SOFT B-HADRON TAGGING

WITH THE ATLAS DETECTOR

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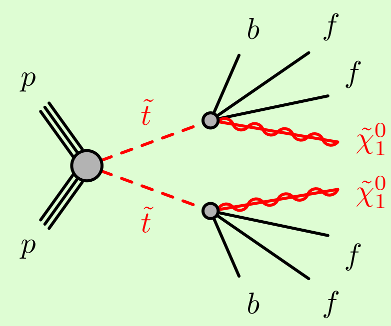
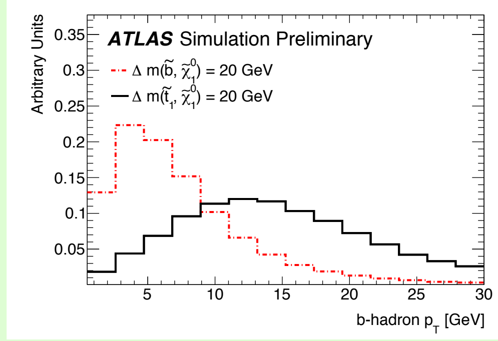
Introduction

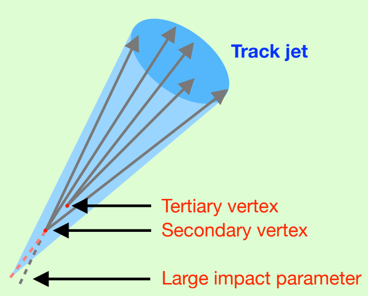
- To identify a b-hadron in ATLAS, the particle's long lifetime and large mass are exploited.
- The standard b-tagging performance is limited for low p_T b-hadrons because it relies on the calorimeter jet reconstruction (Jet p_T > 20 GeV).
- In compressed 3rd generation SUSY (stop and sbottom) searches, the final states contain low p_T b-hadrons which cannot be tagged by the standard b-tagging.
- Challenging signature due to the short flight length of the low p_T b-hadron.
- Three methods targeting such low p_T b-hadrons have been developed.





Algorithms

Track jet b-tagging



Track Jet Reconstruction

- Jet formed by tracks without calorimeter clusters
- Anti-k_t algorithm
- Jet p_T > 5 GeV
- Variable radius cone size

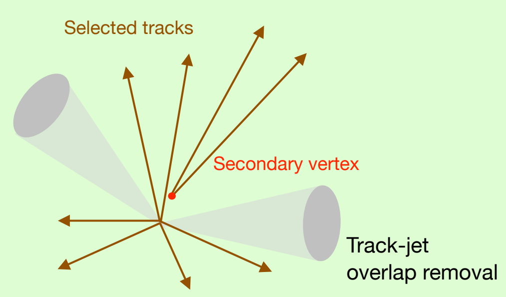
  $R(p_T) = (30\ \text{GeV})/p_T$

  $R_{\max} = 0.4, R_{\min} = 0.02$

MV2c10 Algorithm

- Same as the standard b-tagging for calorimeter jets
- Multivariate discriminator based on the following low-level taggers
  - IP2D, IP3D: 2D and 3D likelihoods on impact parameter significance
  - SV1: Secondary vertex finder
  - JetFitter: Topological secondary and tertiary vertices

Track based Low p_T Vertex Tagger (T-LVT)



Track selection

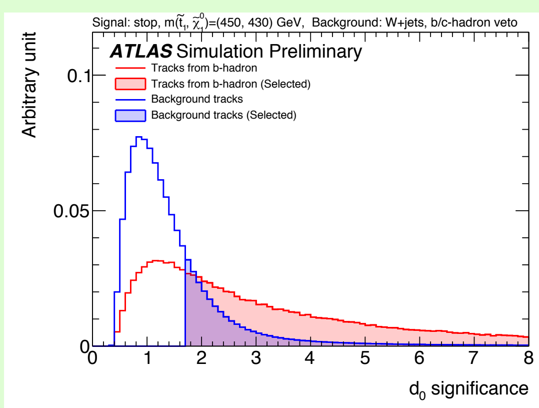
- Important step to reduce fake vertices originating from random-crossing tracks
- Require large impact parameters (IP)

  transverse IP: $d_0/\sigma_{d_0} > 1.7$

  longitudinal IP: $z_0/\sigma_{z_0} > 0.5$
- Track-jet overlap removal

  $\Delta R(\text{track}, \text{jet}) > 0.4$
- Pile-up track suppression

  $|z_0 \sin\theta| < 1.2$ mm



Vertex Fitting

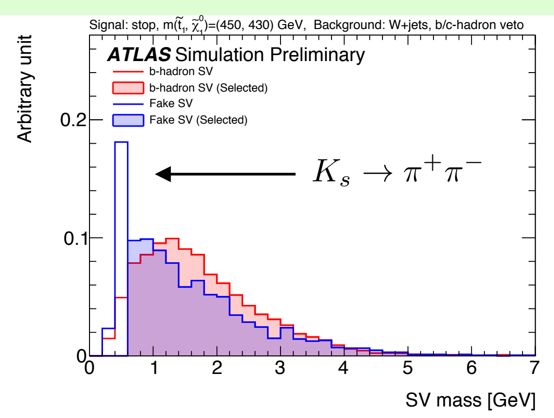
- Try to fit vertices from all combination of 2 tracks in the selected track collection
- 2-track vertex preselection based on cosθ: angle between $\boldsymbol{r}_{SV}$ and $\boldsymbol{p}_{SV}$
- Form n-track vertices (n≥2) from 2-track seeds.

