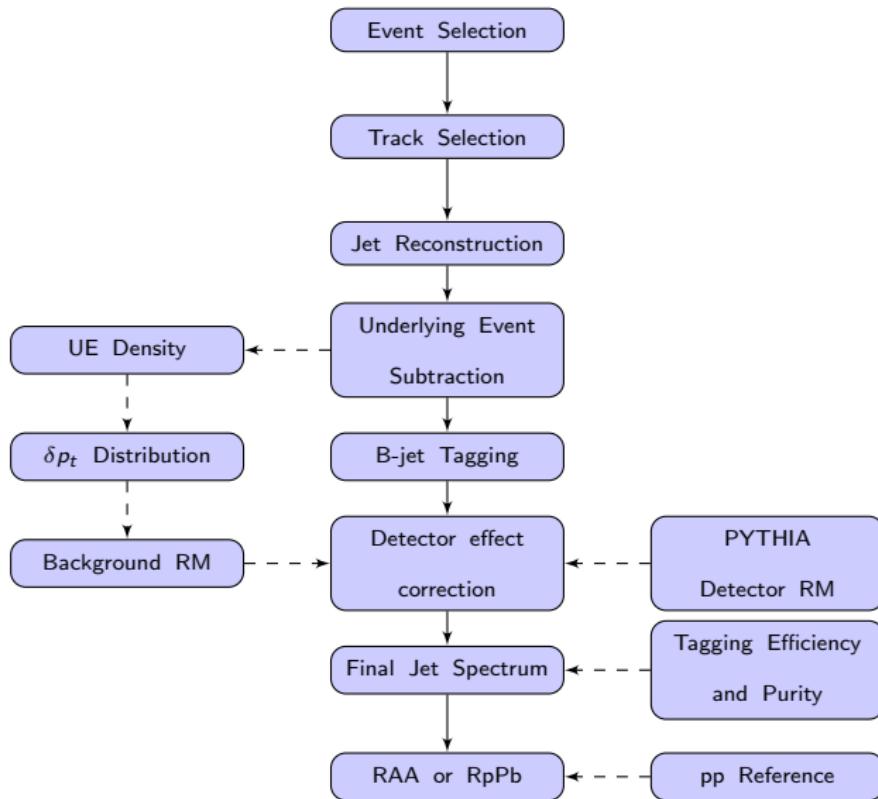


B jet analysis in pPb at $\sqrt{s} = 5.02 \text{ TeV}$

Hadi Hassan

18/12/2017

Analysis Steps



DATA Sets

- LHC16t : 267166, 267165, 267164, 267163, 267161.
pass1_CENT_wSDD, pass1_FAST.
- LHC16q: 265305, 265308, 265309, 265332, 265334, 265335, 265336, 265338, 265339, 265342, 265343, 265344, 265377, 265378, 265381, 265383, 265384, 265385, 265387, 265388, 265419, 265420, 265421, 265422, 265424, 265425, 265426, 265427, 265435, 265499, 265500, 265501, 265521, 265525.
pass1_CENT_wSDD, pass1_FAST.

Event Selection

- Physics selection: MB events (`AliVEvent::kINT7`).
- Primary vertex contributers should be > 0 .
- SPD vertex contributers should be > 0 .
- $|Z_{Vrtx}^{SPD} - Z_{Vrtx}^{Pri}| < 0.5\text{cm}$.
- The Z_{Vrtx}^{SPD} reconstruction resolution (RMS of the vertex position) should be < 0.25 .
- $|Z_{Vrtx}^{Pri}| < 10\text{cm}$.
- PileUp rejection MultiVertex PileUp rejection
`AliAnalysisUtils::IsPileUpMV(event)`.

Track Selection and Jet Reconstruction

- Track Selection:

- Charged track selection.
- Hybrid Tracks with filter bit 4 and 9.
- $|\eta| < 0.9$.
- $P_T > 0.15$.

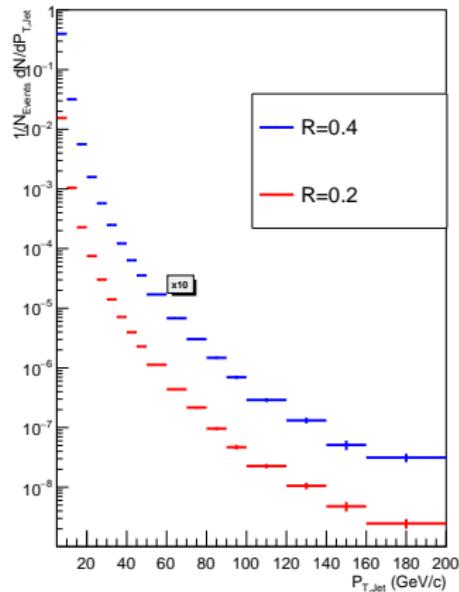
- Jet Reconstruction:

- $R = 0.4$, Anti- kt algorithm (and kt algorithm for underlying event subtraction), pt-scheme.
- $|\eta| < 0.5$.
- $P_T > 5 \text{Gev}/c$.
- Area $> 0.6\pi R^2$.

