Analysis of b-jet production in p–Pb and pp collisions at $\sqrt{s_{\mathrm{NN}}}$ = 5.02 TeV with ALICE

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Due to their large mass, b quarks are produced in initial hard scatterings and their production rate is calculable from perturbative quantum chromodynamics. In heavy-ion collisions, the production of b jets is affected by jet quenching and cold nuclear matter (CNM) effects. The size of the CNM effects can be assessed from the measurement of b-jet production in p–Pb collisions.

b jets can be efficiently tagged through displaced decay vertices of b hadrons ($c\tau \approx 500$ μm). The ALICE experiment at the LHC [*] reconstructs such vertices with help of excellent tracking capabilities of the Inner Tracking System detector.

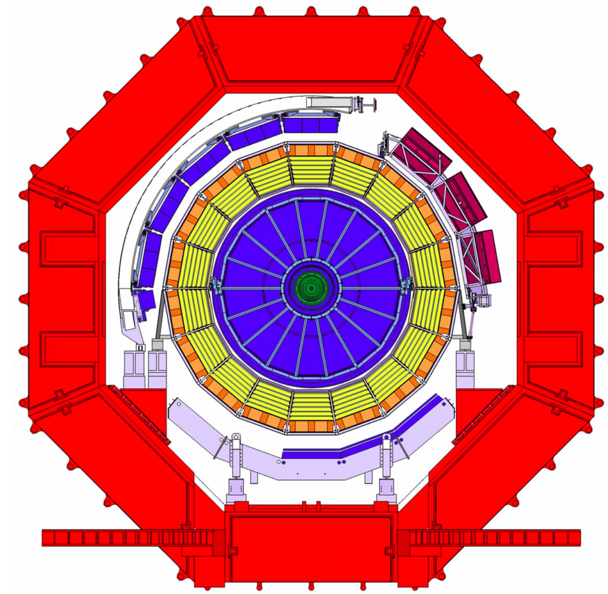

Figure 1.: Cross section of the ALICE detector in the plane perpendicular to the beam showing the Inner Tracking System (green), the Time Projection Chamber (blue) and the solenoidal magnet (red).

[*] ALICE Collaboration, B. Abelev et al., “Performance of the ALICE Experiment at the CERN LHC” Int.J.Mod.Phys. A29, 1430044 (2014).

Reconstruction of b-jet candidates

- **Charged-particle** based jets were reconstructed using the **anti-k_T** algorithm with $\boldsymbol{R}$ **= 0.4,** where R – is the radius of the jet cone.
- Jet constituents have $\boldsymbol{p_T}$ **> 150 MeV/*c*** and pseudorapidity $|\eta| < 0.9$.
- Pseudorapidity of jets was constrained to $|\eta_{jet}| < 0.5$.
- Two independent methods were used for b-jet tagging
  1) **Impact parameter** method - distance of closest approach of jet constituents to primary vertex.
  2) **Secondary vertex** (SV) method - properties of most displaced 3-prong secondary vertex.

  Discrimination variables to tag b-jet candidates and suppress the admixture of light-flavor and c-quark jets used in the SV method:

  - **Minimal significance of the SV displacement:** $SL_{xy} = L_{XY}/\sigma_{Lxy}$

    L_{XY} – distance between primary and secondary vertices

    σ_{Lxy} – uncertainty of L_{XY} measurement
  - **Upper limit on the SV resolution:** $\sigma_{SV} = \sqrt{\sum_{i=1}^{3} d_i^2}$

    d_i – distance of closest approach (DCA) of the i-th prong to the SV

Default cut: $\sigma_{SV} < 0.03$ **cm,** $L_{XY}/\sigma_{Lxy} > 7$

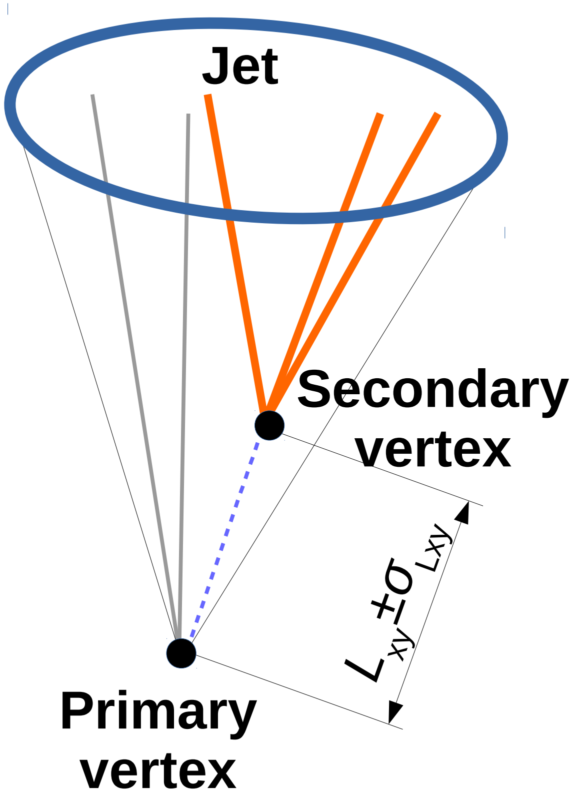

Figure 2: Illustration of the b-jet tagging algorithm via SV reconstruction.

