Study of jet fragmentation in ALICE

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1. Motivation

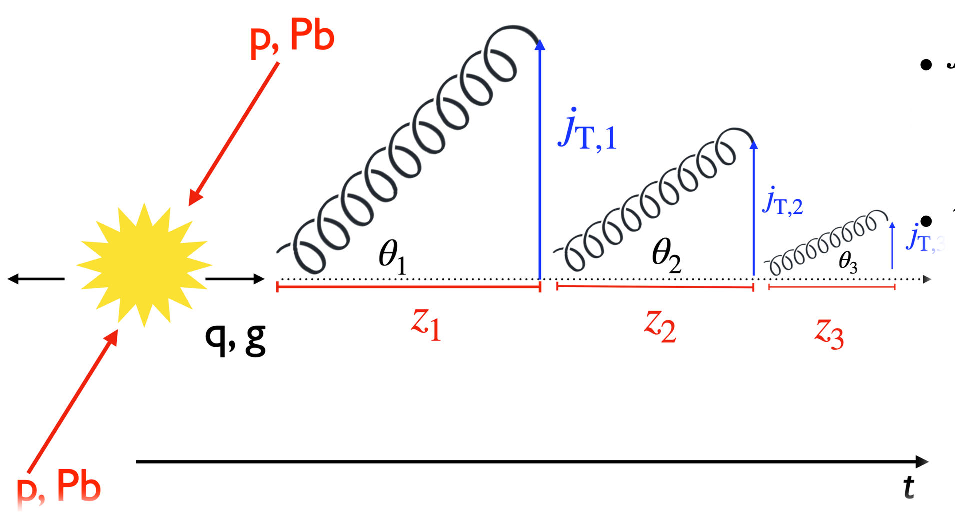

Figure 1.1. QCD jet evolution process

$$j_T = \frac{|\vec{p}_{jet} \times \vec{p}_{track}|}{|\vec{p}_{jet}|}$$

$$z = \frac{\vec{p}_{jet} \cdot \vec{p}_{track}}{p^2_{jet}}$$

$\theta_1 > \theta_2 > \theta_3$

$j_{T,1} > j_{T,2} > j_{T,3}$

$z_1 > z_2 > z_3$

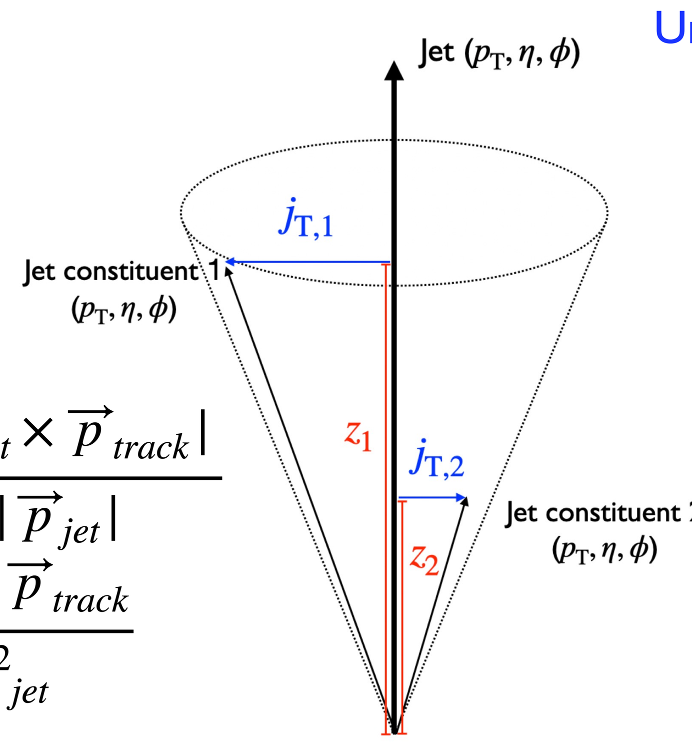

Figure 1.2. j_T and z

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
- 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)
- 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 further explore the parton shower evolution
- Requires changing from a 2D to 3D unfolding procedure

(JHEP09 (2021) 211)