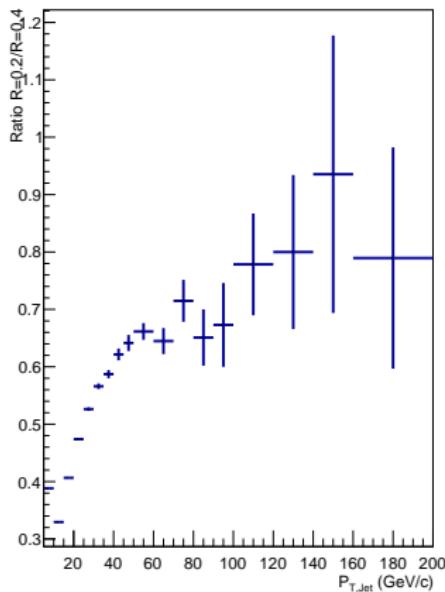
Jet P_T distribution

The P_T reach is around 200 GeV/c.

Inclusive jet spectra



Ratio $R=0.2/R=0.4$

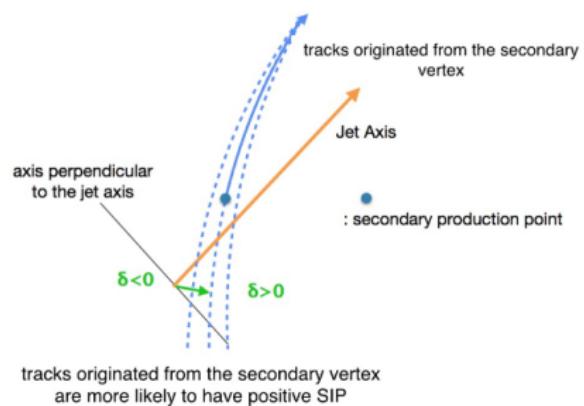
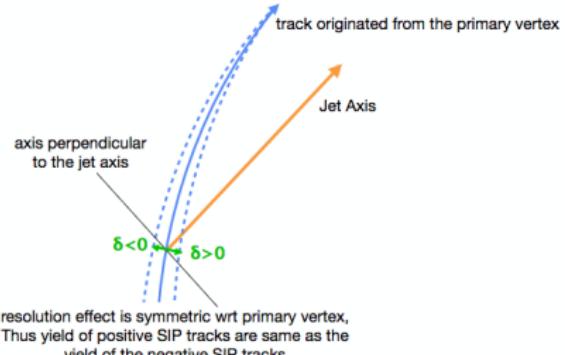


Underlying event subtraction

- UE density (using the CMS method for pPb):
 $\rho_{CMS} = median\left(\frac{p_{T,i}}{A_i}\right).C$, where $C = \frac{CoveredArea}{TotalArea}$.
- The background density is subtracted from the measured uncorrected jet $p_{T,j}^{Sub} = p_{T,j} - \rho_{CMS} A_j$.
- UE fluctuation is determined (for the Unfolding) by the Random Cones method $\delta p_T = p_T^{RC} - \rho \pi R^2$.

b tagging using the track counting algorithm

- It uses 2D signed impact parameter significance
 $sIPs = \text{sign}(\vec{IP} \cdot \vec{P}_{\text{Jet}}) \cdot IP / \sigma_{IP}$.
- Loop over all the tracks inside the jets.
- The selected tracks should pass the quality selection.
- A jet is tagged as a b-jet if it has at least N tracks with $sIPs$ larger than a certain threshold parameter.



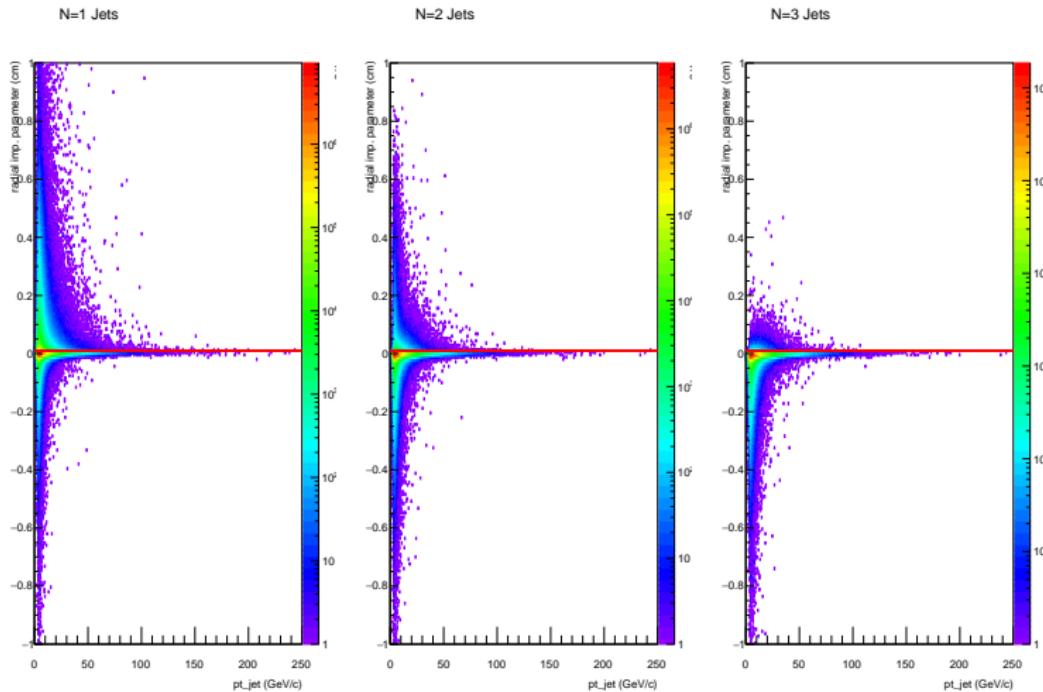
Quality tracks selection

The selected tracks inside jets should pass the quality selection:

