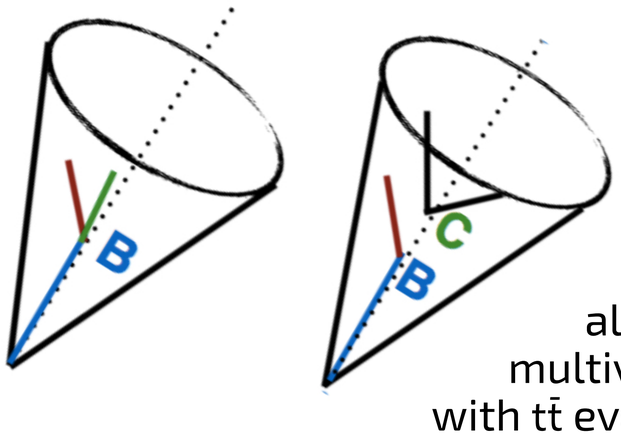
Secondary Vertex Finder Algorithm

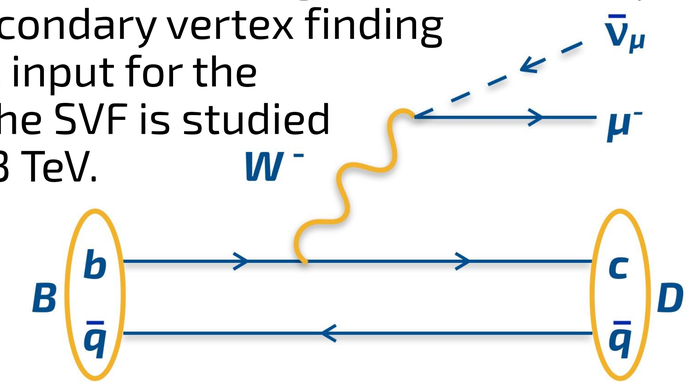
based on "*Secondary Vertex finding for jet flavour identification with the ATLAS Detector*"
ATL-PHYS-PUB-2017-011

Sebastian Heer for the ATLAS Collaboration

MOTIVATION: Identification of jets containing *b*-hadrons



If a jet originates from a *b*-quark, a *b*-hadron is formed during the fragmentation process. In its dominant decay modes, the *b*-hadron decays into a *c*-hadron via the electroweak interaction. Both *b*- and *c*-hadrons have lifetimes long enough to travel a few millimetres before decaying. Thus displaced vertices from *b*- and subsequent *c*-hadron decays provide a strong signature for a *b*-jet. Reconstructing these secondary vertices (SV) and their properties is the aim of the secondary vertex finding algorithm (SVF). The reconstructed features are used as input for the multivariate baseline tagger in ATLAS. The performance of the SVF is studied with $t\bar{t}$ events, requiring at least one lepton, simulated at $\sqrt{s}$ = 13 TeV.



Jet selection:
- p_T > 20 GeV
- $|\eta|$ < 2.5

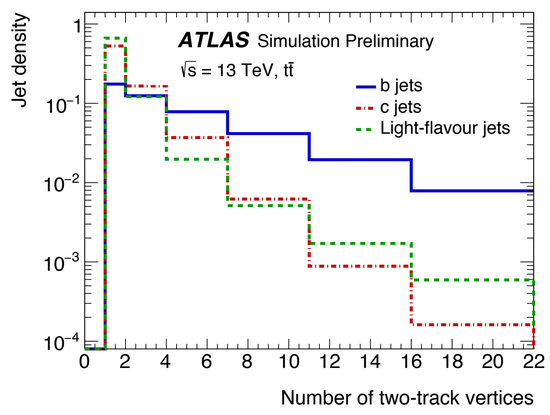
Additional selection:
- Pileup rejection cut for jets with p_T<60 GeV & $|\eta|$ < 2.4 (JVT > 0.59)