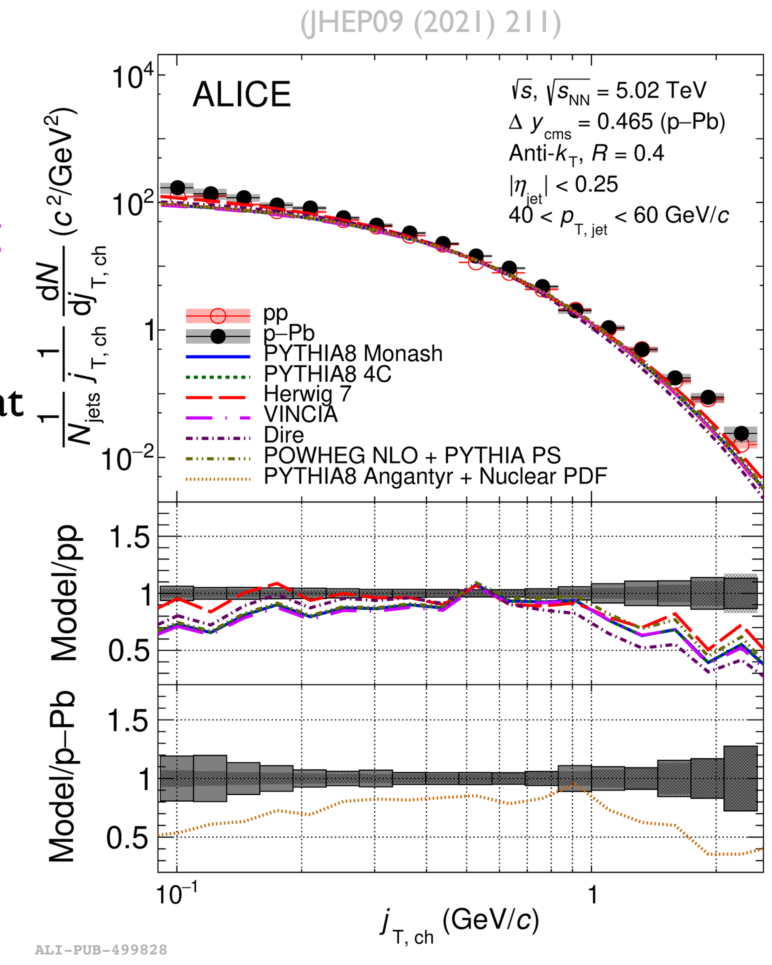

Figure 1.3 The previous results

2. Analysis procedure

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

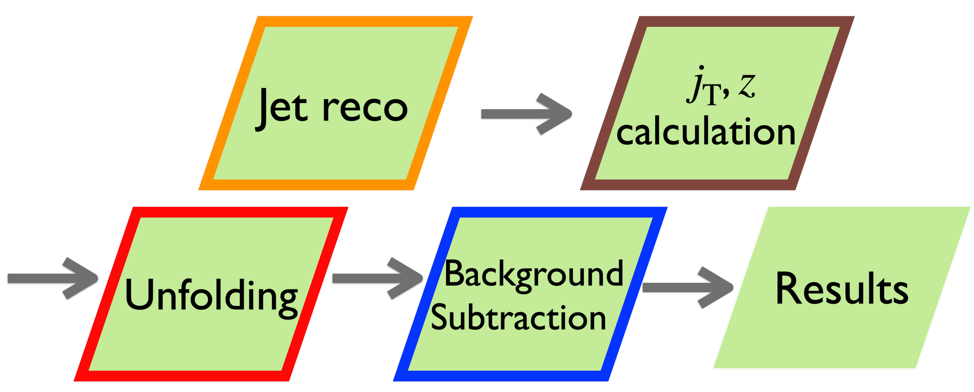

Figure 2.1. Analysis procedure

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 $|\eta| < 0.9$, $0 < \varphi < 2\pi$)
- Anti-k_T algorithm with $R = 0.4$

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

3. Unfolding

3-D Unfolding

- Correct detector effects that smear in jet p_T, z, and j_T by switching to a 3D unfolding procedure

4-D response matrix (Previous analysis)

$(p^{obs}_{T,jet},\ j^{obs}_T,\ p^{true}_{T,jet},\ j^{true}_T)$

6-D response matrix (This analysis)

