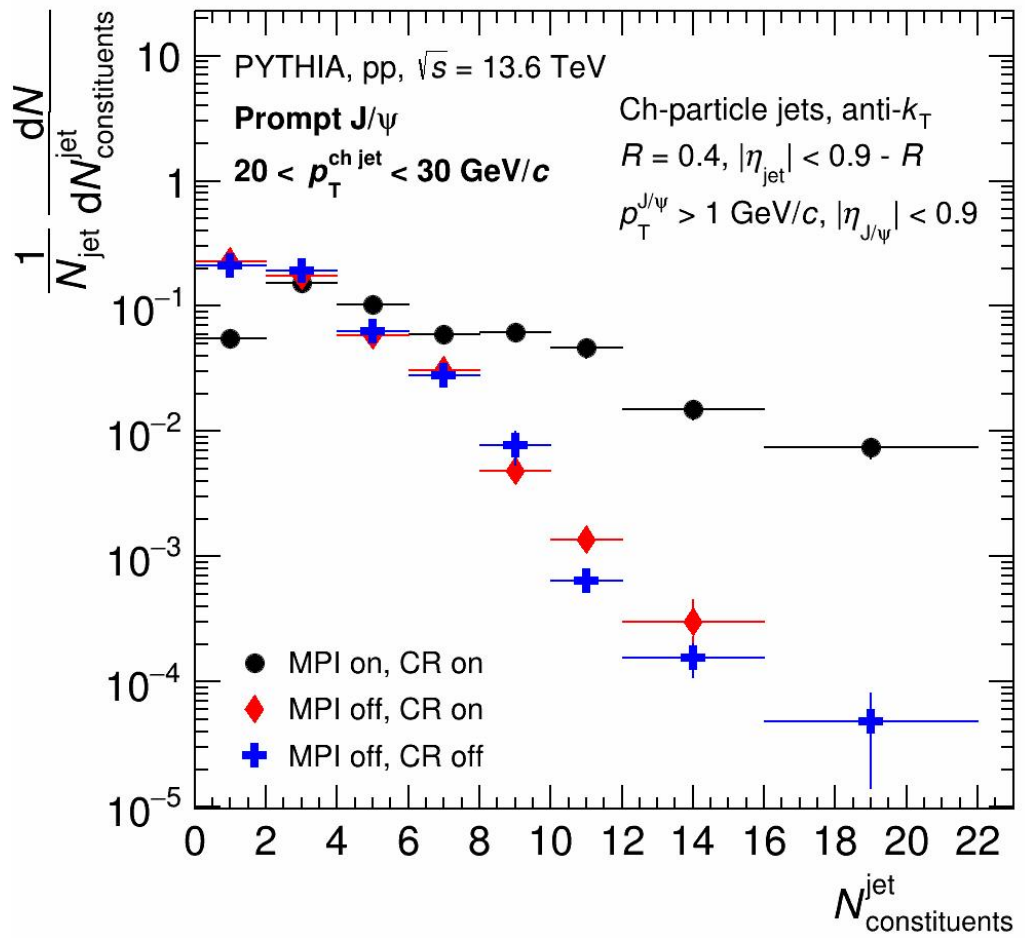
Jets with higher transverse momentum contain more jet constituents

The multiplicity distributions of prompt and non-prompt J/ψ jets in $20 < p_T^{ch\ jet} < 30$ GeV/c intervals

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Multiplicity-Dependent J/ψ-jet Fragmentation

