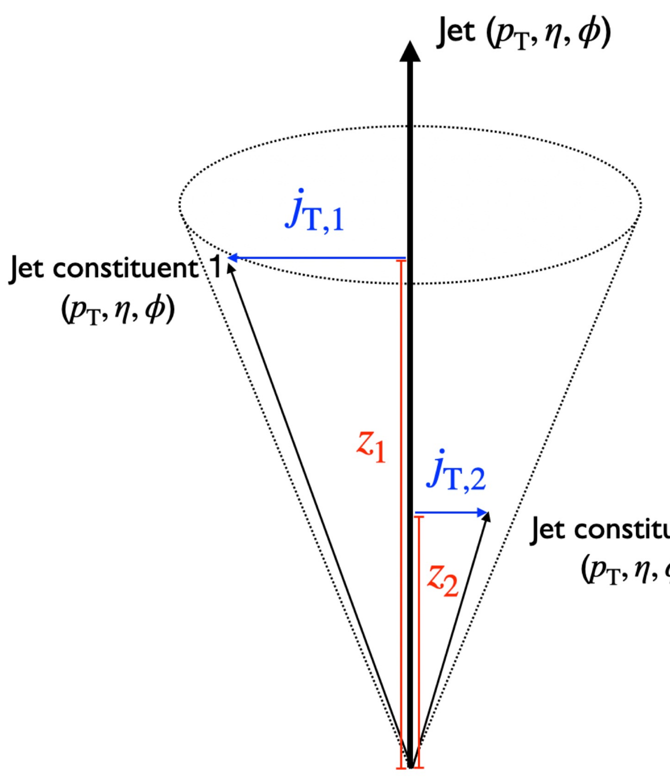
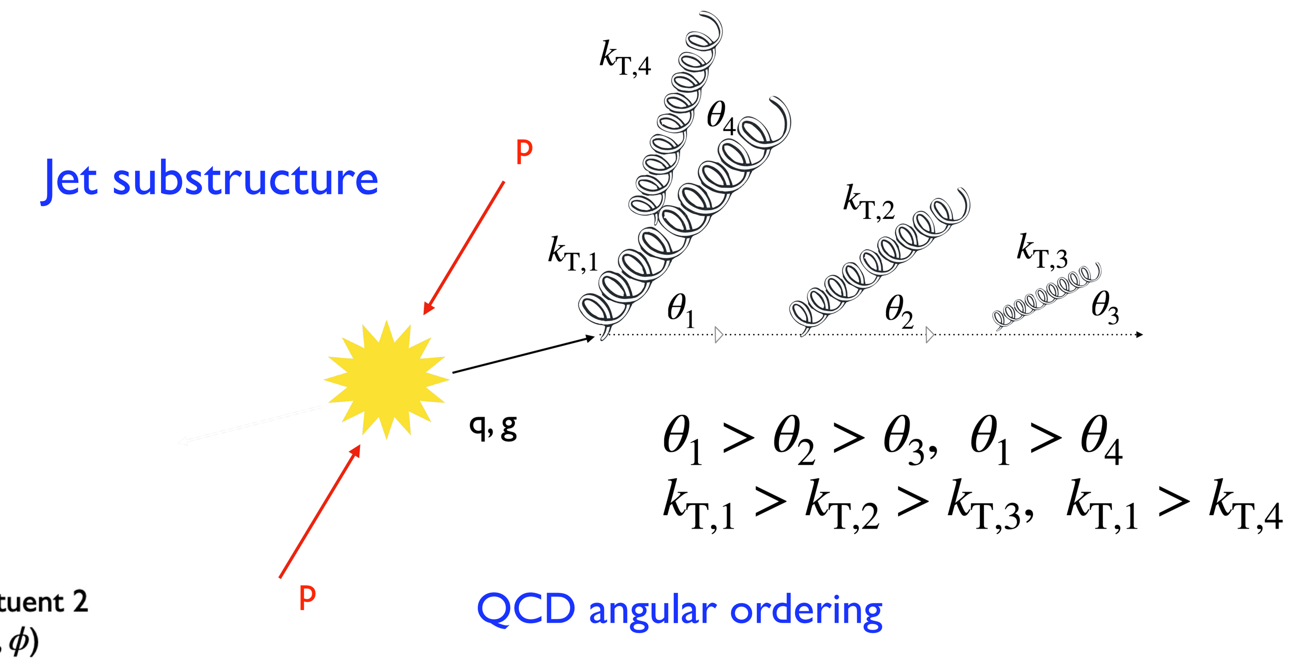
Measurement of transverse momentum (j_T) distributions of charged-particle jet fragments in pp collisions at $\sqrt{s}$ = 5.02 TeV with ALICE

