Influence of background subtraction on jet reconstruction in heavy-ion collisions

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Introduction

In order to get information about the characteristics of the medium produced in high-energy heavy-ion collisions using reconstructed jets, the effect of background subtraction has to be well under control. In this study, we address this issue by embedding jets in a heavy-ion event and then considering the influence of the subtraction method and of different backgrounds, characterized by different mean values and fluctuations, on the momentum imbalance and azimuthal distributions of the two leading jets in each event. Using a flexible toy model to simulate the background, two subtraction methods - an area-based one implemented by FastJet, and a pedestal subtraction technique using the information in calorimetric cells resembling the one employed by CMS - are examined. We also consider the effect of quenching using the Q-PYTHIA Monte Carlo, and some additional background characteristics like elliptic flow. Our aim is to understand the possible differences between the results using the two reconstruction techniques, and how they react to the mentioned modifications of the signal and background. Besides, we compare the results of the Q-PYTHIA Monte Carlo with the dijet observables and missing transverse momentum.

Background Toy Model

In order to study the influence of the background subtraction method on the different jet observables, we use a toy model for generating particles uniformly in pseudorapidity η and azimuthal angle ϕ, with a distribution in transverse momentum p_T which smoothly matches a thermal-like spectrum to a power law.

$$f(p_T) \propto \begin{cases} e^{-p_T/T}, & p_T \le \alpha T, \\ e^{-\alpha}\left(\frac{\alpha T}{p_T}\right)^{\alpha}, & p_T > \alpha T. \end{cases}$$

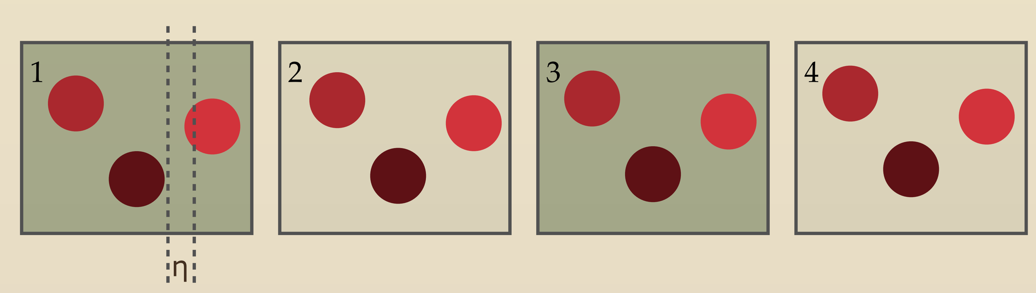
Parameters:
$\alpha = 6$

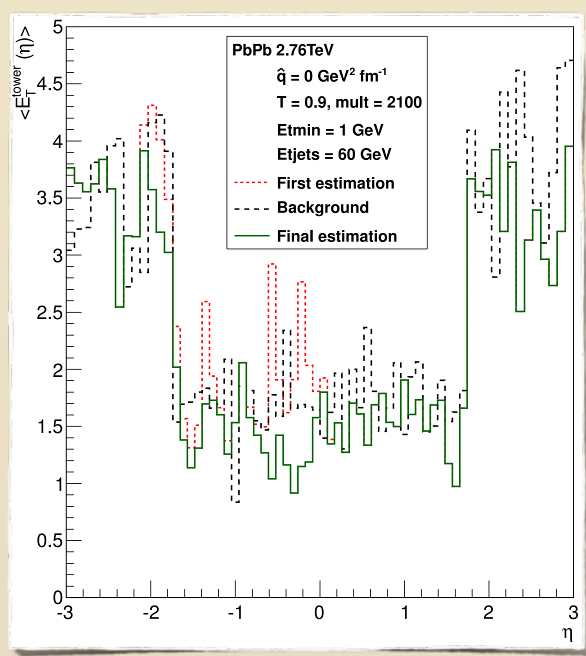
T (GeV)	ρ (GeV/area)	σ (GeV/area)
0.7	137.0	7.70
0.9	212.6	10.74
1.2	325.5	15.14

Jet Subtraction and Reconstruction

Two subtraction techniques:

