Performance of the ALICE secondary vertex b-tagging algorithm

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Motivation

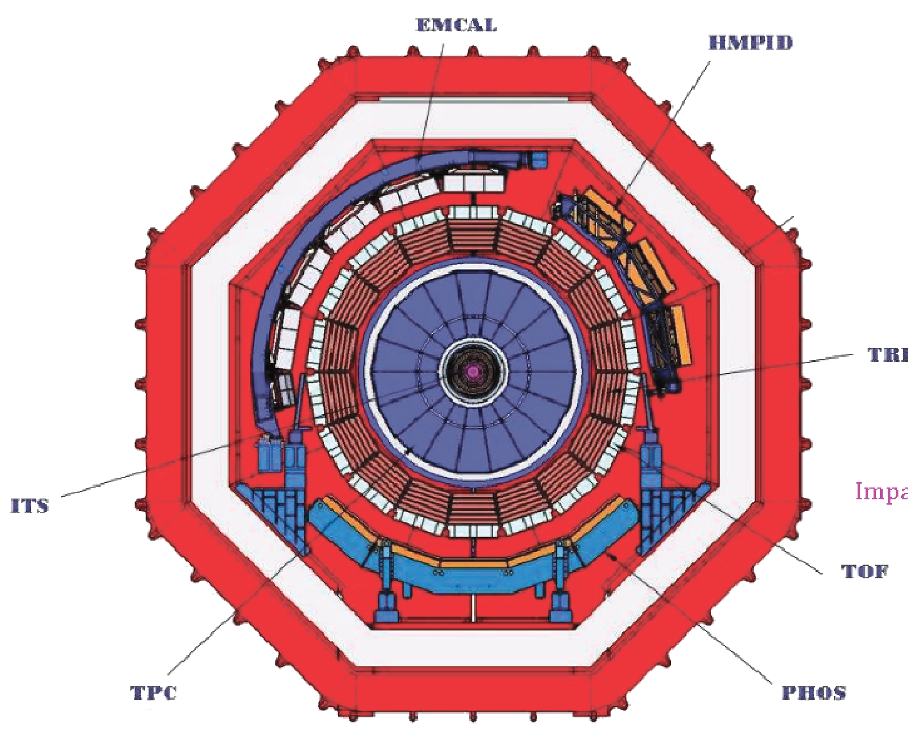
- Determine b-quark production via the measurements of beauty(b)-jets. Jets vs. heavy-flavor hadrons: access the kinematics of hard scattering in an unbiased way.
- Color and mass dependence of parton energy loss in the Quark-Gluon Plasma (QGP).

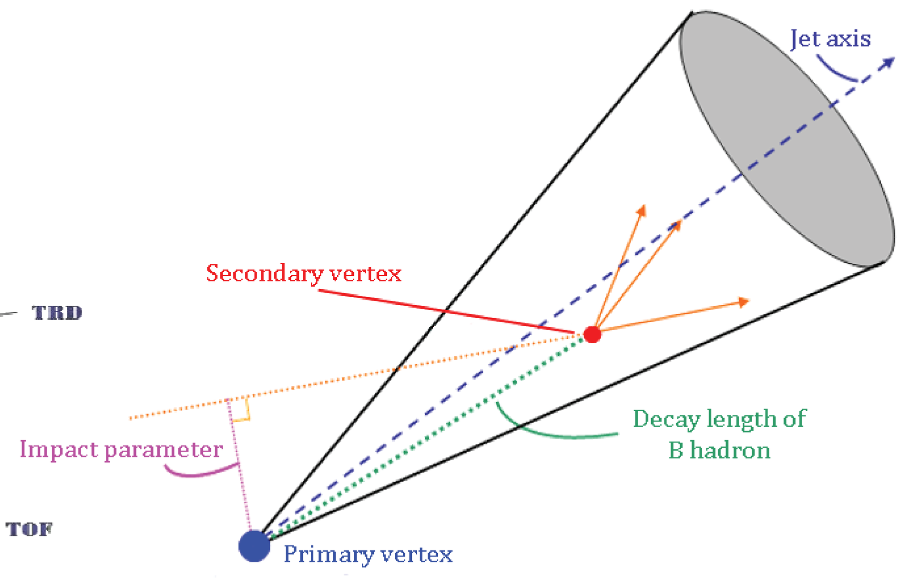
Analysis steps

- Jet-finding: jet reconstruction with charged tracks.
- Jet b-tagging: exploit long lifetime and large mass of beauty hadrons.
- Corrections: correction of jet transverse momentum p_T (or jet energy) for background and detector response (unfolding), corrections for b-tagging efficiency and charm/light jet contamination.
- *The studies presented in this poster are MC based.*