- $p_T^{Track} > 1\text{ GeV}$.
- At least one hit in the Pixel detector SPD.
- Minimum number of ITS clusters = 3.
- Minimum number of TPC clusters = 80.
- $\chi^2/NDF < 5$.
- $IP_{XY} < 1\text{ cm}$.
- $IP_Z < 2\text{ cm}$.
- DCA between the track and the jet should be $DCA_{jet} < 0.07\text{ cm}$.
- The decay length of the b-hadron should be $L_{xy} < 10\text{ cm}$.

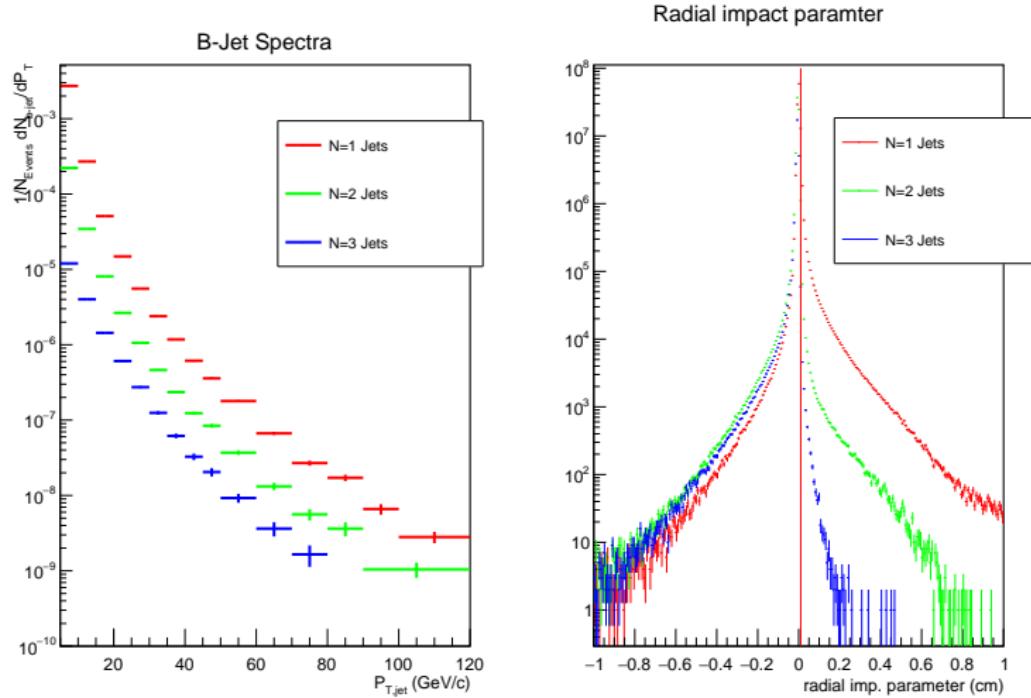
b-jet tagging

The red line is the IP threshold value (0.01cm).



b-jet tagging

The red line is the IP threshold value (0.01cm).