$(p^{obs}_{T,jet},\ z^{obs},\ j^{obs}_T,\ p^{true}_{T,jet},\ z^{true},\ j^{true}_T)$

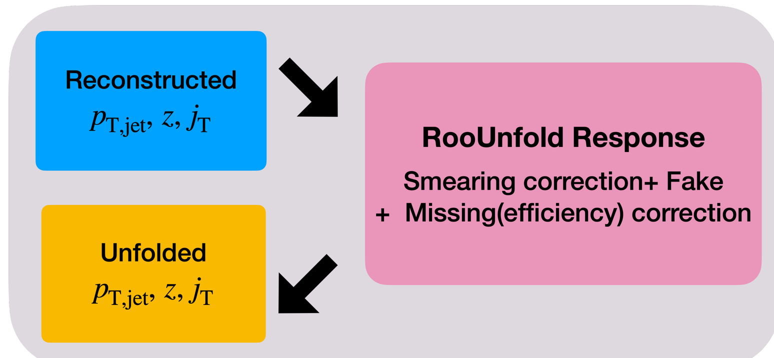

Figure 3.1. Unfolding procedure using RooUnfold

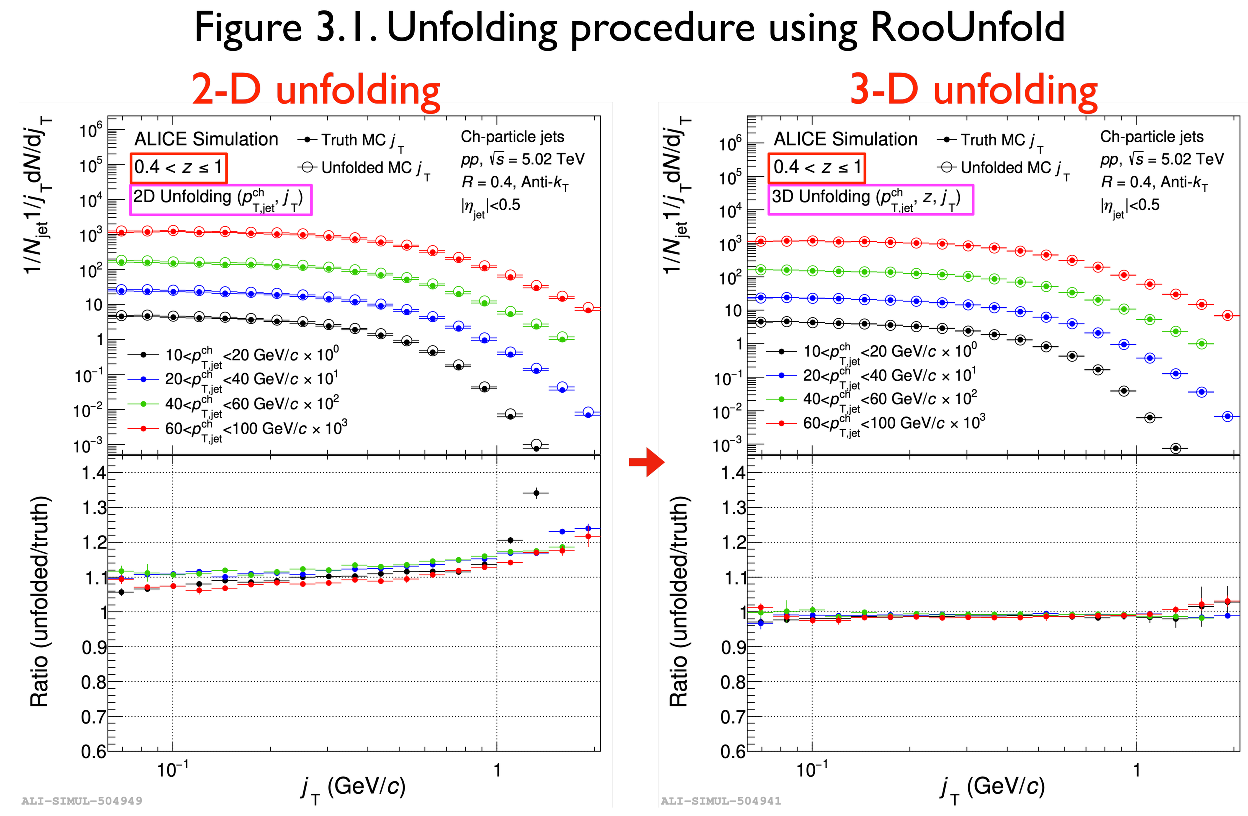

Figure 3.2. MC Unfolding closure test

4. Background estimation

Background estimation

- Perpendicular cone (Default)
  - Rotate the jet axis by 90˚ in a positive ϕ direction
  - If there is no signal jet constituents around the rotated axis(Delta R<0.8), calculate j_T, z w.r.t the rotated axis
- j_T calculated with a perpendicular cone method was unfolded separately and then subtracted
- Used random background method for systematic check