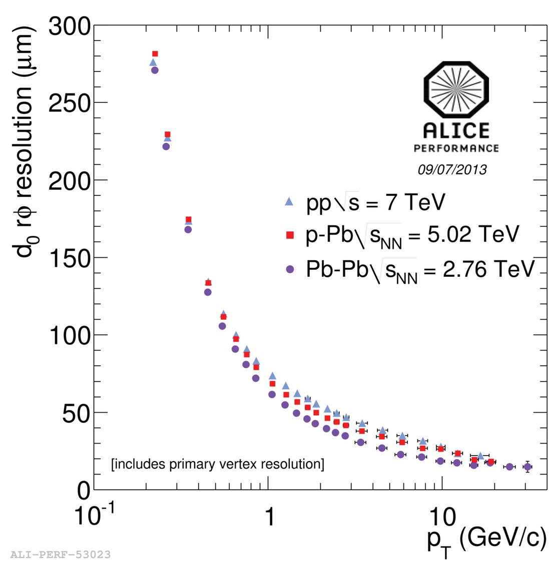
Secondary vertex (SV) tagging algorithm

Benefits from long lifetime ($c\tau$ ~ 500 μm) of beauty hadrons.

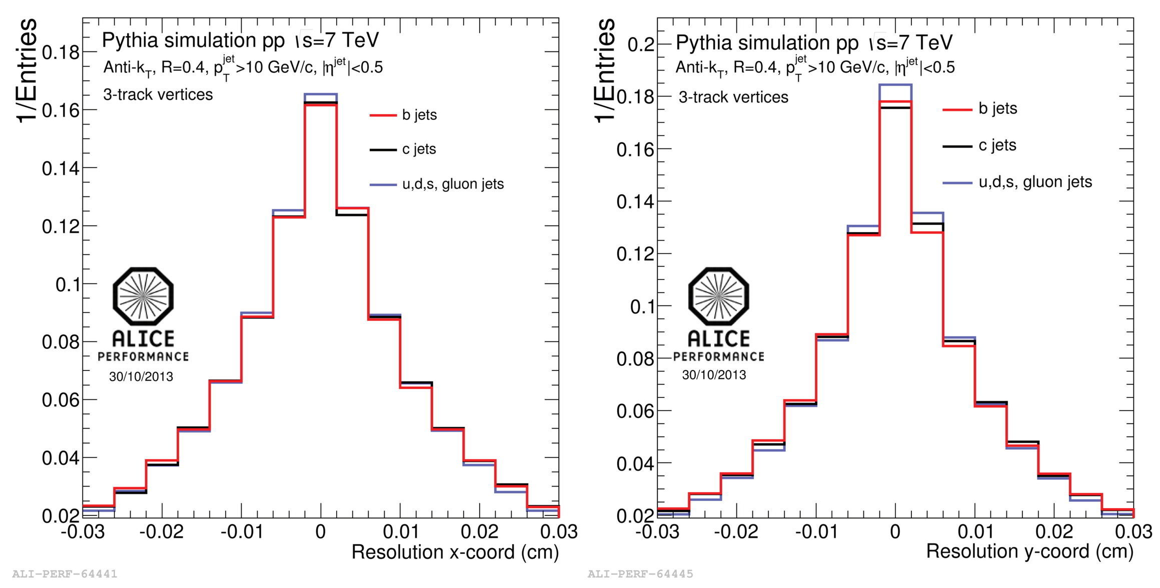




The Inner Tracking System (**ITS**) and Time Projection Chamber (**TPC**) are used for tracking and secondary vertex reconstruction. For all collision systems ALICE measures the track impact parameter d_0 with a resolution better than 70 μm for p_T > 1 GeV/*c*.



Track impact parameter resolution in the transverse plane vs p_T.