Correction of b-jet spectra

Measured spectrum of b-jet candidates needs to be corrected for SV tagging purity and efficiency:

$$\frac{dN^{primary}_{b\text{-}jet}}{dp_{T,\,jet\,ch}} = \frac{dN^{raw}_{b\text{-}jet\ candidates}}{dp_{T,\,jet\,ch}} \times \frac{P_b}{\varepsilon_b}$$

$\boldsymbol{\varepsilon_b}$ – probability that true b jet will pass SV tagging selections.
$\boldsymbol{P_b}$ – fraction of true b-jets among all tagged b-jet candidates.

Purity of b-jet candidates is estimated from:
a) data-driven SV invariant mass template fit method
b) POWHEG simulation based approach, where

$$p_b = \frac{N_b \varepsilon_b}{N_b \varepsilon_b + N_c \varepsilon_c + N_{LF} \varepsilon_{LF}}$$

$\boldsymbol{N_b, N_c}$ – POWHEG p_T spectrum of b and c-jets folded with the response matrix
$\boldsymbol{N_{LF}}$ – p_T spectrum of ligth flavour-jets (LF): $N_{LF} = N_{raw} - N_b - N_c$
$\boldsymbol{N_{raw}}$ – raw p_T spectrum of inclusive jets
$\boldsymbol{\varepsilon_b, \varepsilon_c, \varepsilon_{LF}}$ – efficiency of SV tagging for b, c and LF jets

POWHEG variations were required to provide purity compatible with the data-driven method.

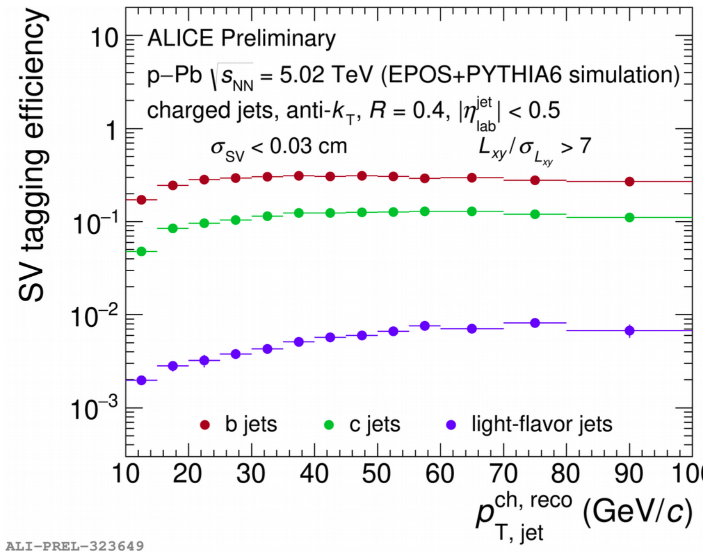

Figure 3: b-jet tagging efficiency and mistagging efficiency for c jets and light-flavor jets

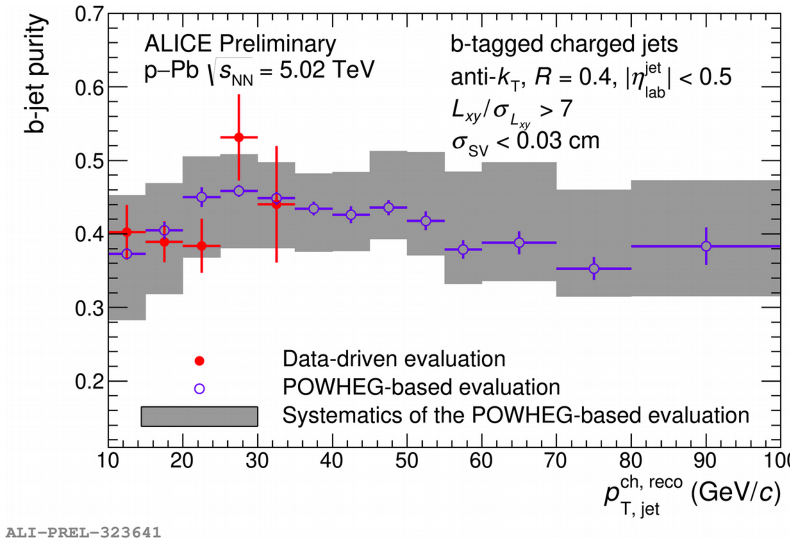

Figure 4: b-jet purities from the data-driven template fit method and the POWHEG for the optimal MC settings