Figure 4.1. Background estimation

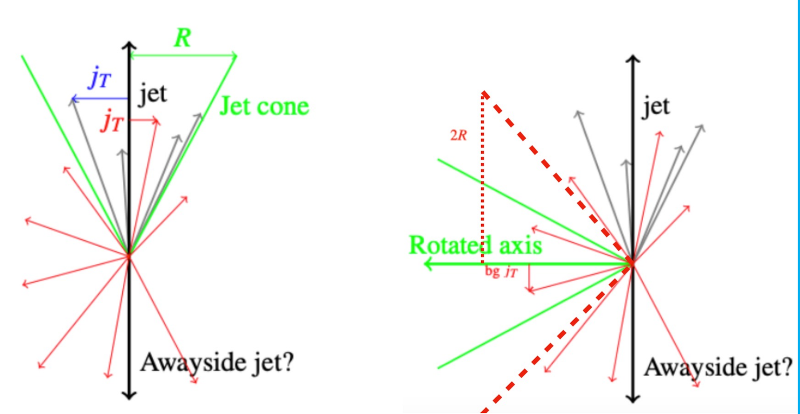

Figure 4.2. Background subtraction using the perpendicular cone method

5. Results

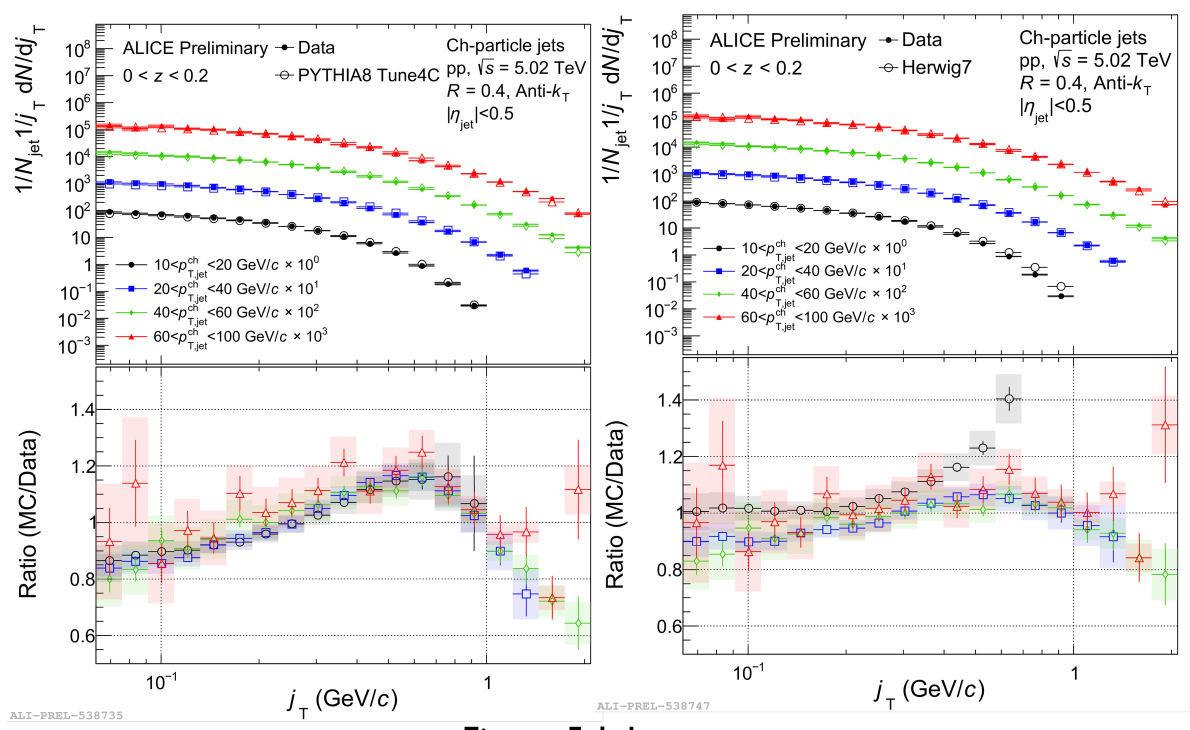

Figure 5.1. Low z

- Figures are the j_T distributions in each z range compared to the PYTHIA8 and HERWIG
- PYTHIA8 describes the perturbative part with p_T-ordered showers and the non-perturbative part with the Lund string model