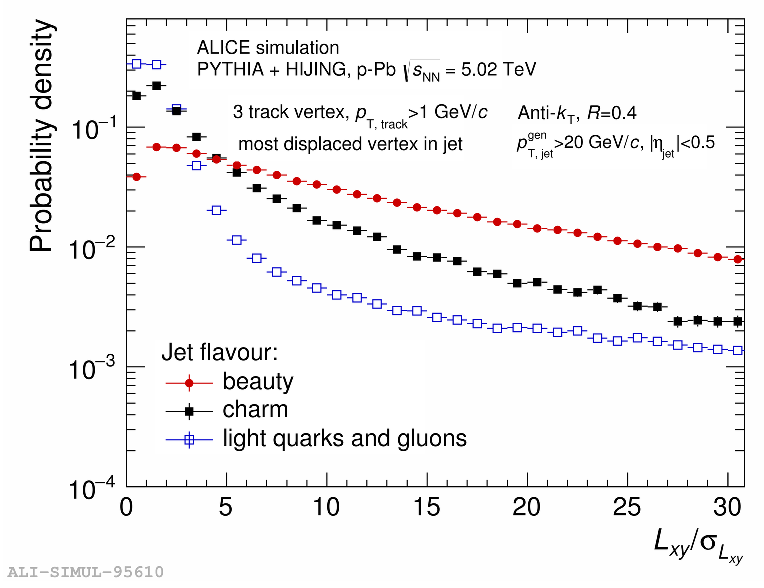
3-prong vertex resolution (in the xy plane).

- Jet reconstruction:
  FastJet Anti-k_T [1], R = 0.4
  $p_{T,track}$ > 0.15 GeV/*c*
- 3-prong SV are reconstructed using tracks in a jet $p_{T,prong}$ > 1 GeV/*c*
- Discriminating variables: significance of signed SV distance of flight L_{xy}/σ_{Lxy} in a transverse plane and SV dispersion σ_{vtx}.

$$L_{xy} = L'_{xy} \times \mathrm{sign}(L_{xy} \cdot p_{T,jet})$$

$$\sigma_{vtx} = \sqrt{d_1^2 + d_2^2 + d_3^2}$$

$d_{1,2,3}$ are the distances of tracks from SV.



Signed flight distance significance of SV. Jets of different flavor defined in MC based in presence of B- (D-) hadron.

[1] M. Cacciari and G. P. Salam, Phys. Lett. B 641 (2006) 57.

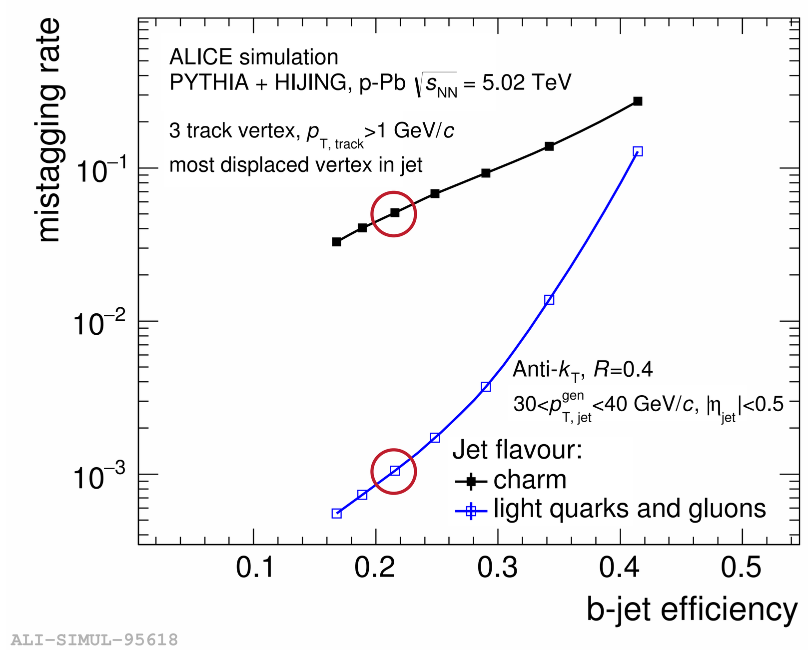
Secondary vertex algorithm performance in p-Pb collisions