Jaehyeok Ryu
On behalf of the ALICE Collaboration

PUSAN NATIONAL UNIV. NUCLEAR PHYSICS LAB

1. Introduction





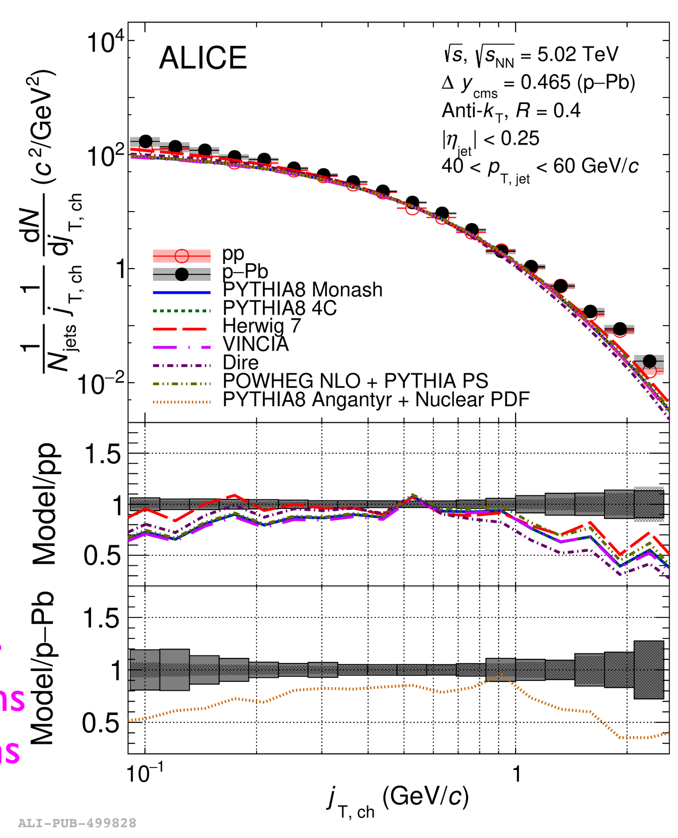
- QCD prefers smaller emitting angles and lower virtuality with increasing number of emitting gluons

- $j_T = \dfrac{|\vec{p}_{jet} \times \vec{p}_{track}|}{|\vec{p}_{jet}|}$
- $z = \dfrac{\vec{p}_{jet} \cdot \vec{p}_{track}}{p^2_{jet}}$

Understanding the QCD jet evolution process

- Test our current understanding of QCD theory by differentially measuring distributions of charged-particle jet fragments in pp collisions and comparing to model predictions