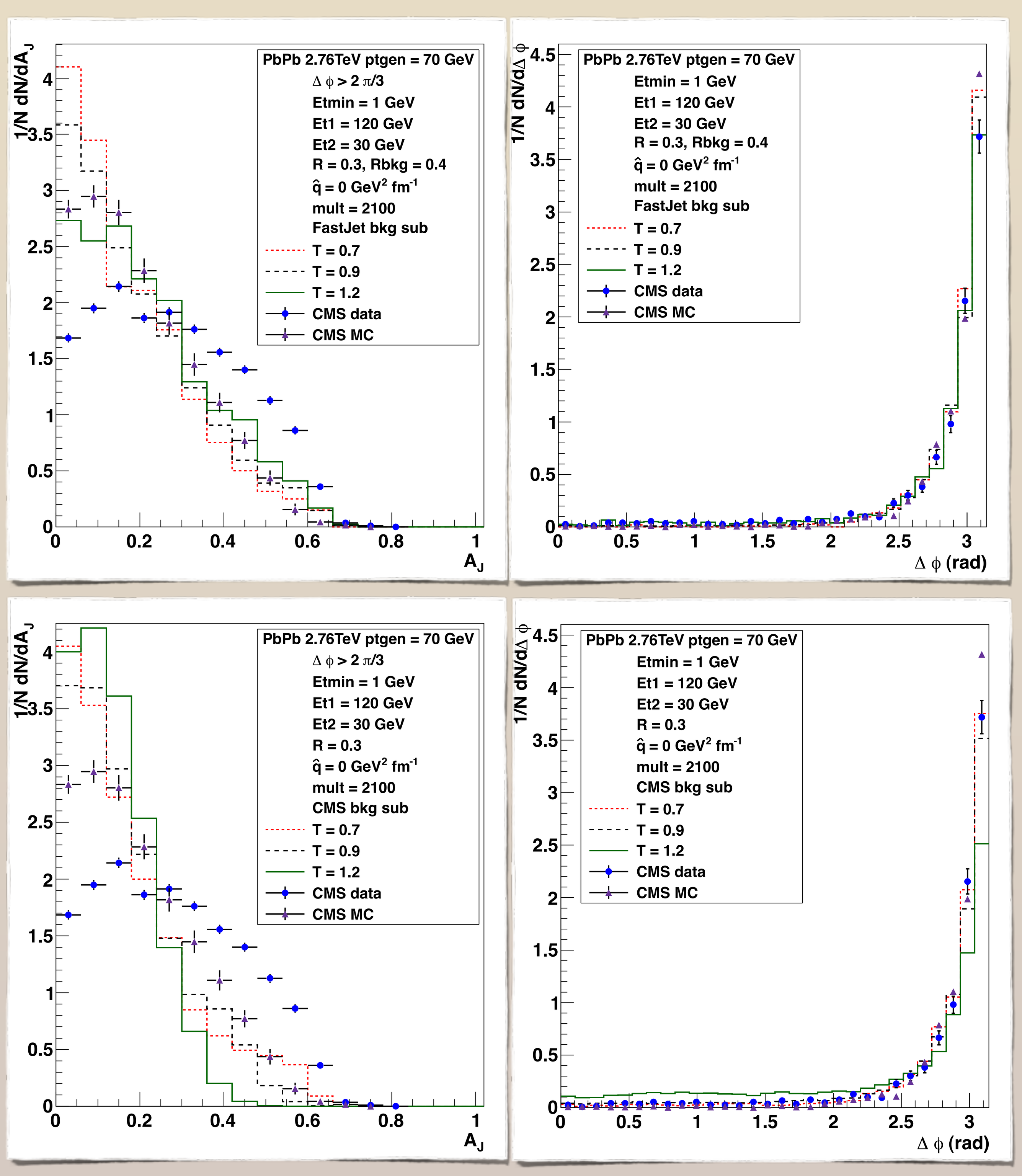
- FastJet (k_t-algorithm with R = 0.4)
- CMS-like (variant of "noise/pedestal" method)
  1. Estimation of background parameters in η slices
  2. Jets found from the subtracted cells ($E_T^* = E_T - \langle E_T(\eta)\rangle - \sigma_T(\eta)$)
  3. New estimation excluding previous list of jets with $E_T > E_{Tjets}$
  4. Jets found from the new subtracted cells
  - Dependency with the cut E_{Tjets}