$$\varepsilon_b(p_T) = \frac{dN_b^{tagged} / dp_T}{dN_b / dp_T}$$

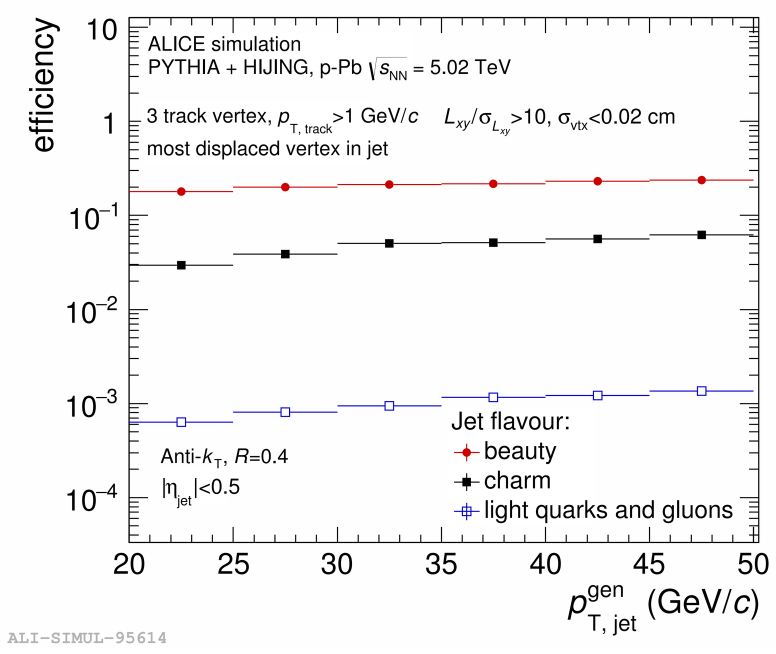
Tagging efficiency: the ratio of properly tagged jets vs all jets of a given flavor. It is obtained via MC studies.

Cut variation → different tagging and mistagging effiiencies.

The goal is to find the working point with high purity and reasonably high efficiency at the same time.



Tagging efficiency and mistagging rate with different cuts on L_{xy}/σ_{Lxy} of SV for 30 < $p^{gen}_{T,jet}$ < 40 GeV/*c*.



(Mis)Tagging efficiencies of SV algorithm for L_{xy}/σ_{Lxy} > 10 cm and σ_{vtx} < 0.02 cm.

Unfolding corrections

$$m(x') = \int dx A(x;x') t(x)$$

The measured spectrum *m(x′)* is a convolution of a true spectrum *t(x)* and detector responce function *A(x;x′)*. The true jet spectrum is found via unfolding procedure.

The Singular Value Decomposition (SVD) unfolding was used [2].

- The constant background density ρ_{CMS} (calculated with CMS method [3]) is subtracted from $p_{T,jet}$:

$$\rho_{CMS} = \mathrm{median}\left\{\frac{p_{T,i}}{A_i}\right\} \cdot C$$

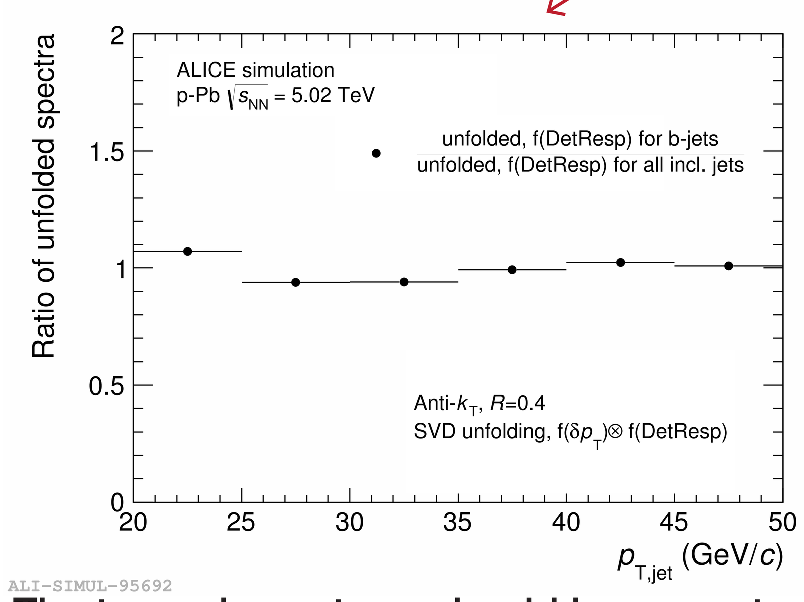
$p_{T,i}$ are soft clusters, found by FastJet k_T, A_i is the jet area, C is the correction factor for the empty clusters.