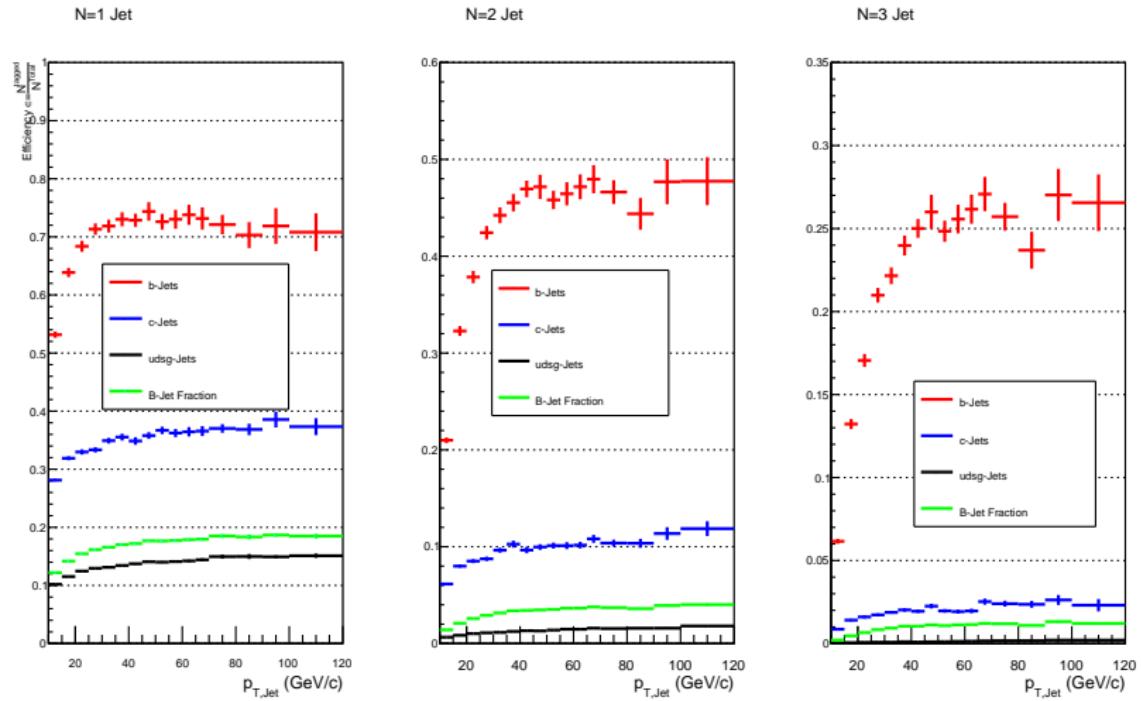


Tagging Efficiency

- The tagging efficiency, is the efficiency to tag a true b-jet as a b-jet
$$\epsilon_b(p_{T, ch.\text{jet}}^{\text{det}}) = \frac{N_b^{\text{tagged}}(p_{T, ch.\text{jet}}^{\text{det}})}{N_b^{\text{Total}}(p_{T, ch.\text{jet}}^{\text{det}})} ..$$
- The mis-tagging efficiency is the efficiency to tag a c or udsg jets as a b-jet
$$\epsilon_{c, udsg}(p_{T, ch.\text{jet}}^{\text{det}}) = \frac{N_{c, udsg}^{\text{tagged}}(p_{T, ch.\text{jet}}^{\text{det}})}{N_{c, udsg}^{\text{Total}}(p_{T, ch.\text{jet}}^{\text{det}})} ..$$

