Outlook for b-jet measurements using heavy-flavour tagging with secondary-vertex method in pp collisions at 13.6 TeV with ALICE

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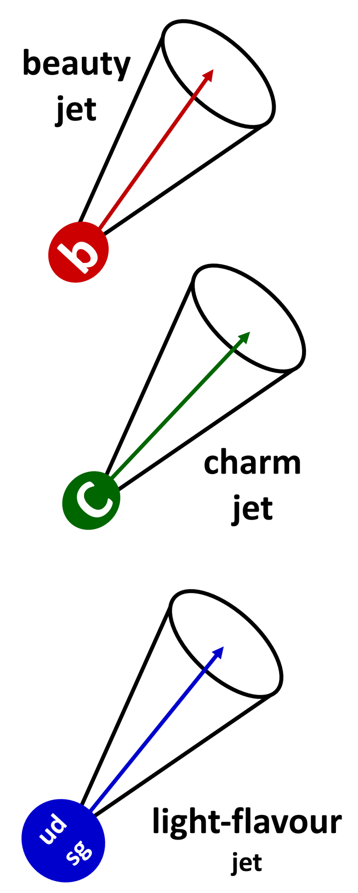
ALICE

Physics Motivation

- **Advantages of heavy-flavour tagged jets**
  - Provide insights into properties of scattered heavy-flavour partons and their fragmentation and constrain pQCD-based models.
  - Heavy-flavour jets allow us to study the flavour dependences of jet quenching, including the impact of mass effects and Casimir colour factors