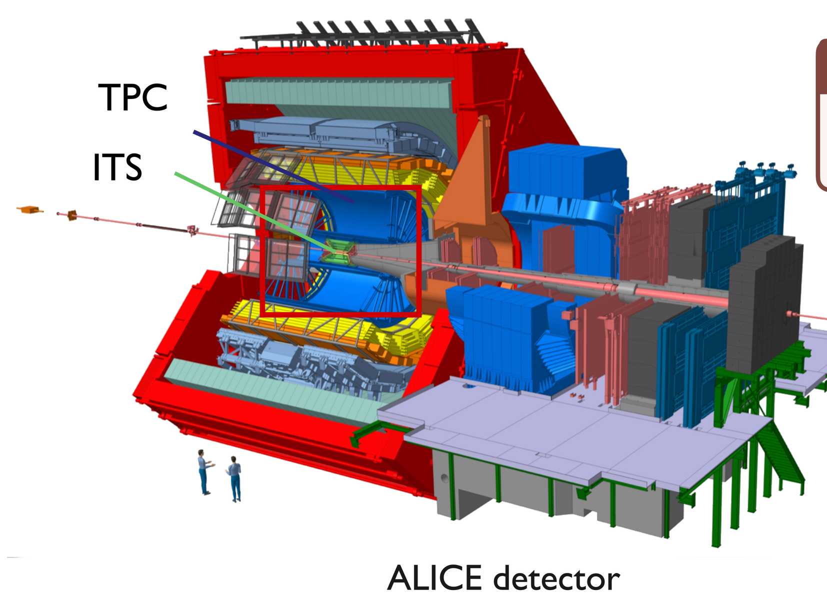
(JHEP09 (2021) 211)



- A previous ALICE publication of the full jet j_T distributions in pp and p-Pb collisions was inclusive in z (JHEP09 (2021 211)
- New ALICE charged-particle jet result extends this to be differential in z to disentangles jet fragmentation and the hadronization process
- Expect dominance of high j_T, z components at the early stage (large angle) and low j_T, z components at the late stage (small angle)

2. ALICE experiment

- 2017 LHC pp collisions at = $\sqrt{s}$ = 5.02 TeV



ALICE detector

j_T, z calculation

- j_T and z are calculated with constituent charged tracks beginning at the minimum track p_T of 0.15 GeV/c

Jet reconstruction

- Charged-particle jets in $|\eta|$ < 0.5 are reconstructed with charged tracks in the ITS/TPC (p_T > 0.15 GeV/c and $|\eta|$ < 0.9, 0 < φ < 2π)
- Anti-k_T algorithm with R = 0.4

3. MC simulation models

PYTHIA8 webpage : https://pythia.org/

PYTHIA 8

- Initial hard scattering
  pQCD calculation at Leading-Order (LO)
- Partonic showers
  Momentum ordered parton shower
- Hadronisation
  Gluon fragmentation
  (Lund string fragmentation)
- Underlying event
  Multi Parton Interaction (MPI)

HERWIG webpage : https://Herwig.hepforge.org/

HERWIG 7

- Initial hard scattering
  pQCD calculation at Next-to-Leading-Order (NLO)
- Partonic showers
  Soft gluon interference via angular ordering
- Hadronisation
  Cluster approach
- Underlying event
  Multiple partonic scatterings