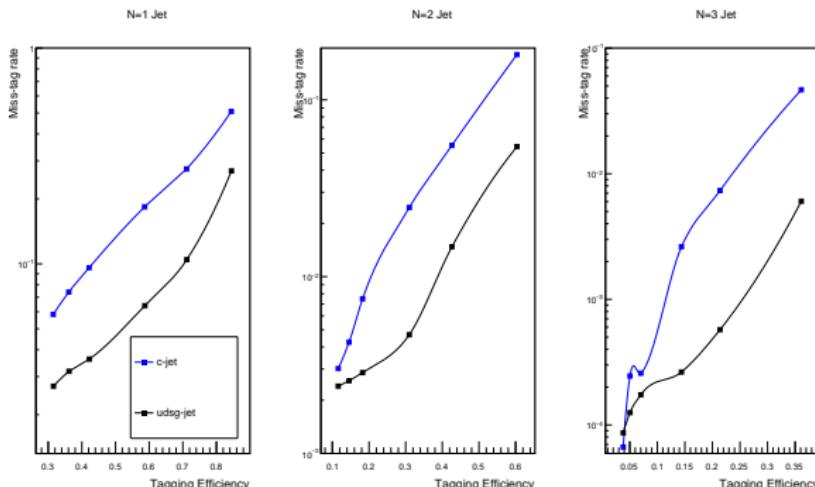
Tagging Efficiency

This tagging efficiency is extracted from the MC set *LHC14g3b*



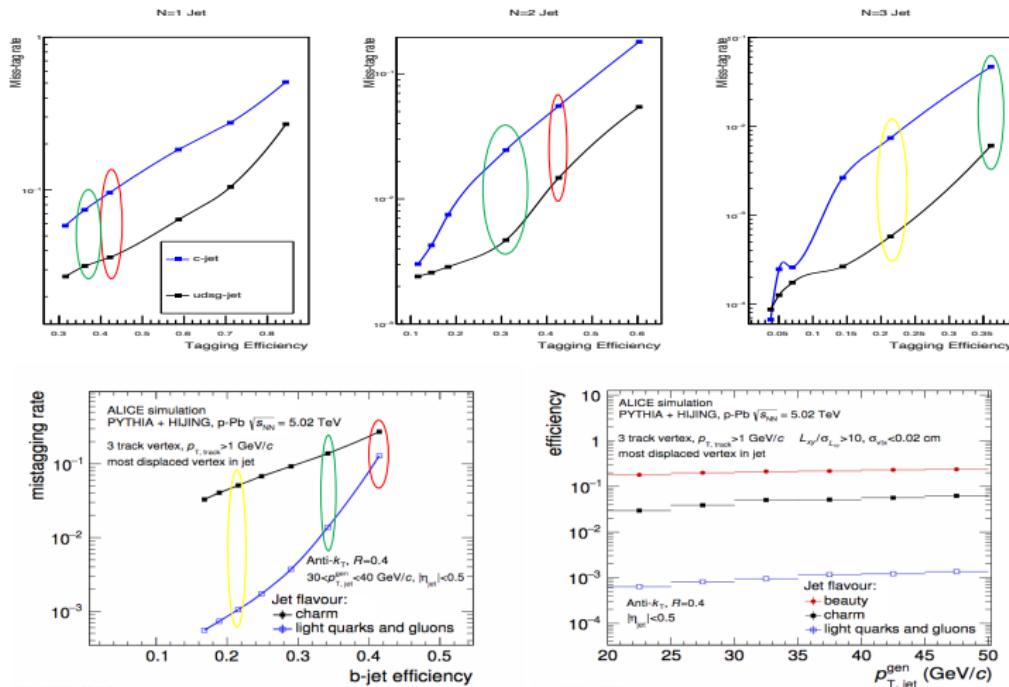
Working Point

- The tagger working point is the IP threshold that gives a high tagging efficiency and a very low miss-tag rate.
- The below plot shows the miss-tag rate Vs the tagging efficiency in jet $50 < p_T < 60 \text{ GeV}/c$.
- The threshold parameter was varied between $0.01 < IP_{Threshold} < 0.06 \text{ cm}$.



Comparison with the SV Algorithm

- The p_T range is [30, 40], and the threshold parameters L_{xy}/σ_{xy} was varied between [2, 14].



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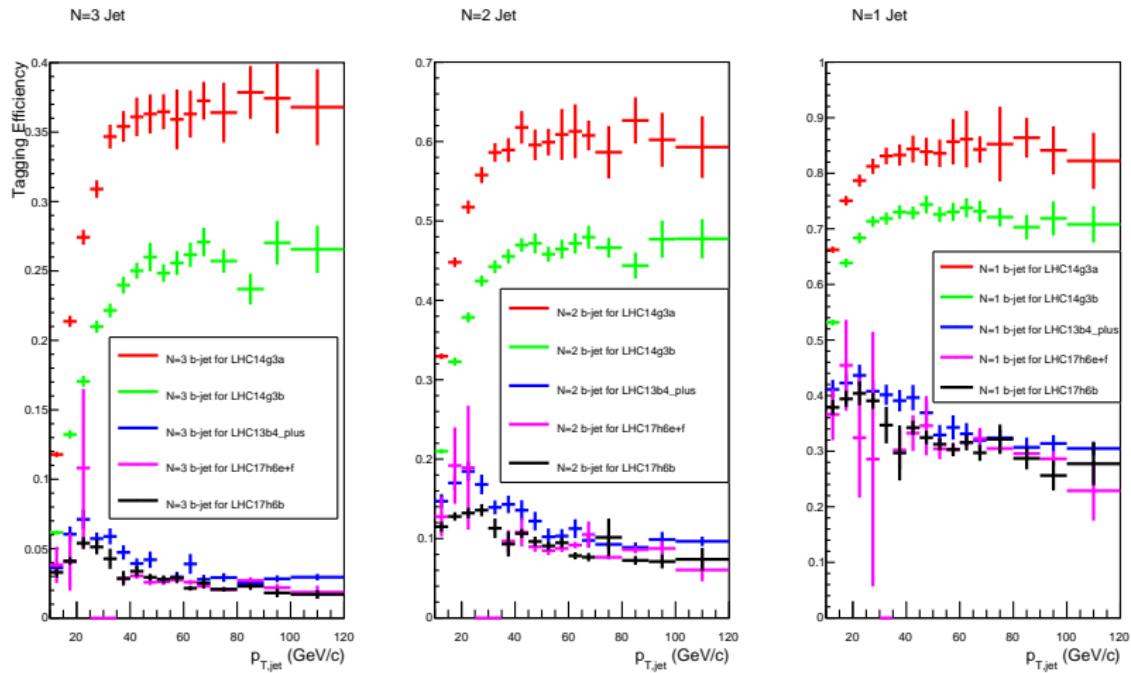
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MC dependence of Efficiency

MC sets used: *LHC14g3a*, *LHC14g3b*, *LHC13b4_plus*, *LHC17h6b, e, f*



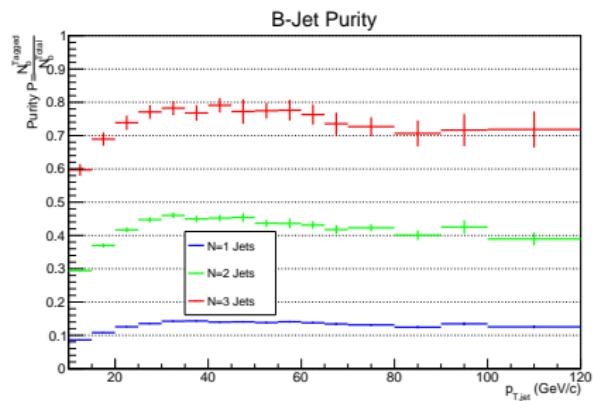
Fixing the efficiency problem

- Reweight the MC.
- Apply V^0 rejection, since K_s^0 and λ have the same properties as the B-meson (long life time, large IP, displaced vertex, ...) they should be rejected. Also reject electrons from photon conversion.
- DATA driven efficiency determination from heavy flavor decay electrons (using the p_T^{rel} method or using the system8 method).

