Reconstruction of beauty jets in proton-proton collisions at $\sqrt{s} = 13$ TeV with ALICE

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ALICE

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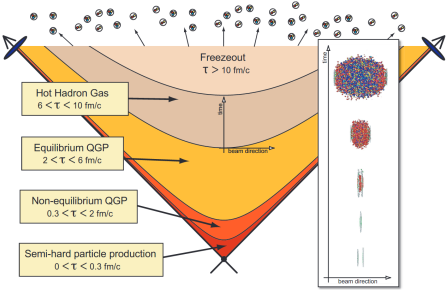
Motivation and Introduction

- b-jet cross section is important ingredient for testing predictions by quantum chromodynamics for production and fragmentation of heavy flavours
- heavy flavours are good probes for investigating properties of the quark-gluon plasma
- ALICE can measure the b-jet production down to low jet momentum due to excellent tracking capabilities

The analysis in short:

- ALICE data for pp collisions at 13 TeV with a luminosity of about $11\,\mathrm{nb}^{-1}$ are analysed
- b-jet selection (“tagging”) based on impact parameter of tracks within jets
- performance estimation via template fits to jet probability distributions in data



[Figure from M. Strickland, arXiv:1410.5786]

b-Jet Selection

Definition of Sd_{xy}

$$Sd_{xy} = |\vec{d}_0| \, \mathrm{sign}(\vec{d}_0 \cdot \vec{e}_{\mathrm{Jet}})/\sigma(\vec{d}_0)$$

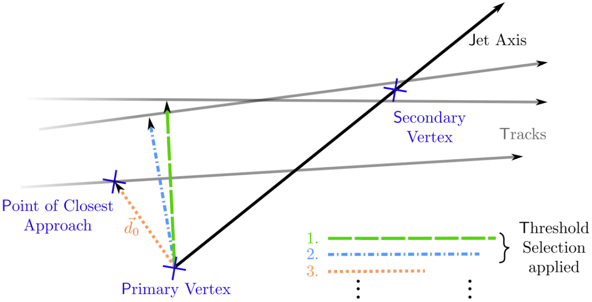
- $\vec{d}_0$ = transverse impact parameter in xy-plane
- $\vec{e}_{\mathrm{Jet}}$ = vector of the jet axis
- $\sigma(\vec{d}_0)$ = impact parameter resolution

- B hadrons exhibit long lifetimes ($\sim 500\,\mu$m)
- secondary vertex of B hadron decays well separated from primary collision vertex (PV)

→ b jets tend to contain tracks with large transverse impact parameter significance Sd_{xy}

In this analysis:

- b jets defined as jets with a b quark within the jet cone
- tracks within jets are ordered such that their Sd_{xy} values are decreasing
- threshold selection based on Sd_{xy} of tracks with the largest and second largest Sd_{xy} within a jet



Performance Correction of b-Jet Spectrum

- jet probability JP: measure probability that jet originates from PV
  $\rightarrow -\ln(\mathrm{JP})$ distributions have wider tails than light-flavour or c jets

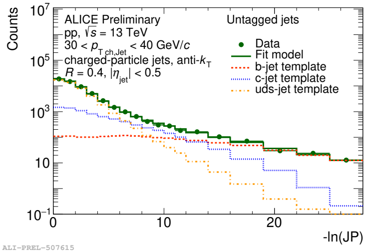
1. simulated $-\ln(\mathrm{JP})$ distributions for different jet flavours using PYTHIA 8+GEANT 3
2. performed template fits to the data before and after the b-jet selection for every bin of the jet momentum $p_{\mathrm{T,ch\ jet}}$

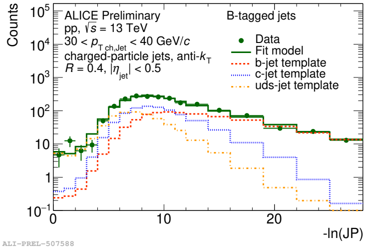
Definition of $-\ln(\mathrm{JP})$

$$\mathrm{JP} = \prod \times \sum_{k=0}^{N_{\mathrm{Tracks}}-1} \frac{(-\ln \prod)^k}{k!}, \quad \prod = \prod_{i=1}^{N_{\mathrm{Tracks}}} P_{\mathrm{tr},i}(Sd_{xy,i})$$

$$\text{with} \quad P_{\mathrm{tr}}(Sd_{xy,i}) = \int_{-\infty}^{-|Sd_{xy,i}|} R(I)\,\mathrm{d}I \Big/ \int_{-\infty}^{0} R(I)\,\mathrm{d}I$$