Results

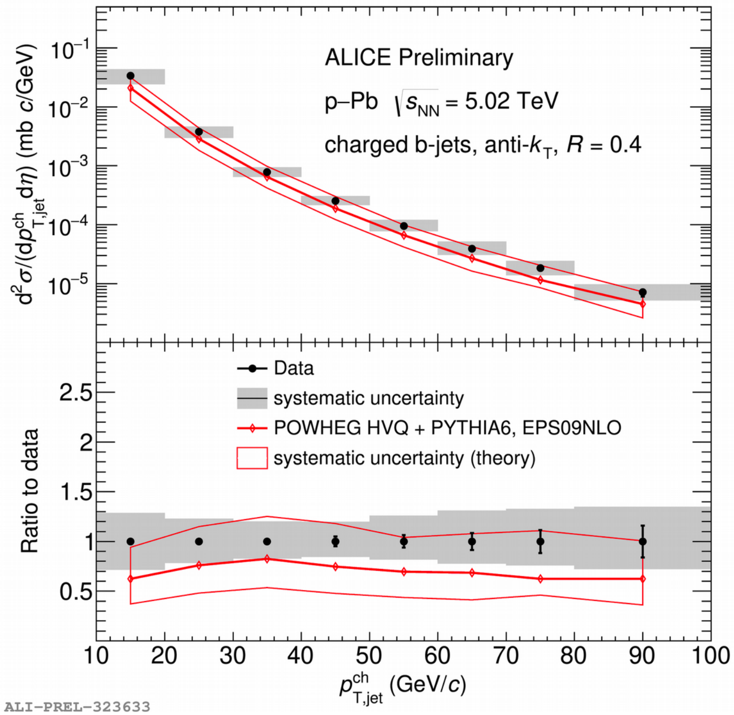

Figure 5: The differential cross-section of charged-particle anti-k_T b jets with R = 0.4 measured in p–Pb collisions at $\sqrt{s_{NN}}$= 5.02 TeV with systematic uncertainties represented by grey rectrangles.

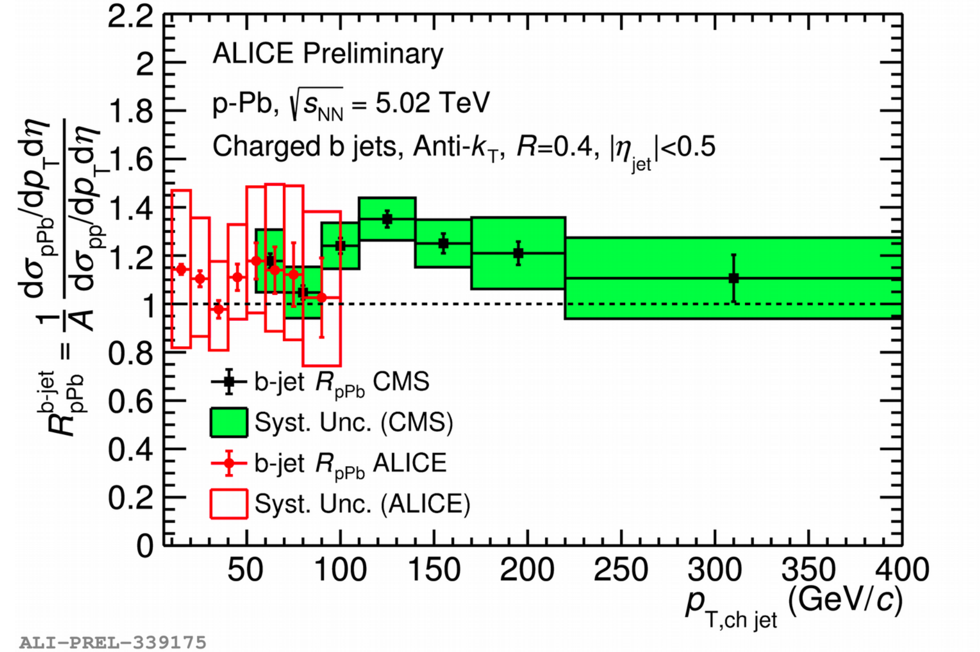

Figure 6: The nuclear modification factor R_{pPb} for charged-particle b jets measured by the ALICE experiment, compared with the b-jet measurement from the CMS experiment [*].

$$R^{\text{b jet}}_{\text{pPb}} = \frac{1}{A}\frac{d\sigma^{\text{b jet}}_{\text{pPb}}/dp_{\text{T,ch jet}}}{d\sigma^{\text{b jet}}_{\text{pp}}/dp_{\text{T,ch jet}}}$$

- Fully corrected p_T-differential inclusive production cross section of charged-particle b jets in p-Pb is compatible with calculation by POWHEG HVQ simulation with EPS09NLO pdfs.
- The ALICE measurement of charged b-jet R_{pPb} is compatible with the analogous CMS measurements for full-jets. No strong CNM effects present in p–Pb.

[*] CMS Collaboration, Phys. Lett. B754 (2016)