The SVF algorithm in steps

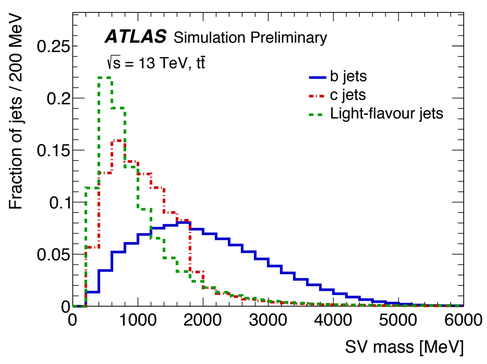
- Select tracks in each jet, satisfying quality cuts
- Form two-track vertices
- Clean obtained vertex set
- Merge two-track vertices into one multi-track vertex
  - merge *b*- and *c*-hadron decay vertices if close
  - or reconstruct the decay vertex with most tracks

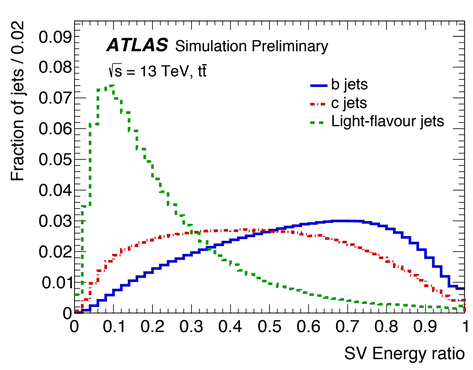
Output

- One SV per jet
- Tracks associated to SV
- SV properties



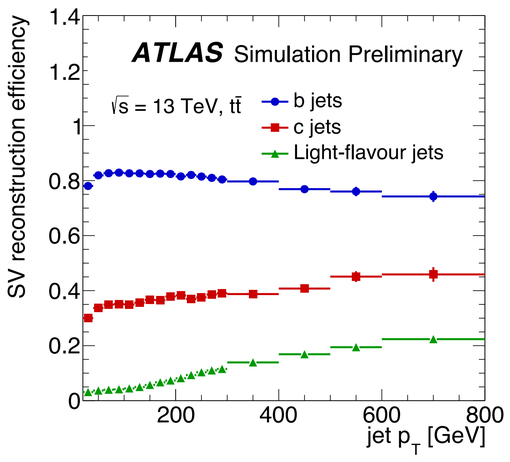
Secondary vertex properties

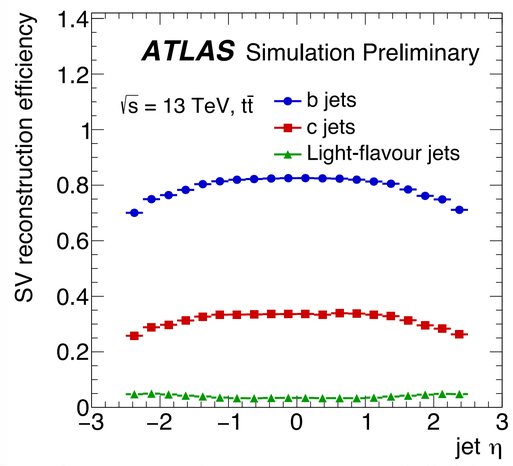




- SV mass: invariant mass of the tracks in the SV
- SV energy ratio : ΣE(tracks in the SV) / ΣE(tracks in the jet)
- Both provide discrimination of *b*-, *c*- and light-flavour-jet vertices