Vertex Selection

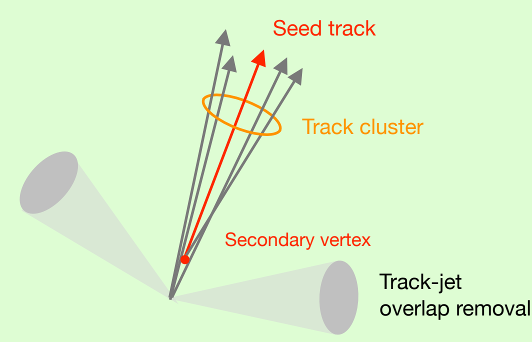
- Require separation from PV

  $L_{3D}/\sigma_{L_{3D}} > 7$

  $L_{xy} \in (0.5, 5.0)$ mm
- Vertex mass > 600 MeV
  - Surpress $K_s \to \pi^+\pi^-$
- Vertex p_T > 3 GeV
- More selections based on track angles



Track-cluster based Low p_T Vertex Tagger (TC-LVT)



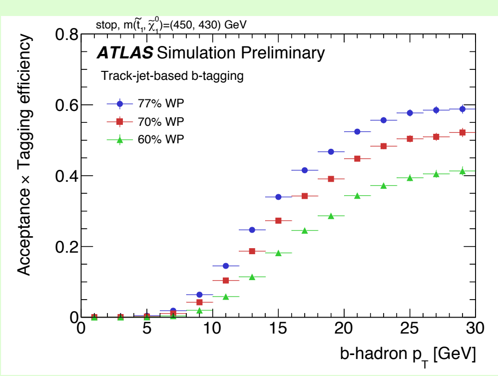
Clustering & Vertex Finding

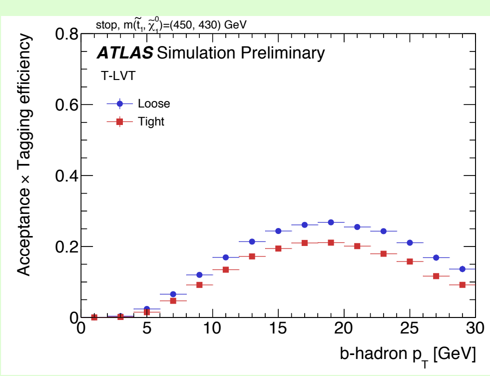
- Find seed tracks requiring large impact parameters
- Track clustering for each seed
- Find a SV for each cluster
- Similar vertex finding and selection to T-LVT

Performance

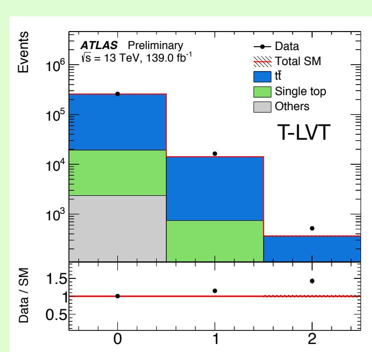
b-hadron Finding Efficiency

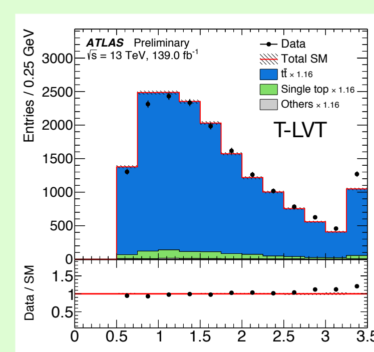
- Track b-jet performs well at high p_T
- Vertexing methods optimized for p_T < 20 GeV
- Efficiency of the vertex tagger drops at high p_T due to the track-jet overlap removal



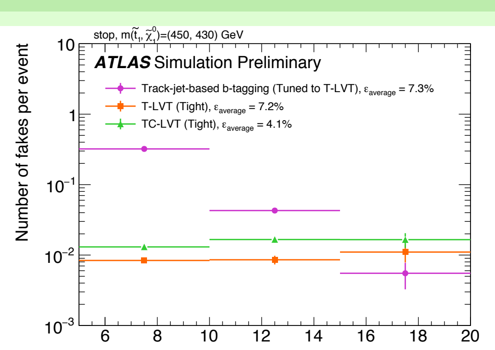


Validation with Data



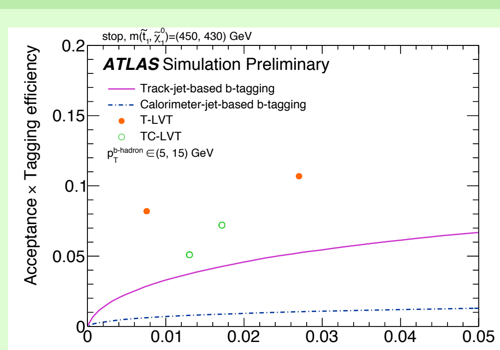


Fake Rate



- Fake rate: Number of fakes per event
- Track b-jet efficiency is tuned to the T-LVT efficiency to compare the fake rates with the same efficiency in each p_T bin
- The vertexing approaches provide better performance below 15 GeV

Low p_T b-tagging vs Calorimeter-jet-based b-tagging



- Loose and Tight working points are shown for both LVTs
- The threshold on MV2c10 discriminant is varied for jet-based b-tagging
- Significant improvement with respect to the standard calorimeter-jet-based b-tagging for p_T < 15 GeV