Purity

- The Purity is extracted from MC by:

$$P(p_{T, ch. jet}^{\text{det}}) = \frac{N_{b-jets}^{\text{tagged}}(p_{T, ch. jet}^{\text{det}})}{N_{\text{total}}^{\text{tagged}}(p_{T, ch. jet}^{\text{det}})}$$

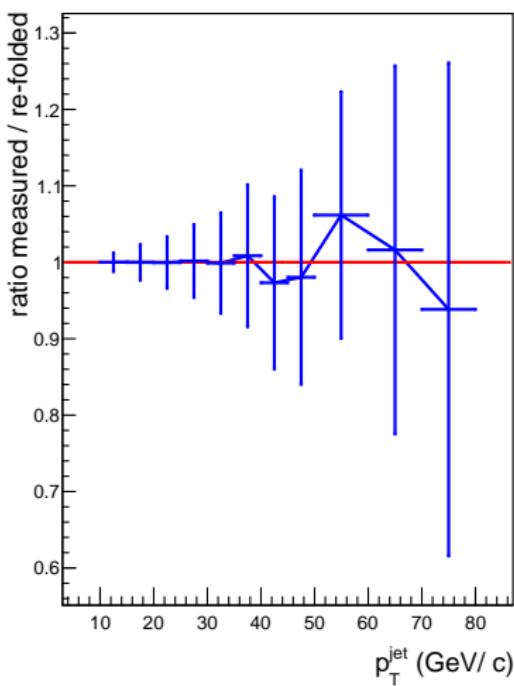
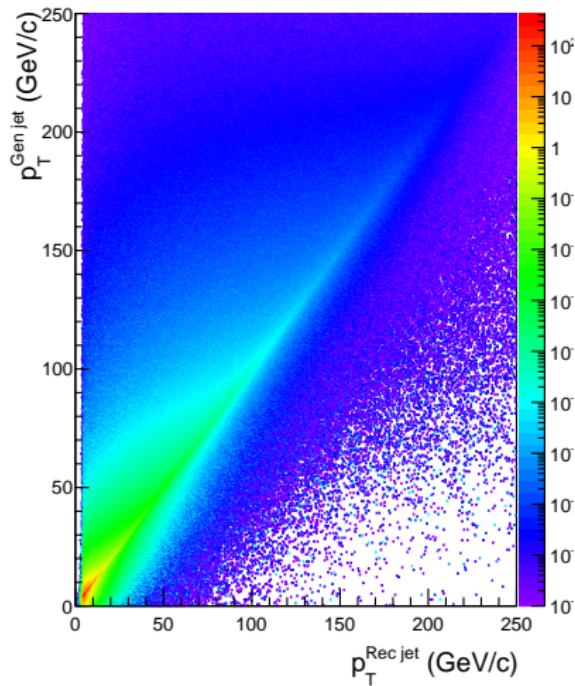


Unfolding

- The detector response matrix was taken from MC *LHC13b4_plus*.
- SVD unfolding $K_{Reg} = 9$.
- Measured range 10-80 GeV/c.
- Unfolded range 5-90 GeV/c.
- The used prior is the unfolded χ^2 spectrum.

Unfolding

Detector Response Matrix



Final Jet Spectrum

- Correct for the tagged UE subtracted spectrum:

$$\frac{1}{N} \frac{dN_{Measured,b}}{dp_T} = \frac{1}{N} \frac{1}{\epsilon_b} \cdot P \cdot \frac{dN_{tagged}}{dp_T}$$

- Unfolding and the final spectrum:

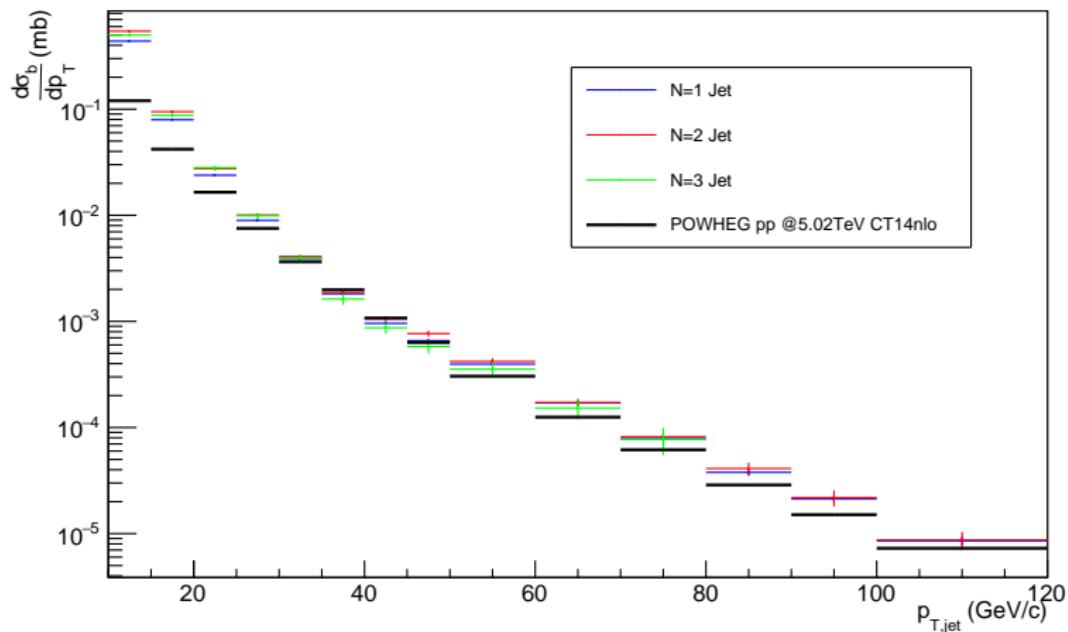
$$\frac{d\sigma_{b-jet}}{dp_T} = \frac{1}{N} \sigma_{V0} \cdot C_{Vertex} \cdot Unfolded \left(\frac{dN_{measured,b}}{dP_T} \right)$$