- HERWIG describes the perturbative part with a coherent parton shower and non-perturbative gluon splitting part with cluster hadronization

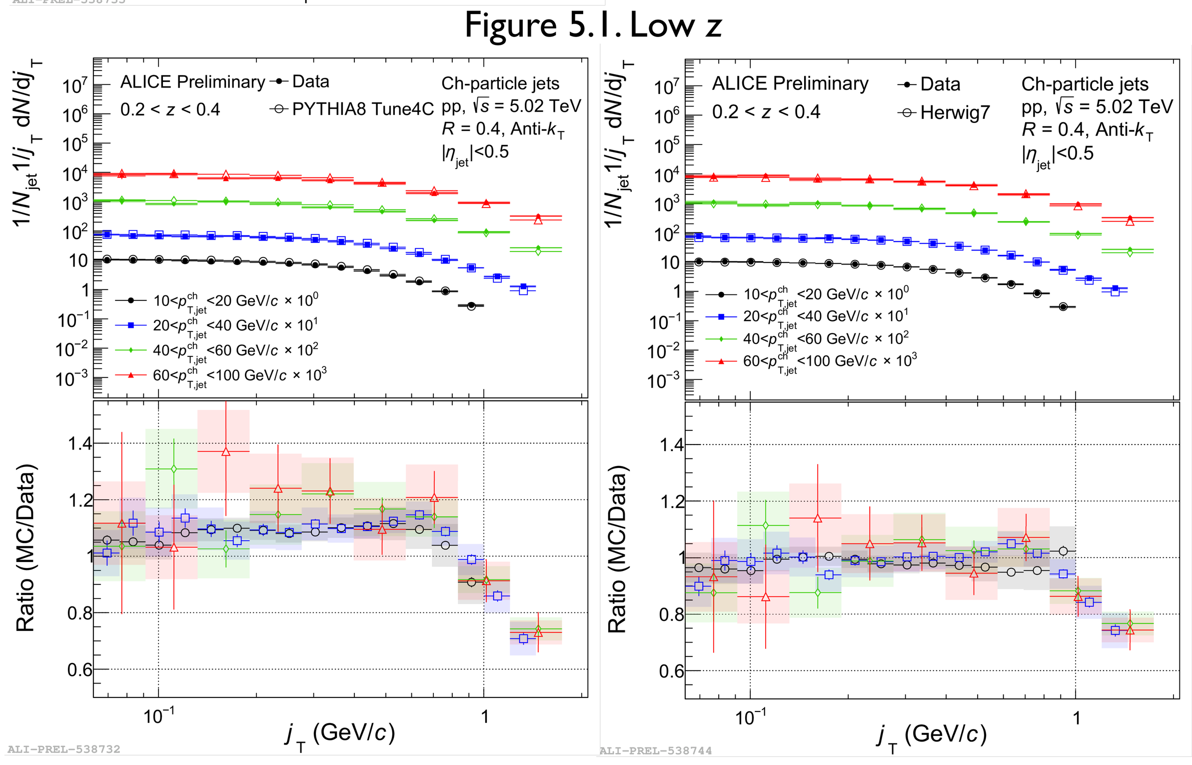

Figure 5.2. Mid z

- In Low z bin, HERWIG has a slightly better description at the low j_T region and is comparable in the high j_T region compared to PYTHIA8
- In HERWIG, different behavior is seen in the high j_T low jet p_T region compared to PYTHIA8

