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Reconstruction of Bottom Jets in Proton-Proton Collisions at $\sqrt{s}$ =13 TeV with ALICE

Graduiertenkolleg 2149 Research Training Group

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ALICE

Motivation

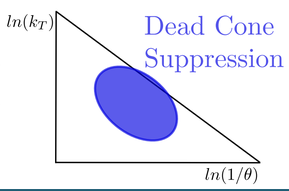
- Heavy flavours experience the whole evolution of the Quark-Gluon Plasma (QGP)
  ($\tau_{\text{QGP}} \simeq 0.3\,\text{fm/c}$, $\tau_c \simeq 0.1\,\text{fm/c}$, $\tau_b \simeq 0.01\,\text{fm/c}$ [1])
- Radiative energy loss of partons within QGP [2]:

massless quarks: $\mathrm{d}P_0 \approx \frac{\alpha_s C_F}{\omega}\frac{\mathrm{d}\omega}{\omega}\frac{\mathrm{d}\theta}{\theta^2}$

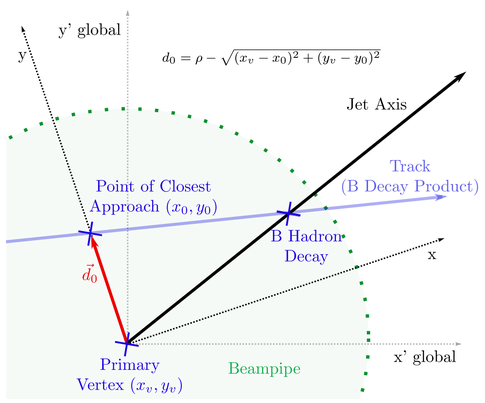
heavy flavours: $\mathrm{d}P_{HQ} = \mathrm{d}P_0\left(1+\frac{\theta_0^2}{\theta^2}\right)^2$ and $\theta_0 = \frac{M}{E}$

→ Dead Cone Effect: Low-angle gluon emission from heavy flavours is suppressed.

→ This manifests in a suppression of the small-angle region in the Lund Plane for bottom wrt. inclusive jets.



Tagging via the Transverse Impact Parameter (IP)

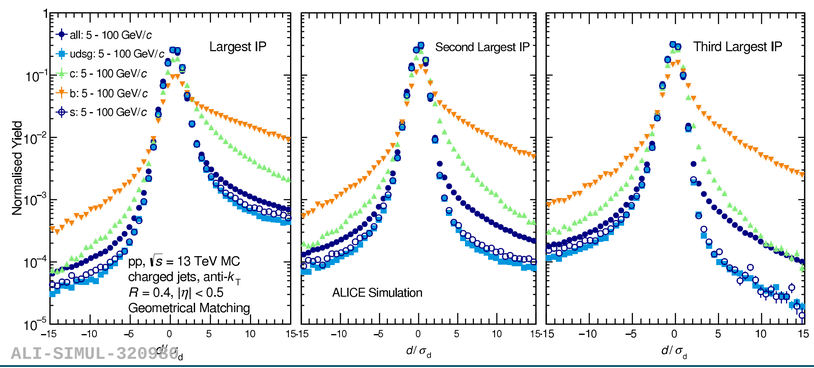


Key observable: $d = d_0\,\text{sign}(\vec{d}_0 \cdot \vec{e}_{\text{Jet}})/\sigma(d_0)$

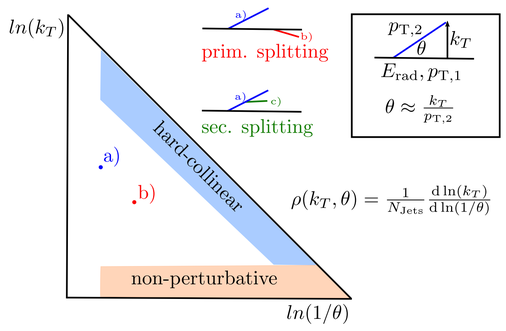
- $d_0 \equiv$ distance of closest approach of track to primary vertex projected onto xy-plane
- Signed according to product of jet axis and IP vector $\vec{d}_0$
- Divided by uncertainty of IP

- Define probability tagger on basis of tracks within jets with the three largest IP values
- Positive side of IP distributions carry lifetime information of primary hadrons

→ B hadrons are identified via their large lifetimes ($c\tau \approx 450\,\mu\text{m}$) which lead to decay tracks with large IPs.