4. Results

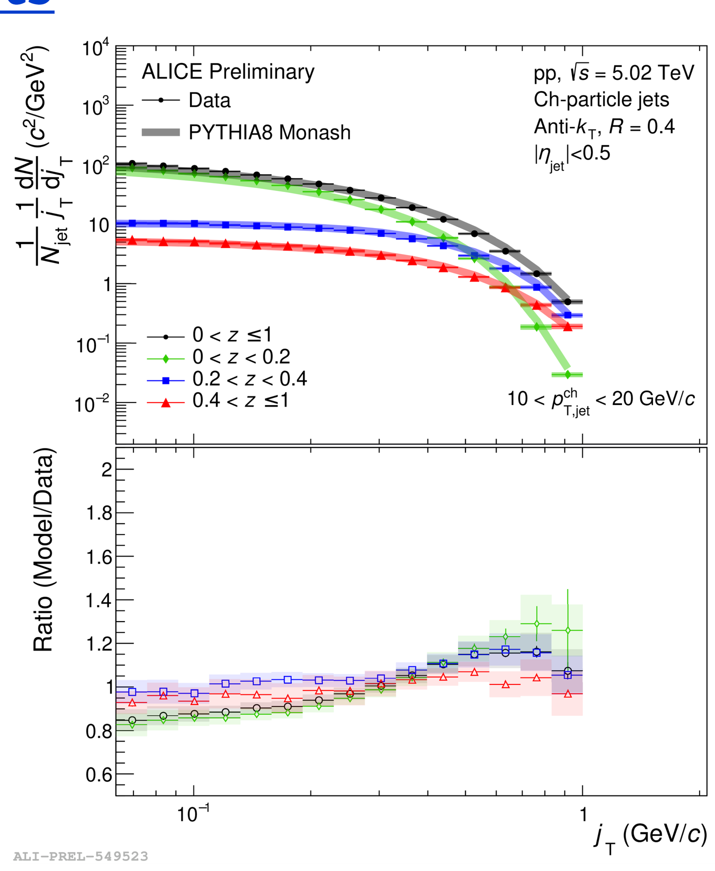


Figure 4.1. j_T compared to PYTHIA8 Monash

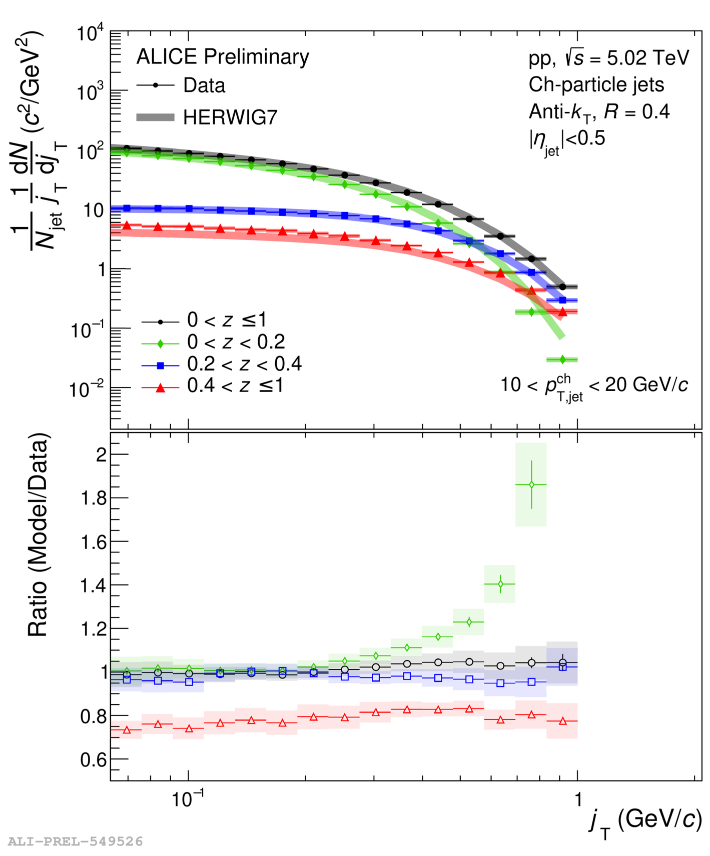


Figure 4.2. j_T compared to HERWIG7

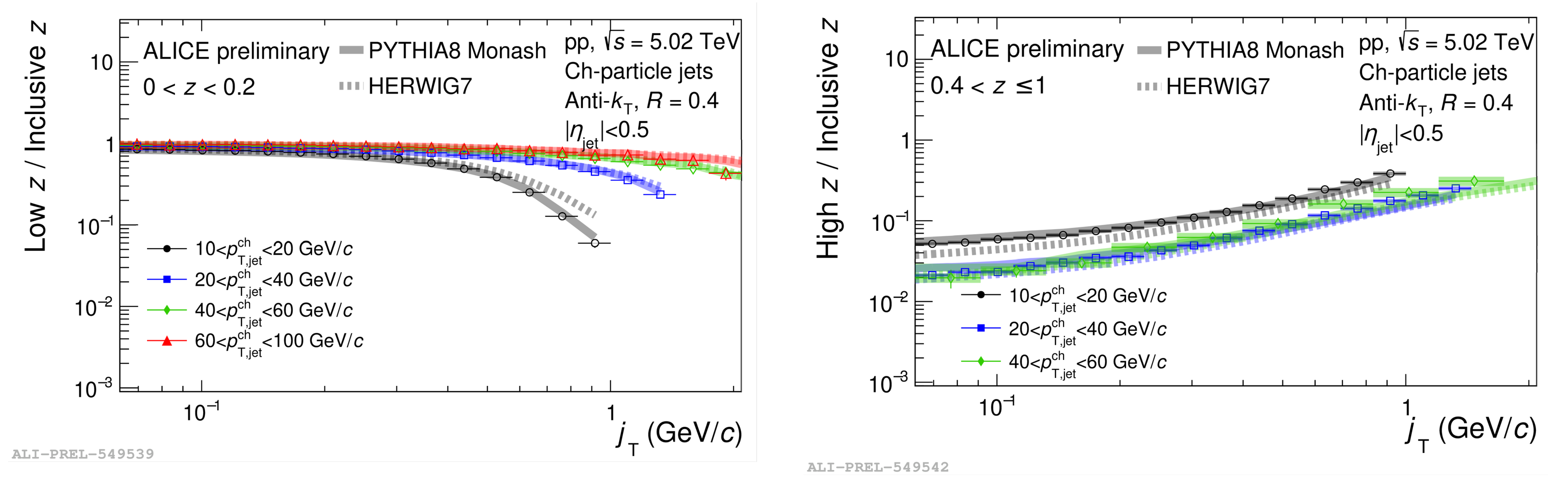


Figure 4.4 Differential z to inclusive z ratio

- Figure 4.4 is the differential z to inclusive z ratio to see the correlation between j_T and z
- High j_T components are dominant at high z, low j_T components are dominant at low z which is consistent with QCD theory
- Values of the ratio of data and MC are different, but the trends of the ratios are comparable

- Figure 4.1 and 4.2 are the j_T distributions for different $p_{T,jet}$ compared with PYTHIA8 Monash and HERWIG 7 with 10 < $p_{T,jet}$< 20 GeV/c
- j_T distributions widen with increasing z
- Herwig underestimate the high z region and overestimate the low z, high j_T region
- Descriptions of models are different in the different kinematic ranges
- Similar behavior found in POWHEG which indicates that the behavior is from the NLO partonic shower process
- Comparisons with MC generators set constraints on models