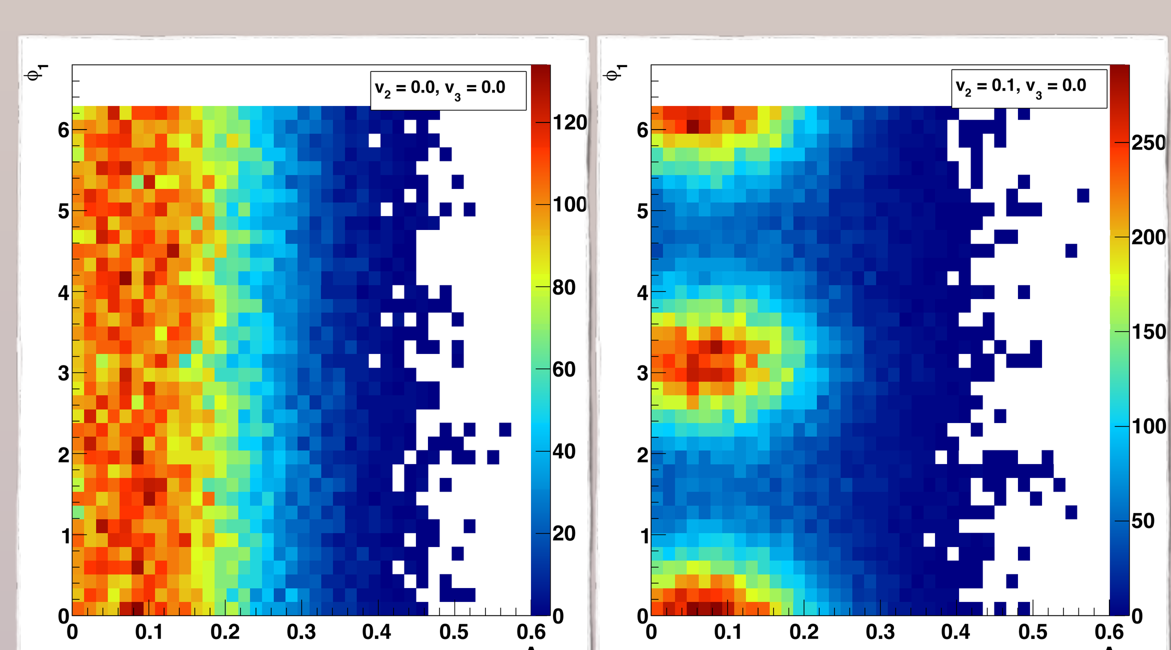
FastJet vs. CMS-like Jet Subtraction

Influence of the T parameter



Background parameters affect the dijet *asymmetry* differently depending on the background subtraction that is used. Dijet *azimuthal* correlation presents small deviations with respect to the background main characteristics when using the FastJet, but for the CMS-like subtraction the deviation is larger, contrary to what happens with *momentum* imbalance.

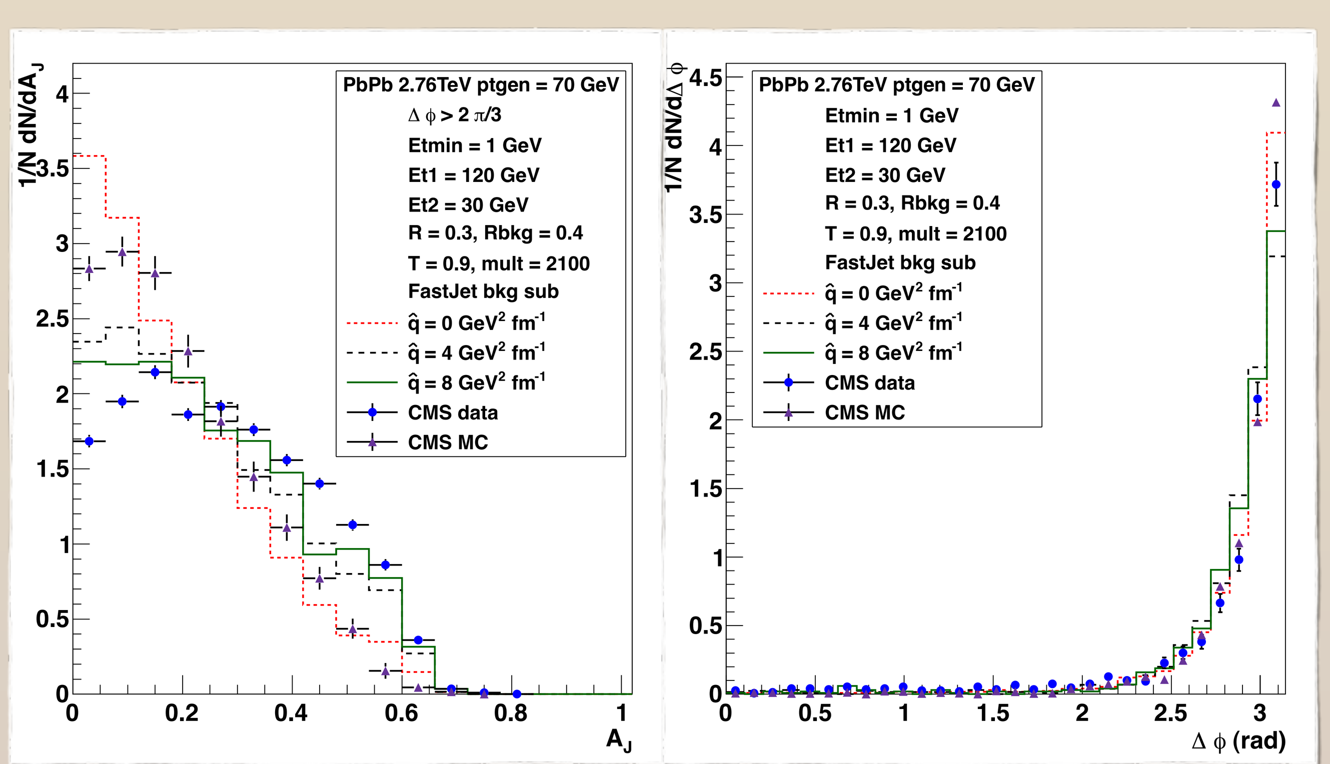
Influence of Flow



Flow is introduced by modulating the particle distribution in ϕ with a component v_2 and v_3. A strong correlation between the dijet asymmetry and the leading jet azimuthal distribution is found. This effect is stronger for the CMS-like method.