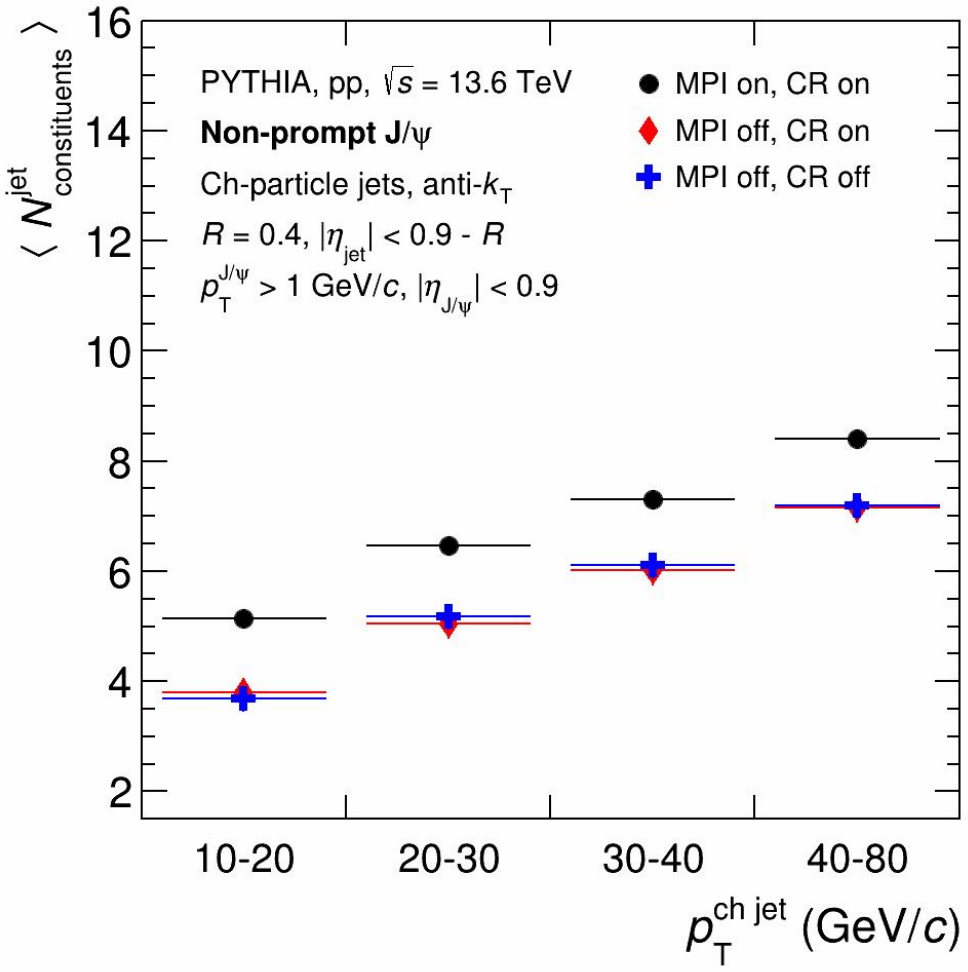


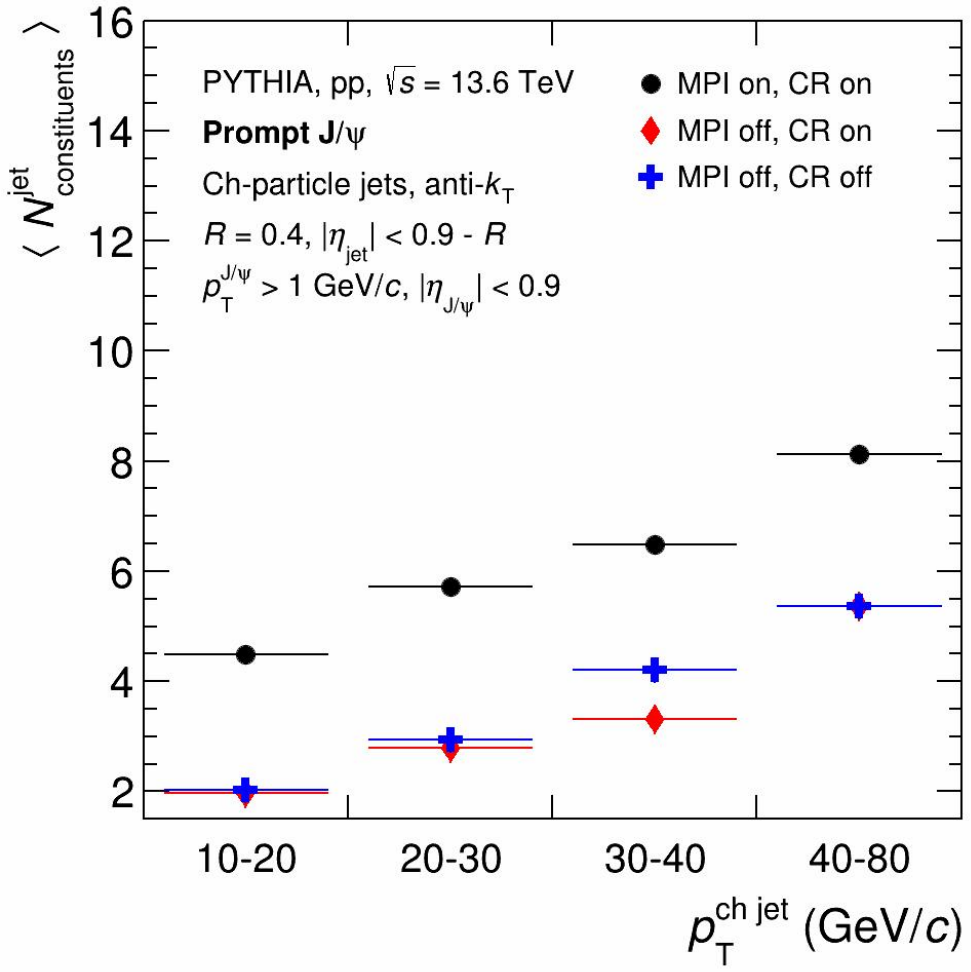


- MPI effect changes the jet constituent numbers largely.
- CR effect has a small influence on jet constituents multiplicities.

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Multiplicity-Dependent J/ψ Fragmentation