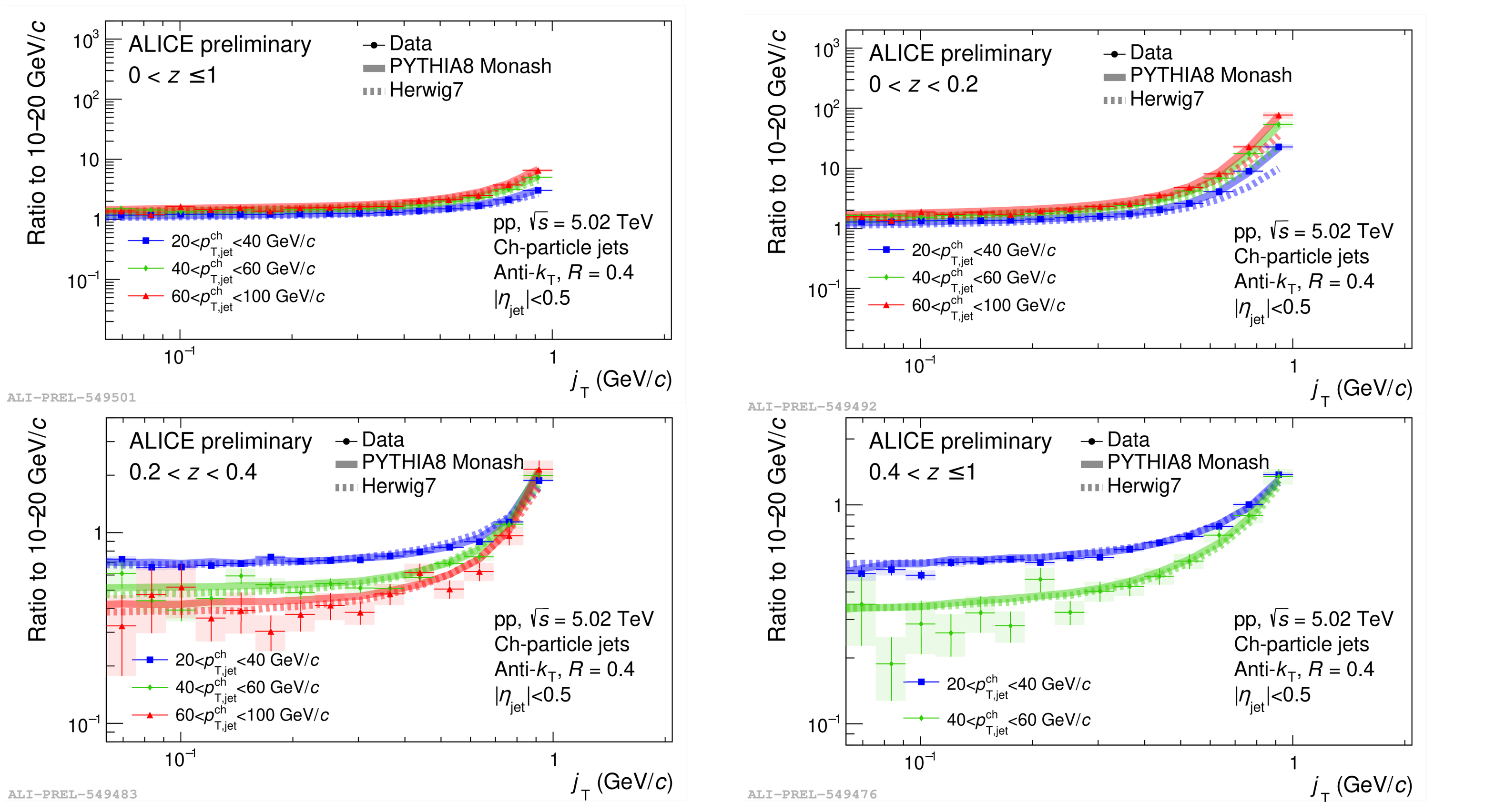
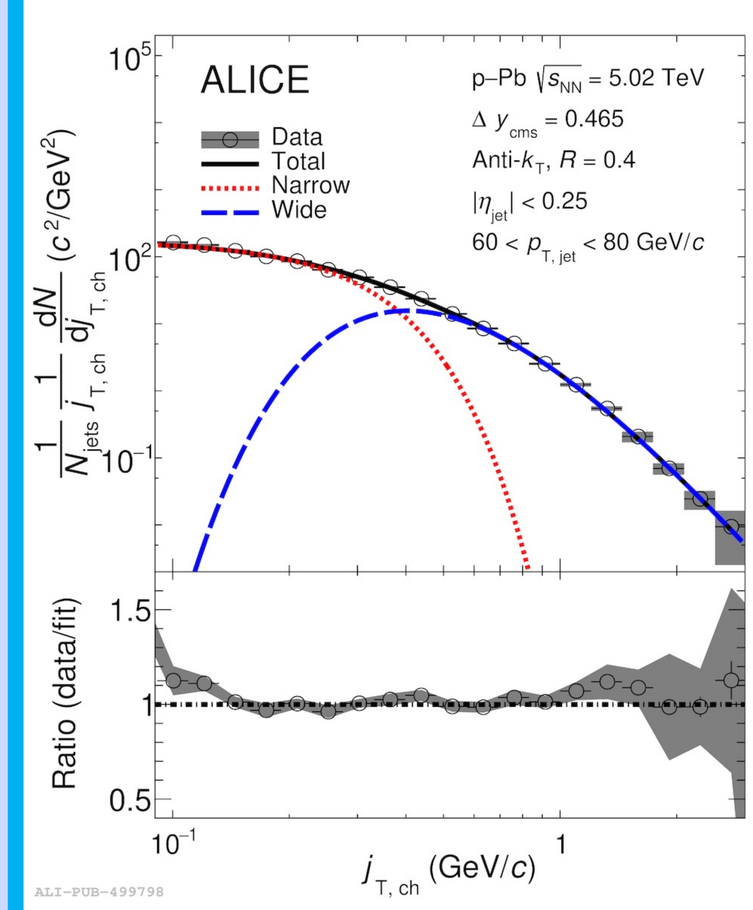
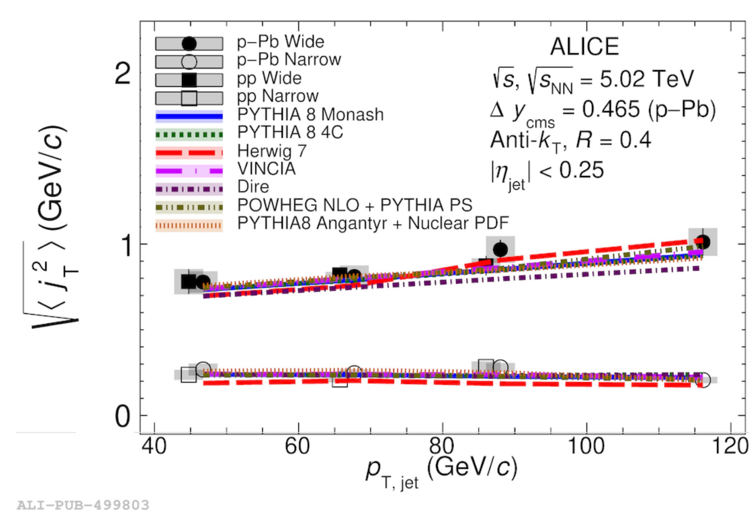