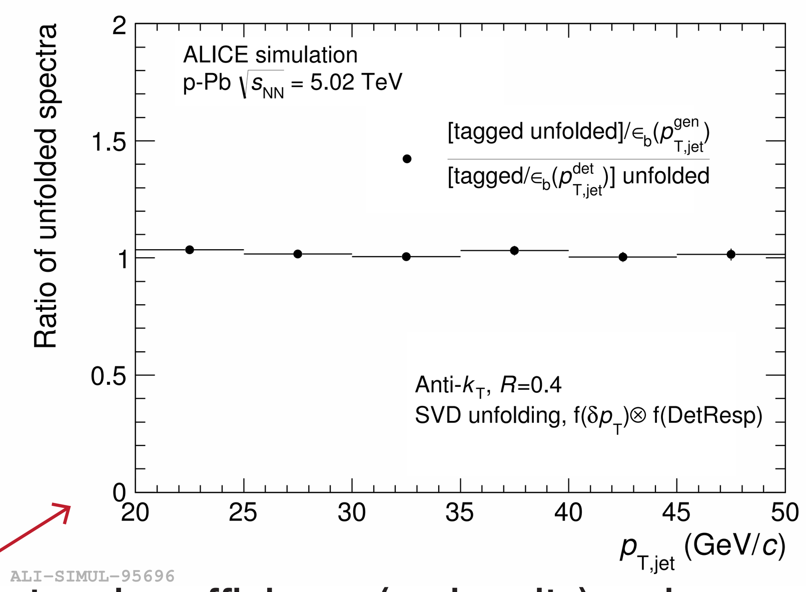
- The background fluctuations δp_T are calculated with MC (HIJING) via random cone method:

$$\delta p_T = \sum_i p_{T,i} - \rho \cdot A_{cone}$$

The sum is over track $p_{T,i}$ in a cone.

- MC b-jet p_T spectrum is unfolded with the combined matrix: detector response and background fluctuations matrix. Same results when unfolding with detector response matrix of inclusive and b-jets
  → no strong influence of detector response in different fragmentation patterns of b- and inclusive jets.





- The tagged spectrum should be corrected for tagging efficiency (and purity) and unfolded. It was verified with p-Pb simulations that the correction order does not give significant differences in the resulting spectrum.

[2] H. Hoecker, V.Kartverlishvili, Nucl. Instrum. Meth. A372 (1996) 469.
[3] CMS collaboration, JHEP 1208 (2012) 130.

Prospects with LHC/ALICE upgrades

- Upgrade of ITS (2018):
  improvement of the track impact parameter resolutions by a factor 3 (6) in the transverse (longitudinal) direction
  → better light flavor rejection in b-tagging analysis.
  [CERN-LHCC-2012-012, CERN-LHCC-2012-013]
- ALICE read-out and LHC upgrades (2018):
  higher integrated luminosities: ~10 pb^{-1} for pp collisions at $\sqrt{s}$ = 14 TeV and ~10 nb^{-1} for Pb-Pb collisions at $\sqrt{s_{NN}}$ = 5.5 TeV required by the ALICE upgrade program
  → high precision heavy-flavor results, posibility to study on-line b-jet tagging.

Summary and ongoing studies

- The tagging cuts for SV algorithms are optimized for keeping beauty efficiencies as large as possible and at the same time charm and light-jet contamination small.
- Corrections for background and background fluctuations as well as for detector response are implemented. It was found that the b-jet spectrum can be corrected with a detector response matrix for all inclusive jets.
- The order of corrections (tagging efficiency vs unfolding) gives compatible results.

- MC and data-driven estimation of tagging purity is under study.
- Study of track cuts and selection for SV reconstruction in order to obtain higher purity is ongoing.

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