b-jet production using heavy-flavour tagging in pp collisions at 13.6 TeV with ALICE

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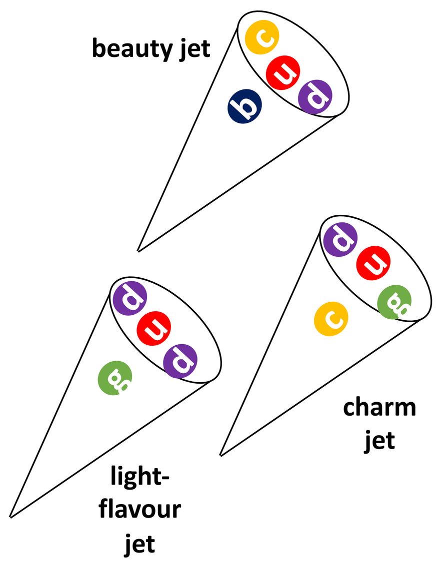
Physics Motivation

- **Significance of heavy-flavour hadrons**
  - **Heavy quarks (charm and beauty)** are produced early in collisions and their cross sections are predicted by **pQCD**, making them ideal probes for the **QGP**.
- **Advantages of heavy-flavour tagged jets**
  - Provide insights into properties of scattered heavy-flavour partons and their fragmentation and constrain pQCD-based models.
  - Heavy-quarks allow us to study the flavour dependences of jet quenching, including the impact of mass effects and Casimir colour factors