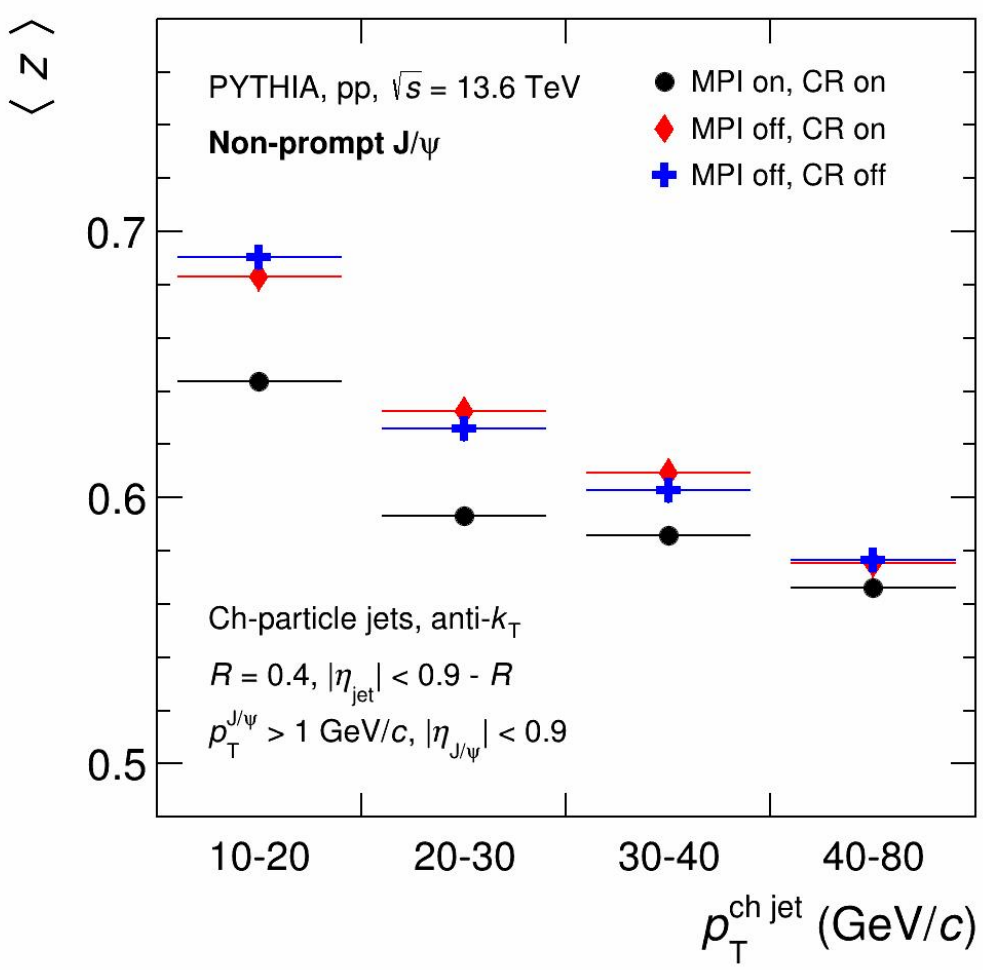


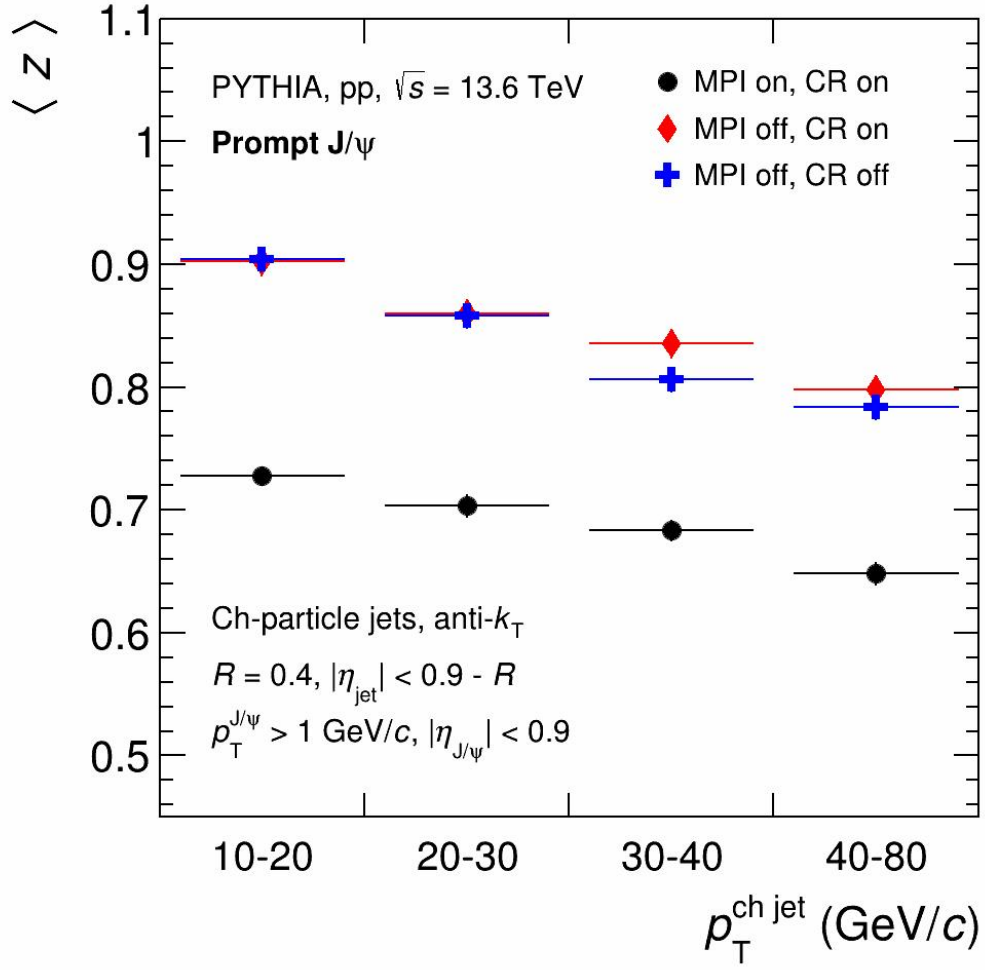


- For prompt jets, switching on MPI almost changes the constituent multiplicity by a factor of 2.
- For non-prompt jets, the trend is similar but the effect is slightly smaller.