- only tracks with $Sd_{xy} > 0$ are accepted for $-\ln(\mathrm{JP})$ calculation
- resolution function $R(I)$ = negative side of Sd_{xy} distribution for inclusive jets





Performance Correction of b-Jet Spectrum

3. calculated efficiency ϵ_b and purity p_b via b-jet fractions obtained from fit results:

$$\epsilon_b = C_b \frac{f_b^{\mathrm{tag}}}{f_b^{\mathrm{untag}}} \frac{N^{\mathrm{tag}}}{N^{\mathrm{untag}}} \quad \text{and} \quad p_b = f_b^{\mathrm{tag}}$$

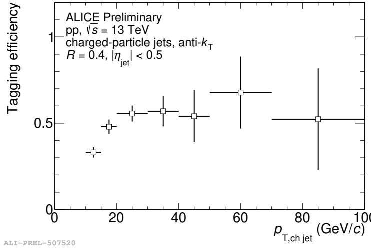
f_b^{tag}, f_b^{untag} and N^{tag}, N^{untag} = b-jet fractions and number of events in tagged and untagged sample
C_b = fraction of b-jets with well defined $-\ln(\mathrm{JP})$

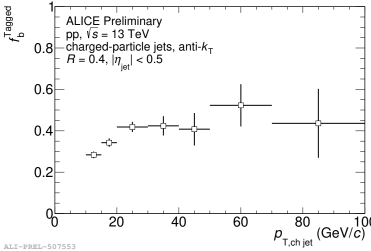
→ tagging purity is about 40 %, efficiency about 50 %

4. obtained fully corrected spectrum via

$$\frac{\mathrm{d}\sigma_{\mathrm{ch,\ b\ jet}}}{\mathrm{d}p_{\mathrm{T,ch\ jet}}} = \frac{\sigma_{\mathrm{V0}}}{N_{\mathrm{ev}}} \cdot \mathrm{Unfolded}\left(\frac{\mathrm{d}N^{\mathrm{raw}}_{\mathrm{ch,\ b\text{-}jet}}}{\mathrm{d}p_{\mathrm{T,ch\ jet}}} \frac{p_b}{\epsilon_b}\right)$$

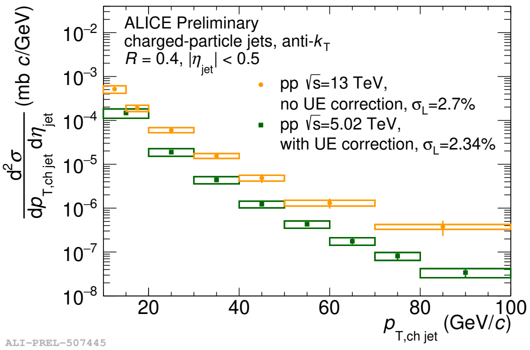
σ_{V0} = reference cross section, N_{ev} = number of events,
$\frac{\mathrm{d}N^{\mathrm{raw}}_{\mathrm{ch,\ b\text{-}jet}}}{\mathrm{d}p_{\mathrm{T,ch\ jet}}}$ = raw b-tagged spectrum



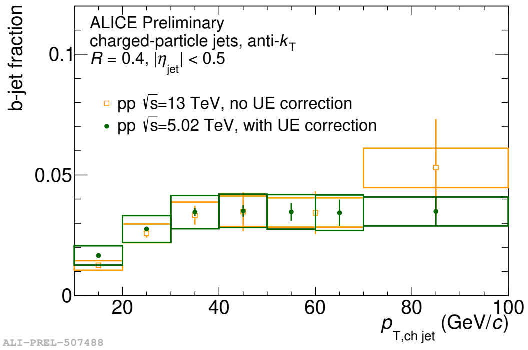


Results

[b-jet spectrum at 5.02 TeV from arXiv:2110.06104]



[spectrum for inclusive jets from arXiv:2202.01548]



- b-jet production measured in pp collisions at $\sqrt{s}$ =13 TeV larger by about a factor of 2-6 from low to large $p_{T,ch\ jet}$ with respect to measurements at 5.02 TeV
- fraction of b jets over inclusive jets compatible for 13 TeV and 5.02 TeV data