Figure 4.3. j_T ratio to 10 < $p_{T,jet}$ < 20 GeV/c

- Figure 4.3 shows the j_T distributions for different $p_{T,jet}$ in several z ranges, and the lower pad shows the ratio to 10 < $p_{T,jet}$ < 20 GeV/c
- In the inclusive z, the result is comparable to the previous result
- There is a $p_{T,jet}$ dependence of j_T distribution but the dependency weakens with increasing $p_{T,jet}$
- Both models have good descriptions of the trend in the ratio for all z ranges which means the difference between the model and data is not from $p_{T,jet}$ dependence

5. Outlook





Hadronisation

Gaussian distribution centered at j_T = 0 GeV/c for the lower j_T

$$\frac{1}{N_{jets}\, j_{T,ch}} \frac{dN}{dj_{T,ch}} = \frac{B_2}{B_1\sqrt{2\pi}} e^{-\frac{j_T^2}{2B_1^2}} + \frac{B_3 B_5^{B_4}}{\Gamma(B_4)} \frac{e^{-\frac{B_5}{j_T}}}{j_T^{B_4+1}}$$

Inverse gamma function for j_T above 1 GeV/c

Fragmentation

- The early and late stages of the j_T distribution were disentangled using a two-component fitting method
- Gaussian distribution was used to fit the lower j_T region, while the inverse gamma function was applied to fit the higher j_T region
- Results will be fitted with a two-component method and RMS j_T values will be extracted and compared to various models
- These results serve as baseline measurements for future studies in high-multiplicity pp and p-Pb collisions, with the goal of investigating potential jet-medium interactions in small collision systems