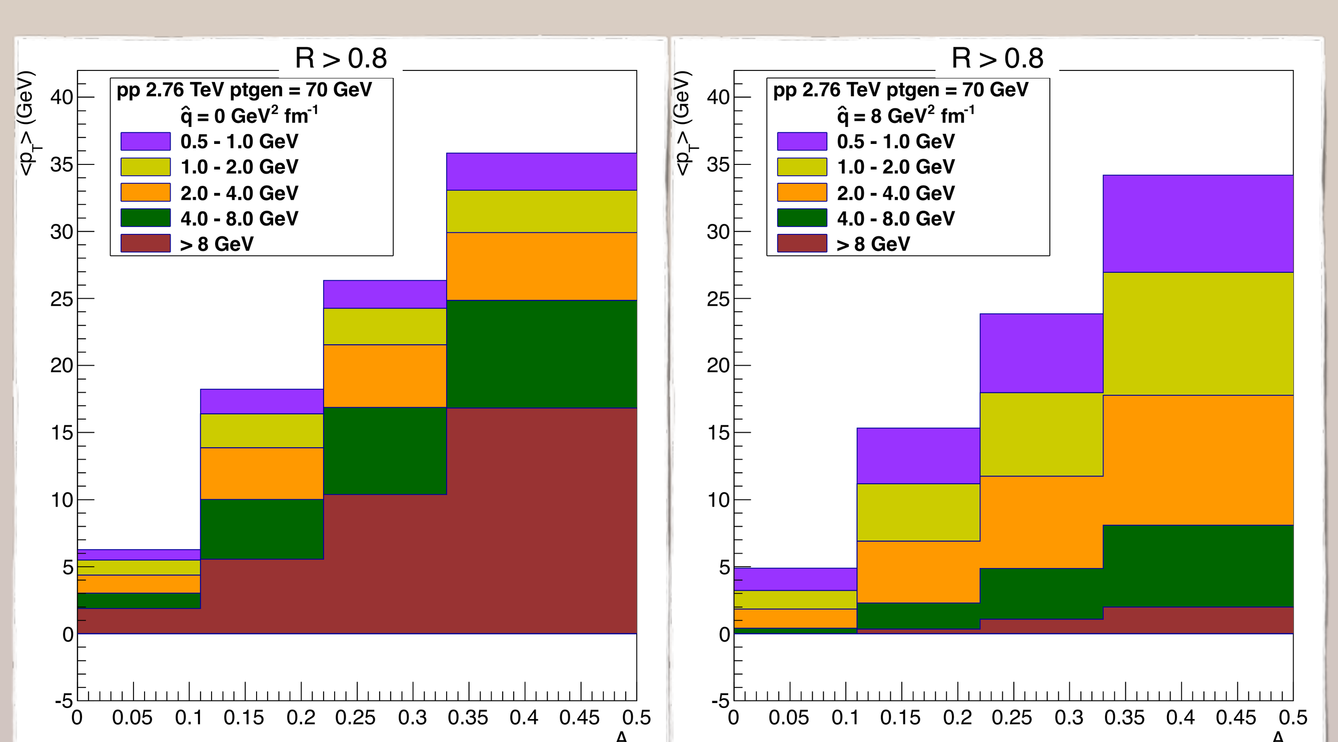
Jet Quenching with Q-PYTHIA

With Background: Dijet Observables



Good compromise between the increasing dijet asymmetry and the dijet azimuthal correlation with Q-PYTHIA.

Without Background: Missing p_T



At the same time, a reasonable description of the transverse momentum distribution of the event at all angles is also achieved, without a compelling need of additional large angle emission mechanisms.

Conclusions

A comparison between the two subtraction methods is presented: using FastJet, where the estimation of the background parameters is made at the jet level, and using a CMS-like method, where the background estimation is made at the particle level. It was shown that they present different sensitivities to the background main characteristics and as a consequence, the dijet observables will depend on the background subtraction that is used. The jet quenching phenomena was investigated by changing the quenching parameter of Q-PYTHIA up to 8 GeV^{2}fm^{-1}. A reasonable description of the main features of the dijet observables and missing transverse momentum is achieved without the need of additional large angle mechanisms.

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