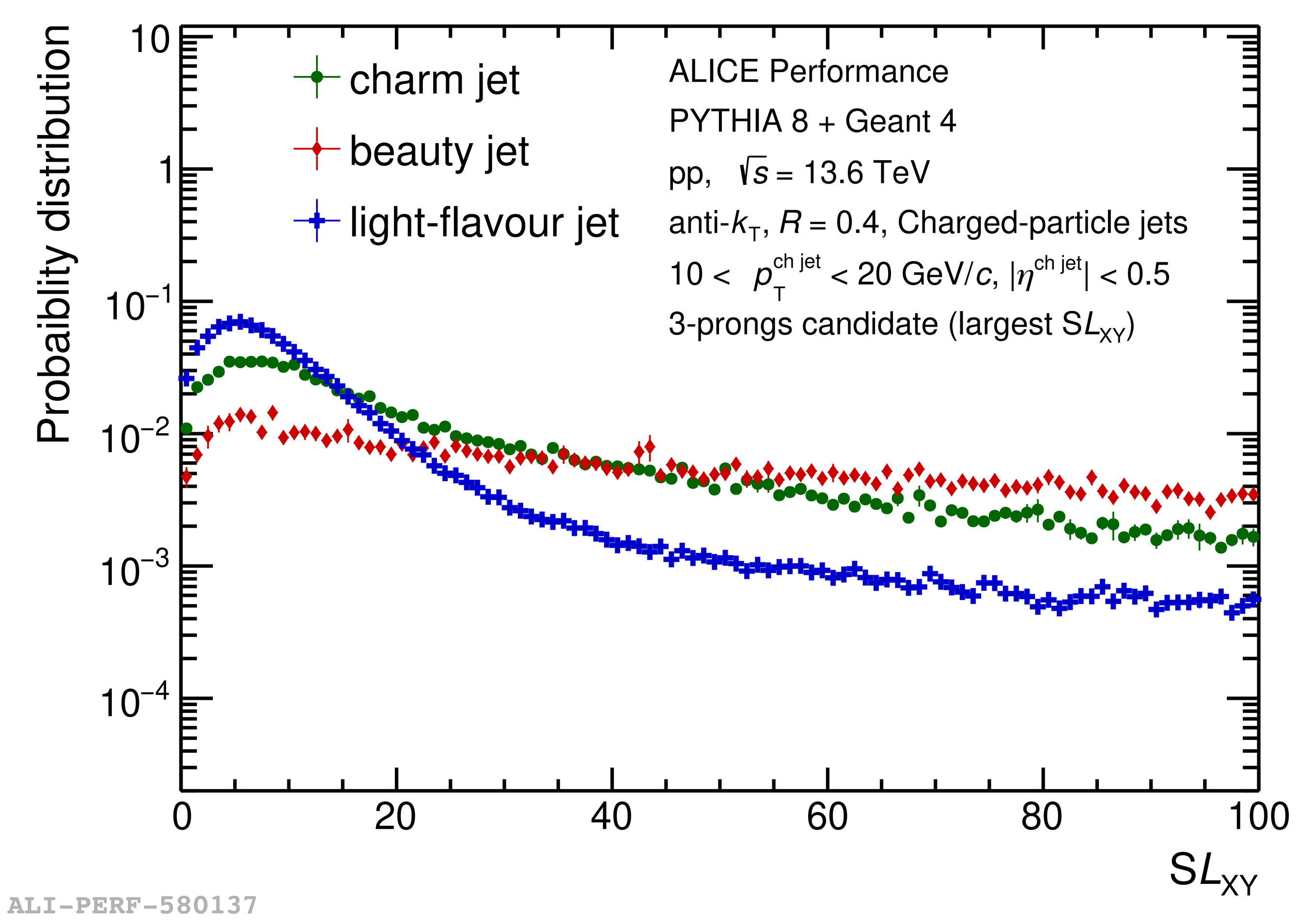
Analysis

- **MC simulations of PYTHIA 8 with GEANT 4 reconstruction of the ALICE detector**
- **Jet reconstruction**
  - anti-k_T algorithm
  - $p_T^{\text{ch jet}} > 10\ \text{GeV}/c$
  - $R = 0.4$
  - $|\eta^{\text{ch jet}}| < 0.5$
- **Track reconstruction**
  - $p_T^{\text{track}} > 0.15\ \text{GeV}/c$
  - $|\eta^{\text{track}}| < 0.9$
- **b-jet tagging algorithms in ALICE**
  - Method utilising large impact parameter of heavy-flavour hadron decay products
  - **Method utilising large decay length of heavy-flavour hadron**
  - ➢ Machine learning models trained on a variety of topological properties of the displaced decay products and reconstructed decay vertices



Secondary-vertex method

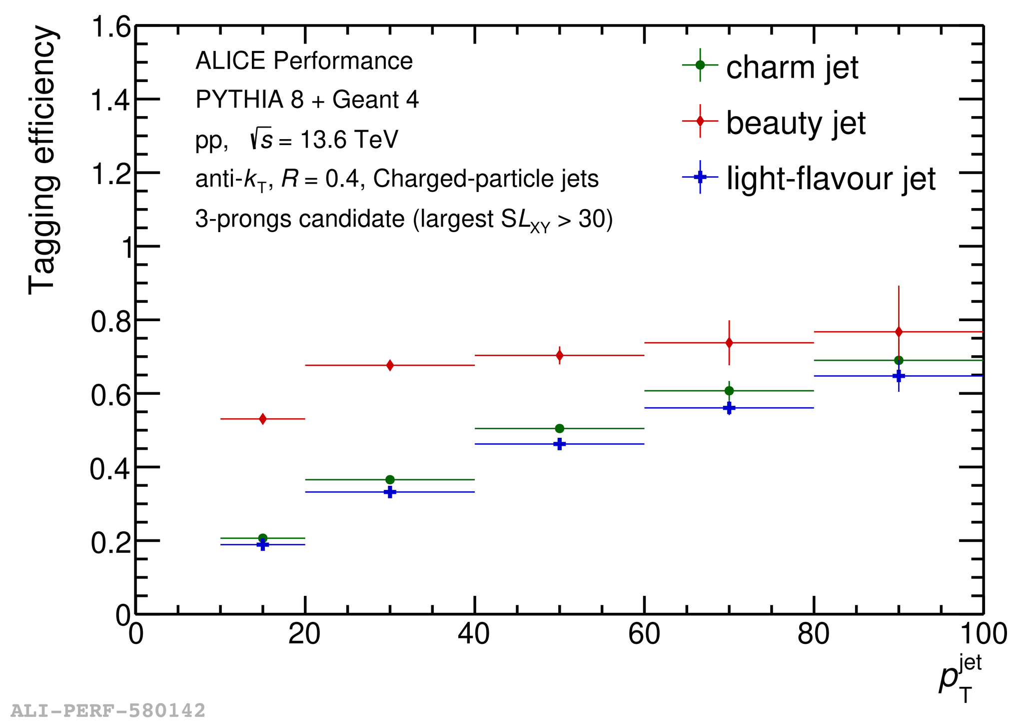
- **Secondary-vertex selection**
  - 3-prong decays
    - Beauty hadrons often decay into three tracks, forming a secondary vertex.
  - Point of Closest Approach (PCA)
    - Tracks are selected based on their closest approach to the primary vertex, identifying displaced decay products.
  - Maximum transverse decay length ($D_{\text{max}} < 4$ cm)
- The long lifetime of heavy-flavour quarks allows for the identification of a secondary vertex, displaced from the primary vertex
- Decay length significance: $SL_{xy} = L_{xy}/\sigma_{L_{xy}}$ (L_{xy}: decay length in the x-y plane)



- Selects the secondary vertex within the jet with the **highest** $\boldsymbol{SL_{xy}}$.
- Different jet flavours can be discriminated at large $\boldsymbol{SL_{xy}}$