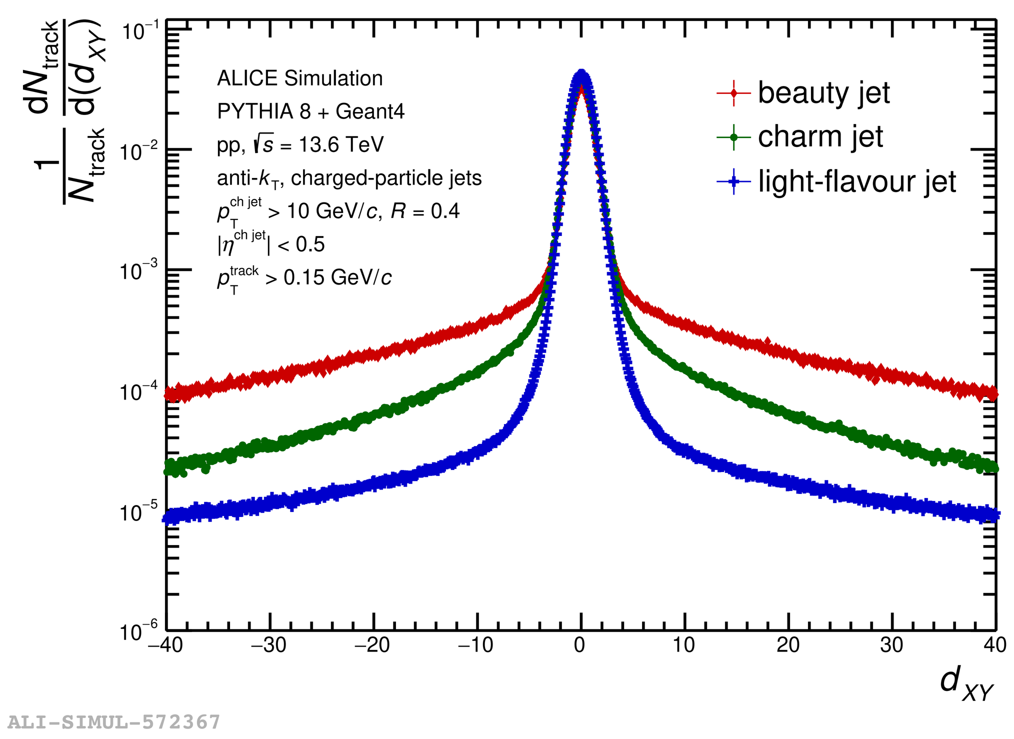
Analysis

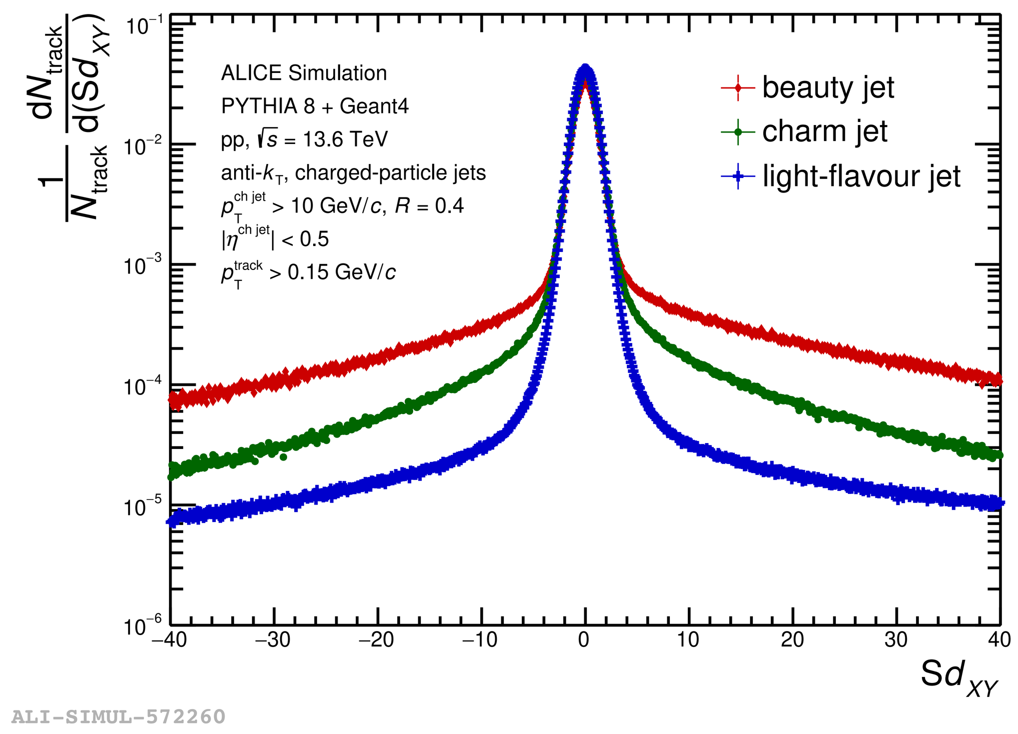
- **MC simulation using PYTHIA 8 and Geant4**
- **Jet reconstruction**
  - anti-k_T algorithm
  - $p_T^{\text{ch jet}} > 10\ \text{GeV}/c$
  - $R = 0.4$
  - $|\eta^{\text{ch jet}}| < 0.5$
- **Track reconstruction**
  - tracks inside jets
  - $p_T^{\text{track}} > 0.15\ \text{GeV}/c$
  - $|\eta^{\text{track}}| < 0.9$
- **Heavy-flavour jet classification methods**
  - Classifies jets based on the probability of heavy-flavour decays within jets.



Impact parameter method

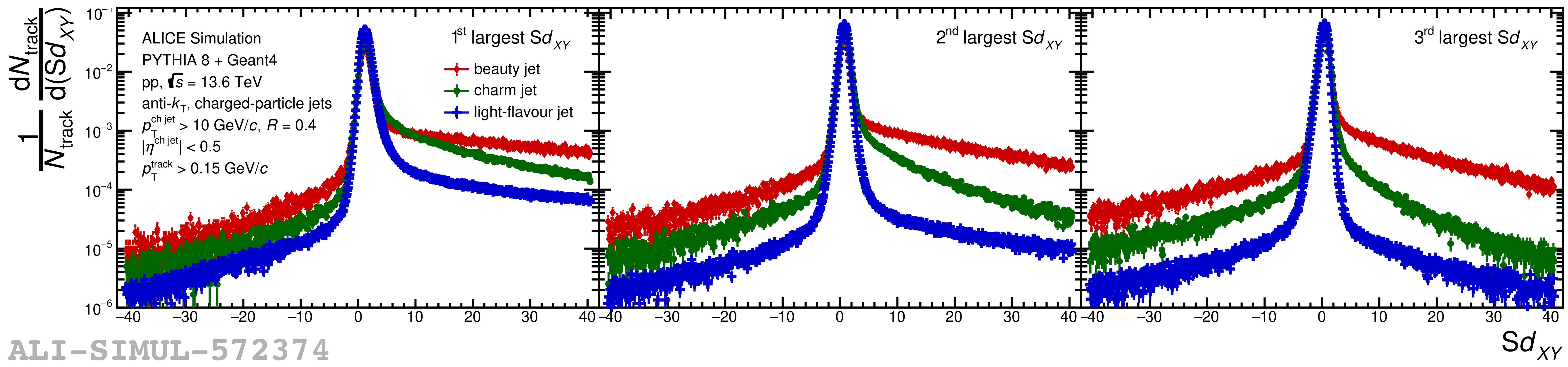
- Uses distance of closest approach (DCA) of tracks to the primary vertex of the collision which is called impact parameter.
- **Geometric sign:** $sign\left(\overrightarrow{DCA_{xy}} \cdot \overrightarrow{Jet_{p_T}}\right) = \pm 1$
  - Tracks originating from the **primary vertex** $\overline{DCA} = 0$
    - Limited resolution: **positive and negative**
  - Tracks from **secondary decays**
    - **positive** DCA values due to displacement from primary vertex
- **DCA significance**
  - $d_{xy} = DCA_{xy}/\sigma_{xy}$
  - $Sd_{xy} = \text{Geometric sign} \times d_{xy}$