Performance of the SVF algorithm



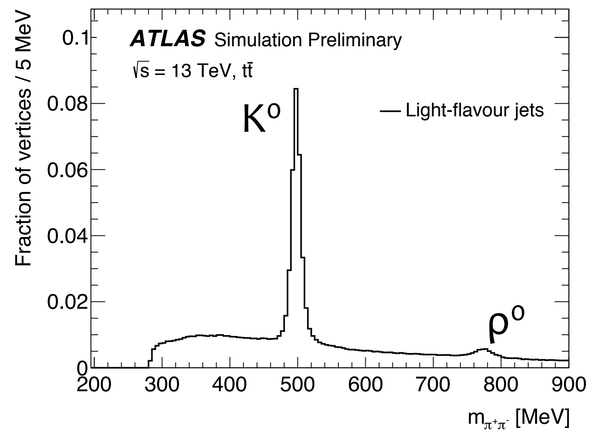


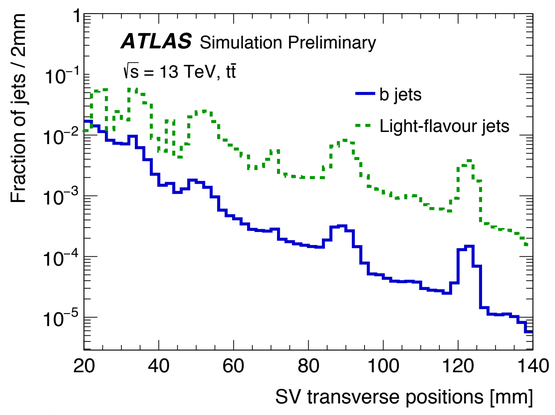
- Reconstruction efficiency of *b*-jet vertices up to 80%
- Drop for high p_T & non-central η region

Cleaning procedures

1) Removal of background vertices

- photon conversions: m_{ee} > 40 MeV
- K^0, Λ^0 vertices: $|m_{\pi\pi} - m_{K0}|$ > 22 MeV, $|m_{p\pi} - m_{\Lambda 0}|$ > 8 MeV

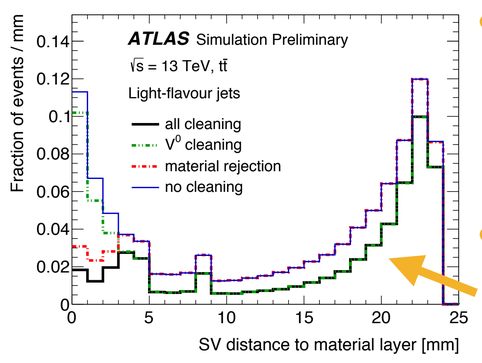




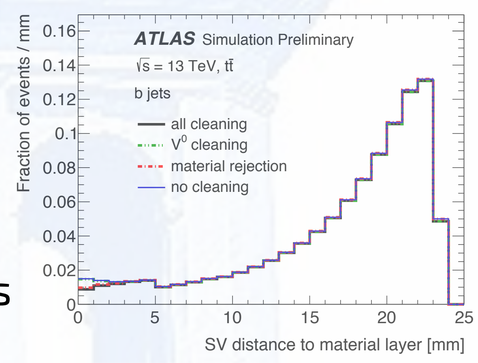
2) Removal of material interaction in detector material

- using the radial distribution of two-track vertices
- peaks corresponding to Pixel detector layers are visible:
- Beampipe: ~25mm
- Pixel detector layers: 34 mm, 51 mm, 89 mm and 123 mm

Combined cleaning performance

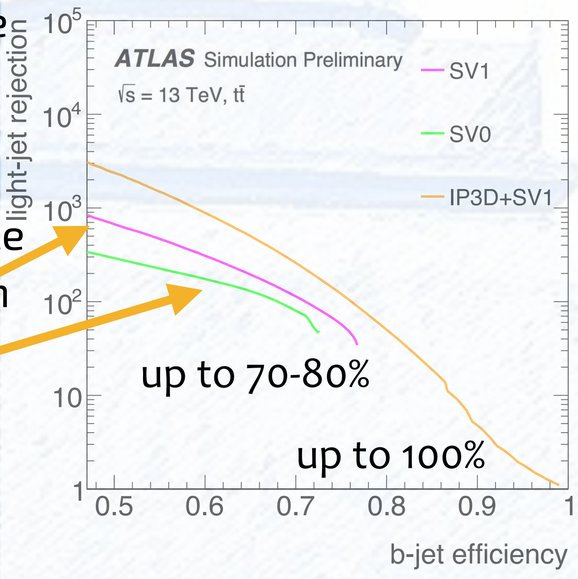


- *b*-jet vertices unaffected by cleaning procedure
- Vertex rate in light-flavour jets is reduced



Propagation to b-tagging algorithms in ATLAS

- SV-based algorithms limited by the ability to reconstruct SV in *b*-jets
- Combination with track impact parameter-based tagger (IP3D), yields a more powerful performance
- SV1: log-likelihood based algorithm
- SV0: 3d decay length significance



Conclusions

- Optimized & tuned algorithm
- 80% reconstruction efficiency and 3% fake rate are obtained with $t\bar{t}$ events, simulated at $\sqrt{s}$ = 13 TeV
- Basis of several standalone *b*-taggers
- Important contribution to the combined ATLAS *b*-tagger

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