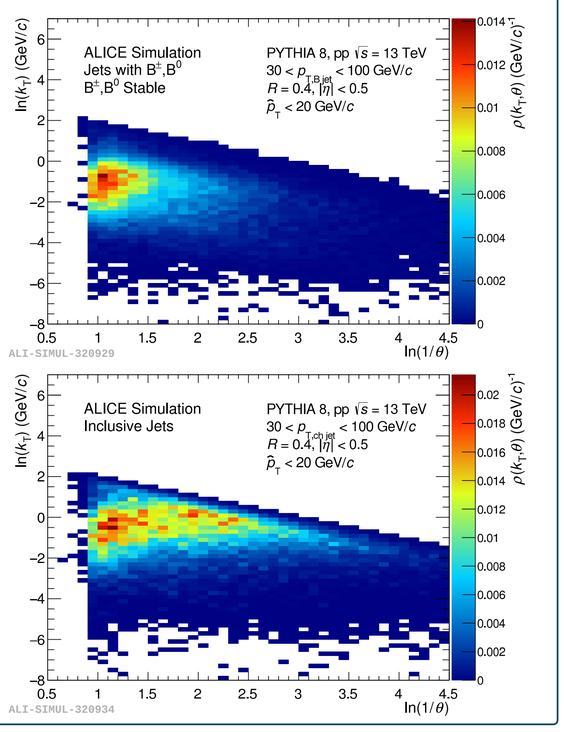


The Lund Plane Assuming Stable B Hadrons



- Tag a jet as bottom jet if it contains a B hadron
- Decluster jets in individual splittings via Cambridge-Aachen algorithm [3] always following the hardest prong
- Fill angle θ and transverse momentum k_T of primary splittings in Lund Plane

→ In B jet Lund Plane, splittings are suppressed at low angles with respect to inclusive Lund Plane.



The Lund Plane Considering B Decays

Simulations with B hadron decays turned on:

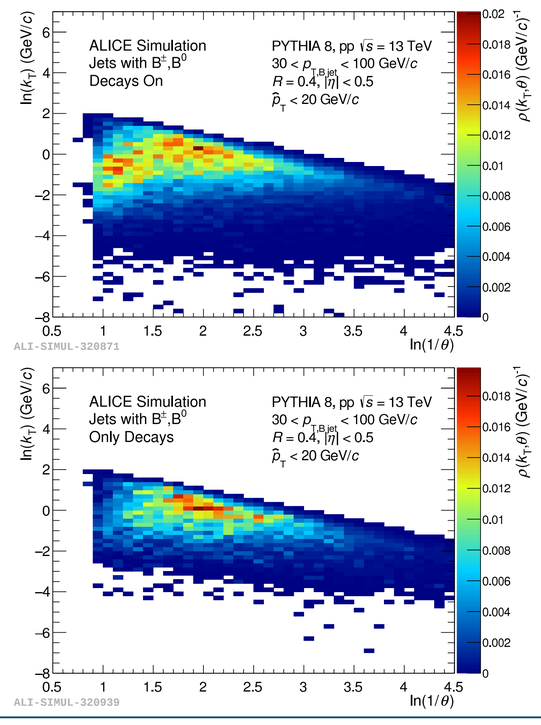
- Tag a jet as bottom jet if it contains a bottom decay particle
- Decluster as for stable B hadrons via following the hardest prong

→ The splittings from B hadron decays are smearing the signal region of the dead cone effect.

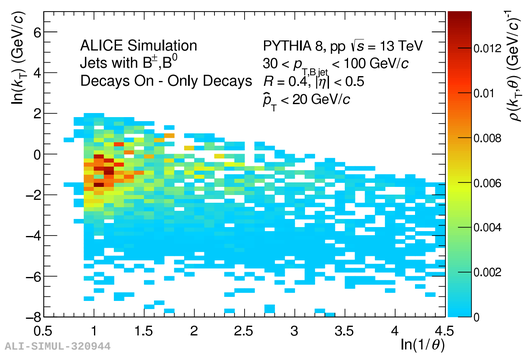
Separating the decay contributions:

- Only accept splittings where both prongs contain a bottom decay particle

→ Is it possible to subtract the decay contributions?