Jet tagging

- Heavy-flavour jets are tagged by the largest $\boldsymbol{SL_{xy}}$ decay products of the secondary vertices that exceed a set tagger working point threshold ($SL_{xy} > 30$)
- Tagging efficiency $= \frac{N_{\text{flavour}}^{\text{tagged}}}{N_{\text{flavour}}^{\text{total}}}$
- High efficiency of b-jet tagging when compared to charm and light-flavour jets

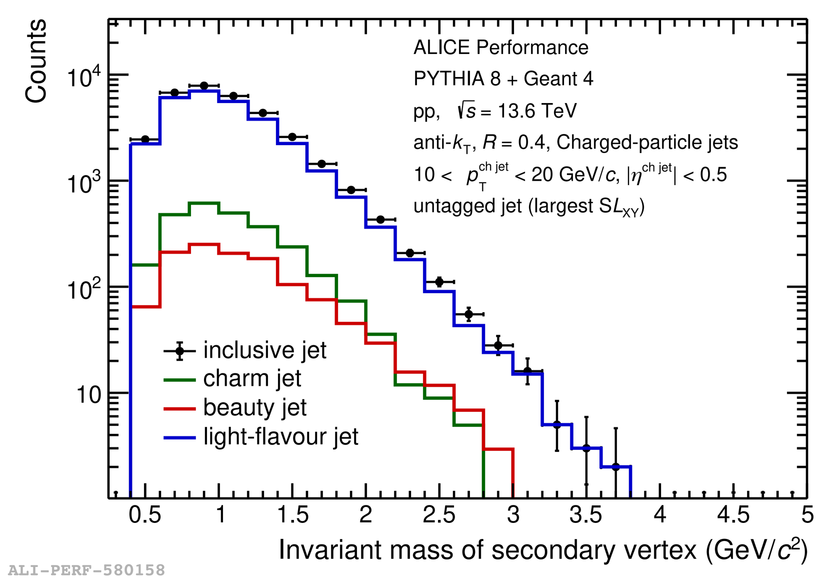


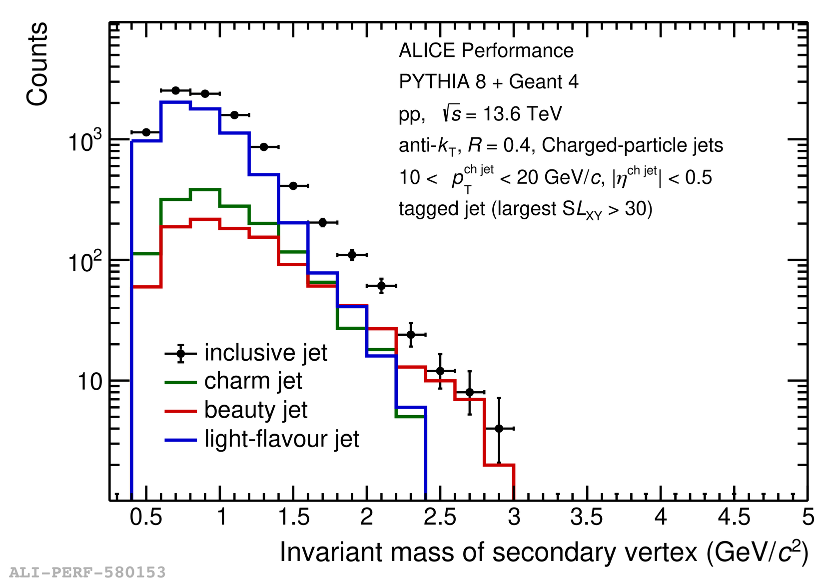
Invariant mass distribution

- The b-jet tagging algorithm enriches the jet sample with b jets.
- The invariant mass distributions of the reconstructed secondary vertices in jets are a discriminant of heavy-flavour and light-flavour jets
- The comparison of invariant mass distributions between untagged and tagged jets shows a clear shift

Sample of inclusive jets with no heavy-flavour jet tagging

Sample of heavy-flavour tagged jets





Conclusion & Summary

- Evaluation of the performance of the Run 3 ALICE detector for heavy-flavour jet tagging using MC.
- $\boldsymbol{S_{xy}}$ is used as it effectively discriminate heavy-flavour jets using **secondary vertices**.
- The efficiency of the heavy-flavour jet tagging depend on the chosen tagger working point.
- Tagged jet of Invariant mass of secondary vertex distribution shows discrimination of heavy-flavour jets with suppression of light-flavour.

Outlook

- Vary working point to optimize beauty-jet efficiency and purity, followed by a measurement of the beauty-jet cross section.
- **Additional tagging** methods (impact parameter, machine learning) to be explored.
- Perform measurement of beauty-tagged jets in **heavy-ion** collisions for further insights into the properties of the QGP.

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