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Multiplicity-Dependent J/ψ Fragmentation

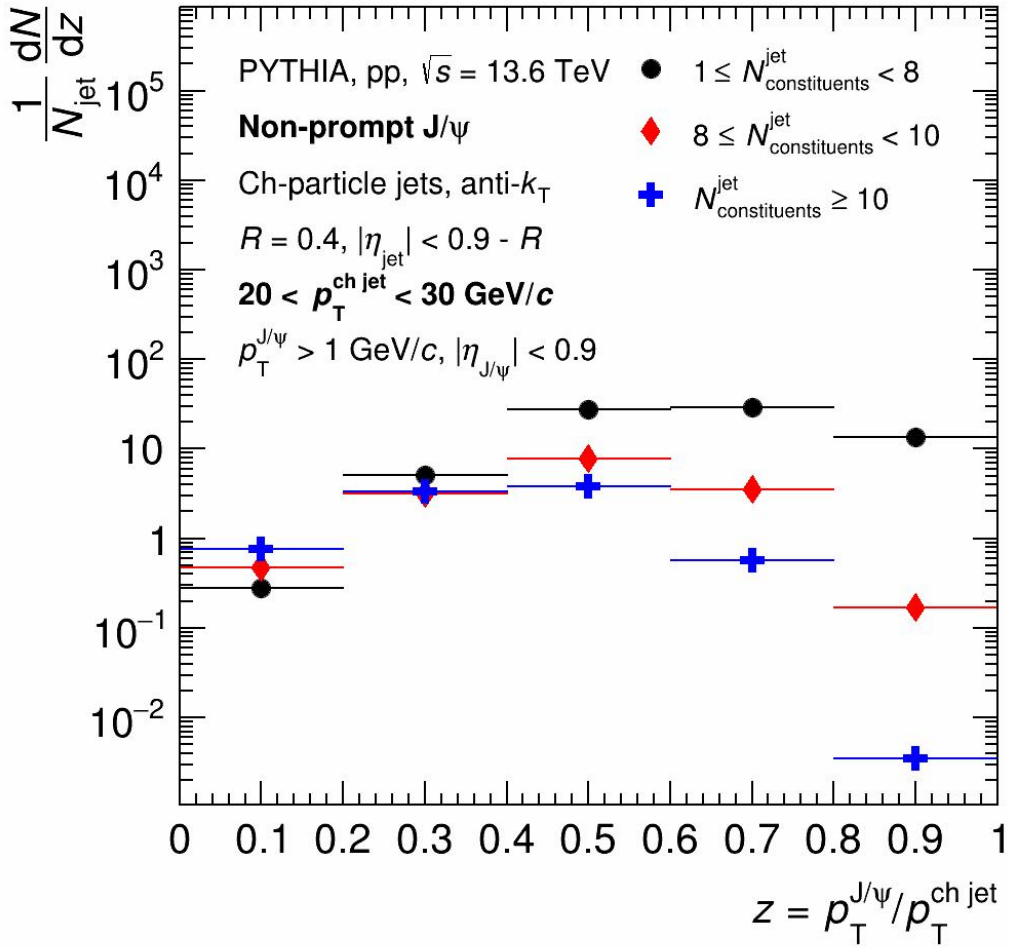


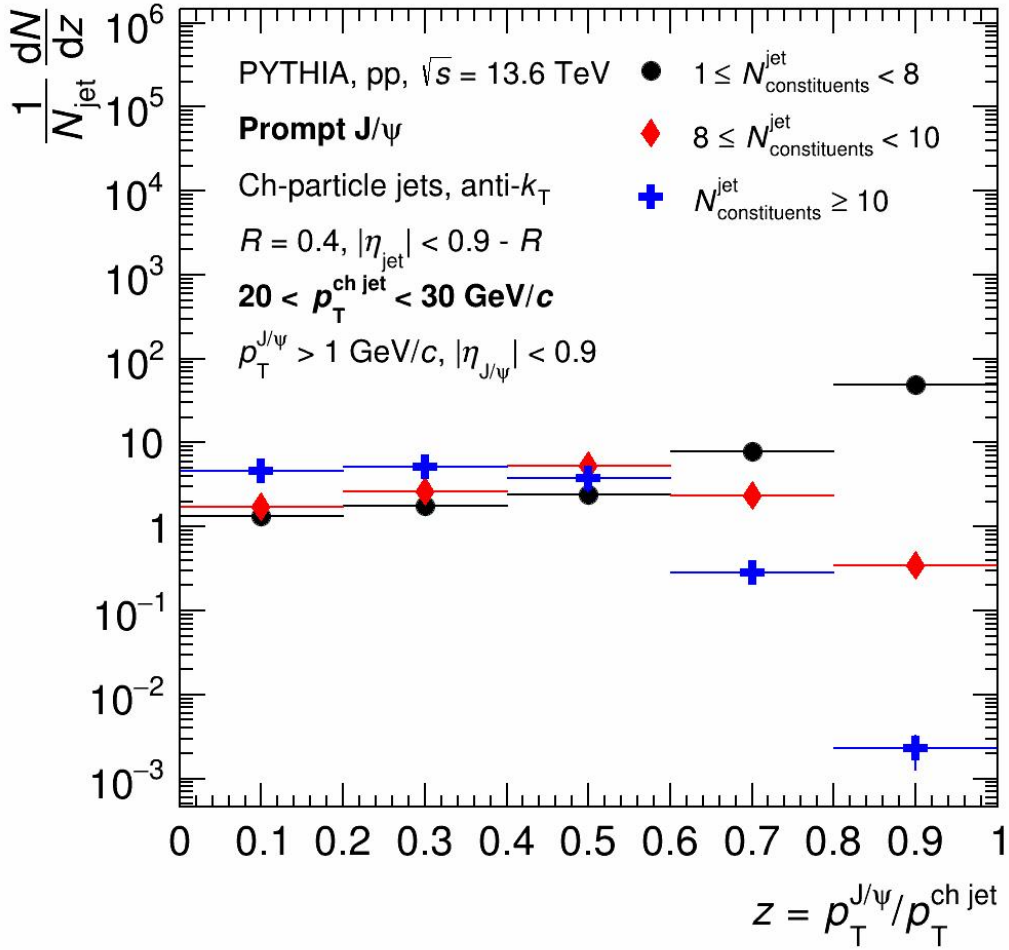


- Such a change on constituent multiplicities also reflected on the <z> accordingly, the MPI makes a much stronger effect for prompt J/ψ- jet FF

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Multiplicity-Dependent J/ψ Fragmentation





- Lower jet multiplicity events lead to a harder jet FF distribution while high jet case has softer fragmentation.
- This pattern is similar for both prompt and non-prompt J/ψ.

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Summary and Outlook

- PYTHIA reasonably describes the momentum fraction distributions of both prompt and non-prompt J/ψ measured by ALICE.

- Compared to different type of jets FF, a clear flavor and mass dependence is observed.

- Multiplicity dependence:
  - Lower jet multiplicity events lead to a harder jet FF distribution while high jet case has softer fragmentation.
  - MPI effect changes the jet constituent numbers largely.
  - CR effect has a small influence on jet constituents multiplicities.

- Outlook: Provide a reference and comparison for future experimental data analyses.