where C_{Vertex} is fraction of the vertex selected events

$$C_{Vertex} = 0.973661.$$

Final Jet Spectrum

b-jet Spectra



V0 Rejection

- The V0 particles like K_s^0 and λ have the same properties as the B-meson (long life time, large IP, displaced vertex, ...) so they can be miss-tagged as a b.
- So rejecting these particles may reduce the miss-tag rate, and increase the b-jet purity.
- Similar thing was done in the D0 and in ATLAS experiments.

V0 Rejection

Two approaches where tested:

- Reconstruct the V0 (using the V0 reconstruction procedure) and then reject them from the tagger.
- Reject all the V0 in the event by looking at MC info (by checking if the MC track is coming from V0).

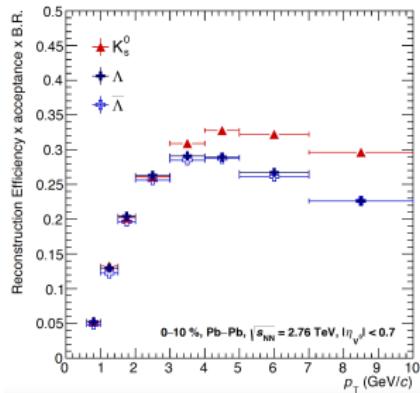
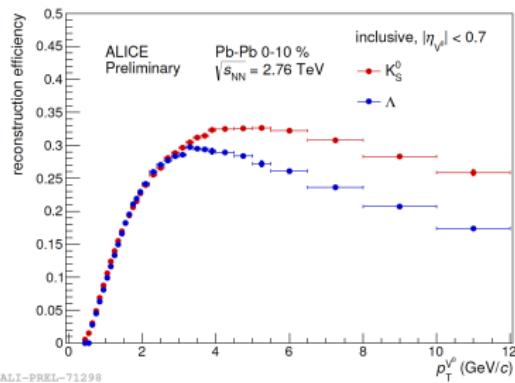
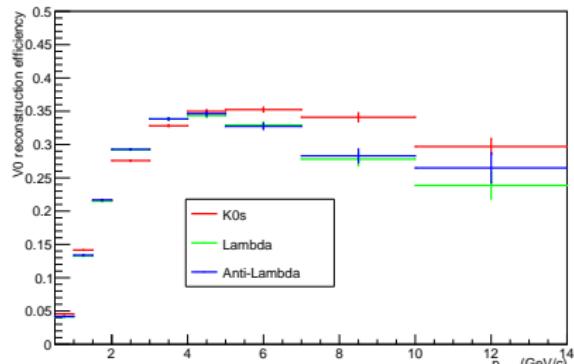
The second approach can't be used in DATA, it was used here to see the effect of rejecting all the V0.

V0 Reconstruction procedure

- The V0 particles are reconstructed using their decay most frequent channel: $K_s^0 \rightarrow \pi^+ \pi^-$, $\lambda \rightarrow p \pi^-$, $\bar{\lambda} \rightarrow \bar{p} \pi^+$.
- The invariant of the decay daughters was used.
- The V0 candidates (and the V0 daughters) were selected using some topological cuts:
 - $|\eta_{Daughters}| < 0.9$ and $|\eta_{V0}| < 0.8$.
 - $DCA_{Daughters}$ to primary vertex $\geq 0.1\text{cm}$.
 - DCA between V0 daughters $\leq 1\sigma_{TPC}$.
 - $|\Delta \frac{dE}{dx}| < 3\sigma_{\frac{dE}{dx}}^{TPC}$ for protons with $p_T < 1\text{GeV}$.
 - Reject Kink daughters.
 - Offline V0 were selected.
 - Radius of the decay vertex $5 < R_{decay} < 100\text{cm}$.
 - Cosine of pointing angle (CPA) ≤ 0.998 .
 - Transverse proper lifetime $\leq 5\tau$.
 - Armenteros Podolanski cut (only for K_s^0) $q_{Arm.}^T \geq 0.2|\alpha|$.