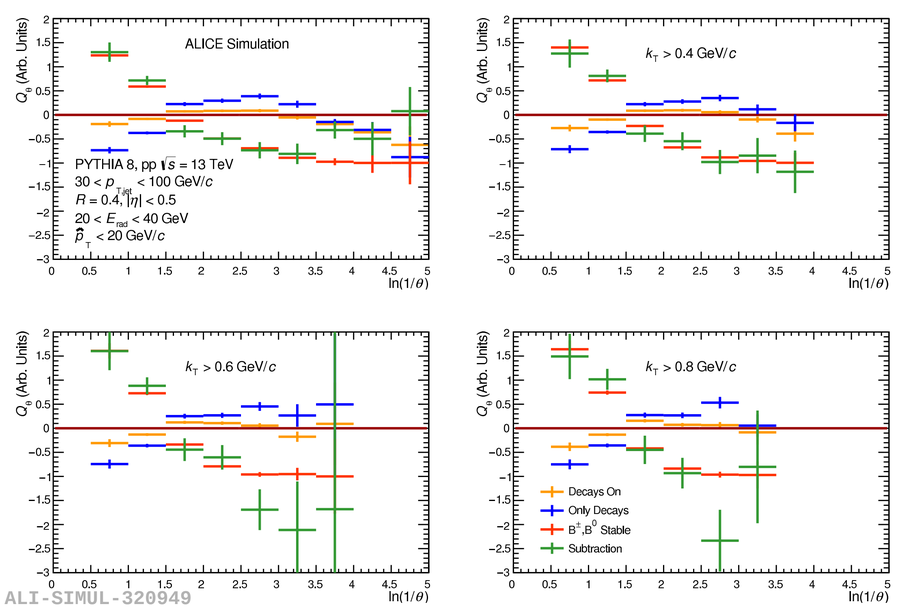
Subtracting the Decay Contributions



- Projections $P(1/\theta)$ in bins of k_T give access to the behaviour of the splitting angle at different scales

- The dead cone effect manifests via $Q_\theta < 0$ for small angles with

$$Q_\theta = \frac{P^{\text{HF}}(1/\theta) - P^{\text{inc}}(1/\theta)}{P^{\text{inc}}(1/\theta)}$$

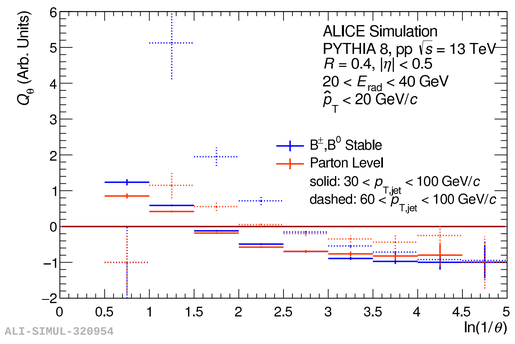


→ Via subtracting the decay contributions, the Q_θ distributions for stable B hadrons are regained.

→ The dead cone is reached at lower angles for larger limits on k_T.

Some Checks

✓ Hadron-level simulations are compatible with parton-level simulations, contributions from non-perturbative effects are negligible.



✓ Deviations arising from following the hardest prong rather than B hadron decay particles are small.

✓ Basic variable distributions, for example for radiator energy E_{rad} or energy fraction z carried by the daughter prongs, are regained via the subtraction.

Analysis Strategy – Summary

Objective: Investigate bottom jets on the Lund Plane in pp collisions at $\sqrt{s} = 13\,\text{TeV}$

Main Tool: Probability tagger for bottom jets based on simulations of transverse impact parameter spectra of tracks within jets

Status: Promising prospects from PYTHIA 8 simulations on the possibility of visualising the dead cone effect for bottom jets on the Lund Plane

References and Acknowledgements

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[1] ALICE Collaboration. "Centrality dependence of high-p_T D meson suppression in Pb–Pb collisions at $\sqrt{s_{\text{NN}}} = 2.76\,\text{TeV}$".
[2] Yu.L. Dokshitzer and D.E. Kharzeev. "Heavy Quark Colorimetry of QCD Matter".
[3] Yu.L. Dokshitzer, G.D. Leder, S. Moretti and B.R. Webber. "Better jet clustering algorithms".
[4] Leticia Cunqueiro and Mateusz Płoskoń. "Searching for the dead cone effects with iterative declustering of heavy-flavor jets".
[5] Frédéric A. Dreyer, Gavin P. Salam and Grégory Soyez. "The Lund Plane".

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