Track counting method

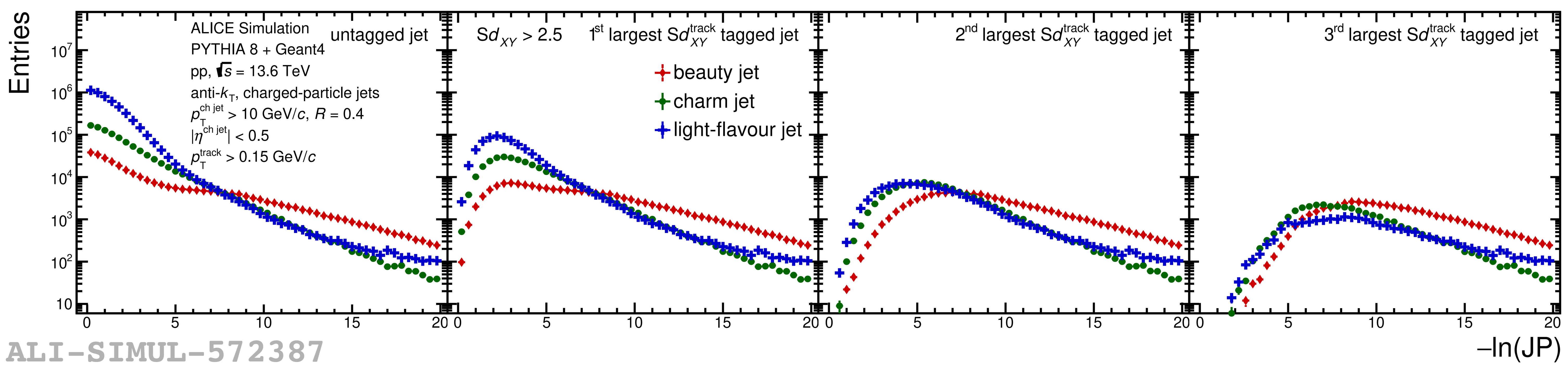
- Selects the N tracks within the jet with the **highest Sd_{xy}**.



- Larger for heavy-flavour tracks than light-flavour tracks, showing more pronounced **asymmetry** in beauty and charm jets
- It tags the heavy-flavour jet by counting the tracks that exceed a set **tagger working point** threshold

Jet probability method

- Assesses the probability of a jet containing heavy-flavour hadrons decay daughters based on track DCA.



- **Track probability** $P_{\text{tr}}(Sd_{xy})$ is determined using a resolution function $R(Sd_{xy})$ which is a combination of gaussian and an exponential

$$P_{\text{trk}}(Sd_{xy}) = \frac{\int_{-40}^{-|Sd_{xy}|} R(x)dx}{\int_{-40}^{0} R(x)dx}$$

- **Jet probability** (*JP*) is calculated assuming a Poisson distribution

$$JP = \prod \times \sum_{k=0}^{N_{\text{trk}}-1} \frac{(-\log \prod)^k}{k!}, \prod = \prod_{i=1}^{N_{\text{trk}}} P_{trk}$$

- The $-\ln(JP)$ distribution provides a clear separation between jets with low and high probabilities of containing heavy-flavour hadron decays.

Conclusion & summary

- Evaluation of heavy-flavour jets in Run 3 using MC.
- **Asymmetry** in Sd_{xy} observed for heavy-flavour jets, highlighting distinct characteristics.
- ***Sdxy*** is emphasized as it effectively discriminate heavy-flavour jets using the **track counting method**, associated with **secondary decays**.
- Combining the **jet probability method** with the **track counting tagger** significantly improves discrimination accuracy

Outlook

- Perform measurements of beauty jet **efficiency** and **purity**, followed by beauty-jet **cross section** determination
- **Additional tagging** methods (secondary vertex, machine learning) to be explored.
- Perform measurement of beauty-tagged jets in **heavy-ion** collisions for further insights into the properties of the QGP.