V0 Reconstruction efficiency

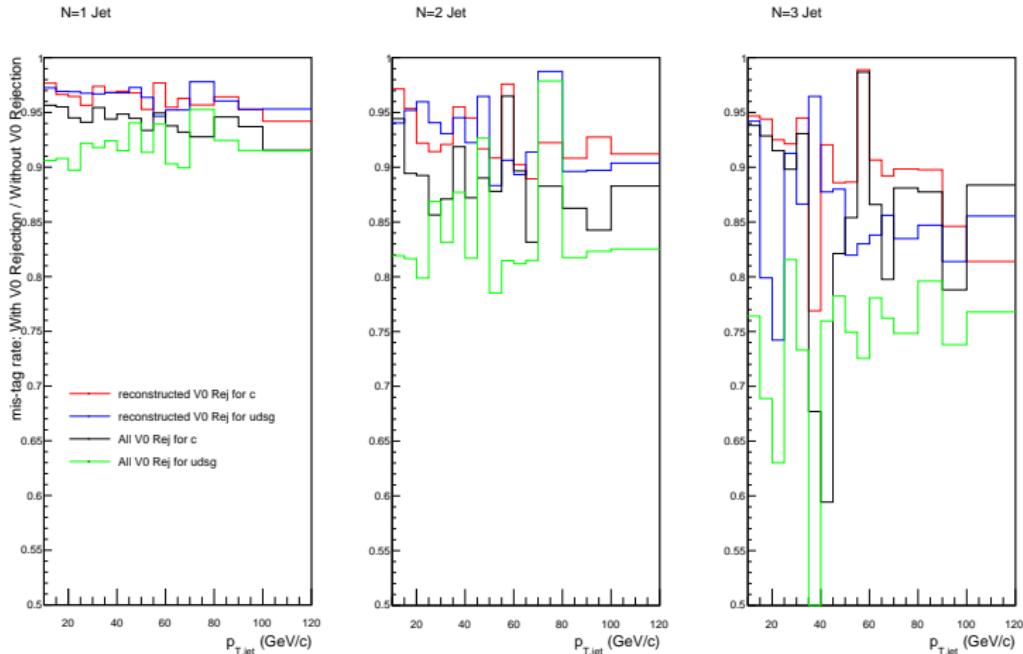
V0 Reconstruction Efficiency



Electrons from photon conversion

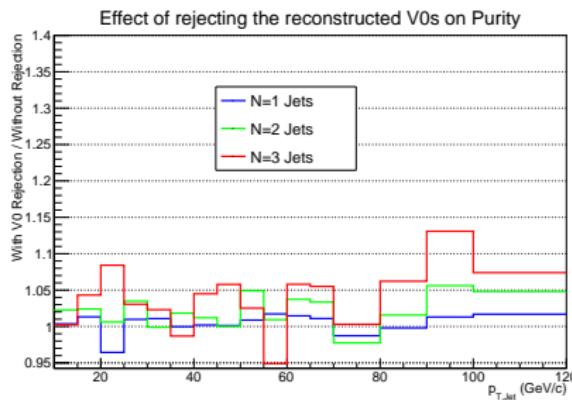
- Electrons from photon conversion have similar properties as b-decays electrons. So they should be rejected.
- The delta AOD *AliAODGammaConversion.root* was used.
- The photon candidates were selected using some topological cuts (taken from PWG-GA):
 - Offline V0 were selected.
 - $|\eta_{e_e}| < 0.9$.
 - Radius of the decay vertex $0 < R_{decay} < 180\text{cm}$.
 - TPC cross rows over findable cluster > 0.6 .
 - $-3 < |\Delta \frac{dE_e}{dx}| < 5\sigma_{\frac{dE}{dx}}$.
 - Armenteros Podolanski cut $q_{Arm.,max}^T \leq 0.05$.
 - Track $\chi^2/NDF < 30$.
 - Cosine of pointing angle (CPA) ≤ 0.85 .
 - $\psi_{pair,max} < 0.05$.

Effect on the miss-tag rate

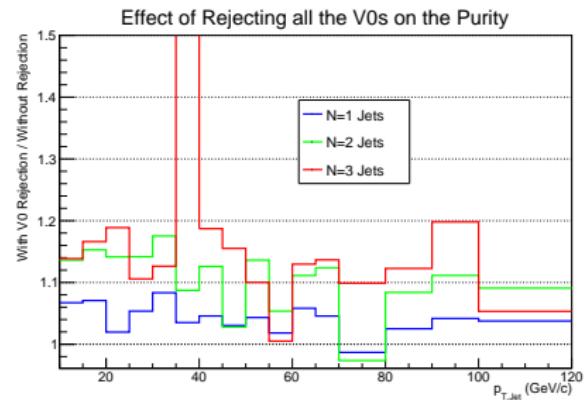


The effect is reducing the miss-tag for $N=1$ by $\approx 3\%$, for $N=2$ by $\approx 5\%$ and for $N=3$ by $5 - 10\%$.

Effect on the purity



The effect is enhancing the purity for $N=1$ by $\approx 1.5\%$, for $N=2$ by $\approx 3\%$ and for $N=3$ by 5% .



The effect is enhancing the purity for $N=1$ by $\approx 8\%$, for $N=2$ by $\approx 12\%$ and for $N=3$ by 12% .

Work to be done

To do:

- Reweight the MC sample.
- DATA driven efficiency calculation using the p_T^{Rel} of the electrons (I am writing the code now).
- Extract the pp reference for the R_{pPb} .
- Systematic uncertainty assessment.
- Find the R_{pPb}^{b-jet} .

Thank you for listening.