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

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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 $\eta$ and azimuthal angle $\phi$, with a distribution in transverse momentum $p_T$ which smoothly matches a thermal-like spectrum to a power law.

$$f(p_T) = \frac{e^{p_T/T}}{e^{\eta/T} + 0.5}, \quad p_T < 0.5$$

Parameters: $T = 6$ GeV, $\eta = 0$ GeV, $p_T > 0.5$

<table>
<thead>
<tr>
<th>$T$ (GeV)</th>
<th>$\eta$ (GeV/area)</th>
<th>$p_T$ (GeV/area)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.7</td>
<td>137.0</td>
<td>7.70</td>
</tr>
<tr>
<td>1.0</td>
<td>222.5</td>
<td>18.74</td>
</tr>
<tr>
<td>1.2</td>
<td>325.5</td>
<td>15.14</td>
</tr>
</tbody>
</table>

### FastJet vs. CMS-like Jet Subtraction

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 $\eta$ 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 Subtraction and Reconstruction

Two subtraction techniques:
- FastJet ($x$-algorithm with $R = 0.4$)
- CMS-like (variant of “noise/pedestal” method)

1. Parameters of background parameters in $\eta$ slices
2. Jets found from the subtracted cells ($E_t > E_{t\text{cut}}$)
3. Jets found from the new subtracted cells by the CMS-like method
4. Jet observables with the cut $E_{t\text{cut}}$

### Jet Quenching with Q-PYTHIA

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

### Without Background: Dijet Observables

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 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.