- In mid z bin, HERWIG has a slightly better description at the low j_T region within the uncertainties and has a similar description in the high j_T region compared to PYTHIA8

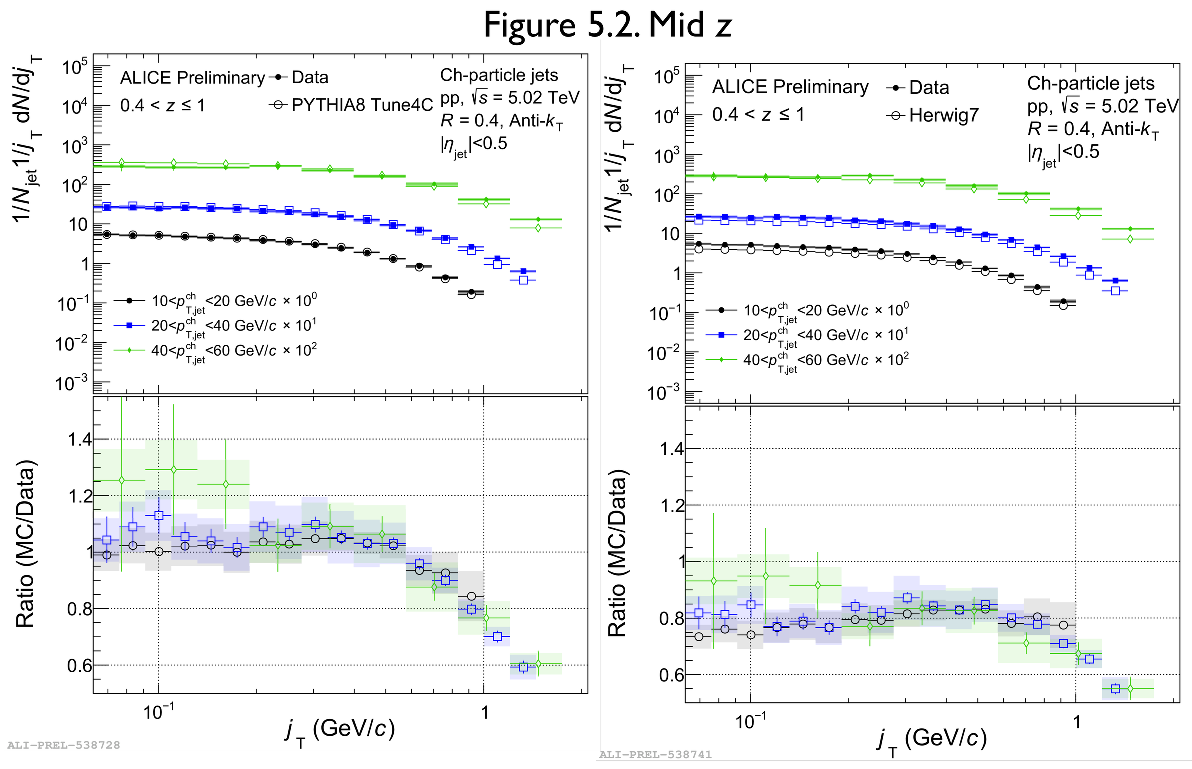

Figure 5.3. High z

- In high z bin, PYTHIA 8 has a good description within the uncertainties at the low j_T region but HERWIG underestimates the data over all j_T ranges

- These model comparisons are expected to help set constrains on the models

- There were analogous studies by ATLAS(Eur. Phys. J. C 71 (2011) 1795) and LHCb(PHYS. REV. LETT. 123 (2019))
- ATLAS measured inclusive full jets which is comparable to the previous ALICE measurement but for a different collision energy and LHCb measured j_T with Z-tagged jet which are mostly quark jet

5. Summary & Outlook

- The transverse momentum(j_T) distribution of charged-particle jet constituents has been measured in various z bins
- To properly correct the smearing effect on the j_T distributions, the 3-D unfolding method has been introduced
- Comparisons with other models (POWHEG / Sherpa etc.) will be added
- The results are expected to set constraints on models for both the perturbative and the non-perturbative QCD region
- Comparison to results from other experiments will be performed to understand jet substructure and quark/gluon jet composition in more detail