Background Subtraction of Heavy-Flavour Jets in Pb-Pb collisions with ALICE at the LHC

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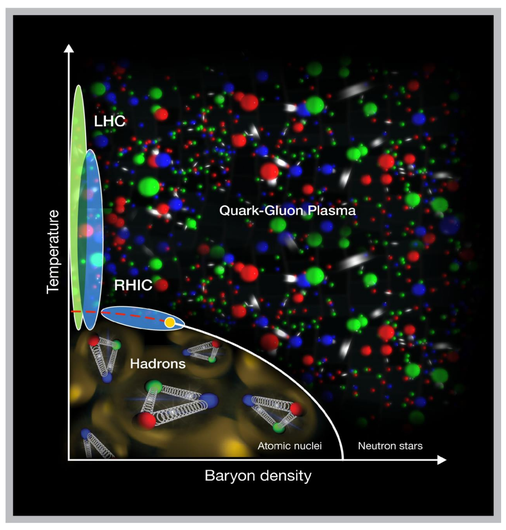
1. Quark Gluon Plasma:

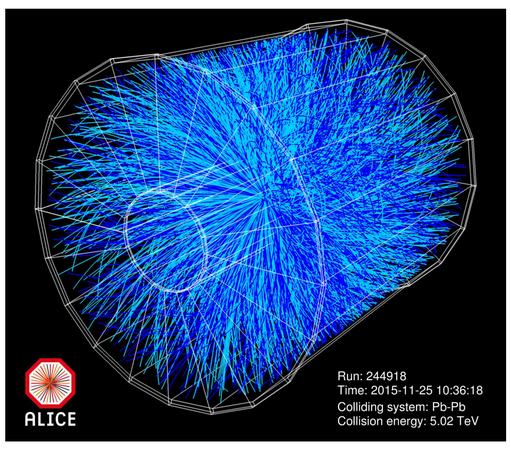
- One of the goals at ALICE is to study the Quantum Chromodynamics(QCD) phase transition from ordinary matter to a deconfined state of quarks and gluons – the Quark Gluon Plasma (QGP).
- The early Universe was in this state around a few microseconds after the Big Bang.



- The QGP can be experimentally produced in the high energy and high density conditions of Pb-Pb collisions at the LHC.

3. Heavy-Ion Background:

- Due to the large number of constituents in a Pb ion, thousands of particles are produced in Pb-Pb collisions.
- Therefore the measured jets will contain a large amount of background which is unrelated to the hard scattered parton.
- This background must be removed to access the jet signal.



4. The Constituent Subtraction method:

- First we estimate the average background density in the event.
- Then we introduce ghost particles with a p_T corresponding to the average background p_T density.
- For each pair of real(i) and ghost(k) particle we compute the quantity $D_{i,k} = p_{T,i}^{\alpha} \cdot \Delta R_{i,k}$.
- Next we choose the pair with the lowest $D_{i,k}$ value and perform the following subtraction:

(a) If $p_{T,i} \geq p_{Tk}^{g}$ we replace $p_{T,i} \rightarrow p_{T,i} - p_{Tk}^{g}$ and remove the ghost particle, i.e. $p_{Tk}^{g} \rightarrow 0$,

(b) Otherwise we remove the Real particle, i.e. $p_{T,i} \rightarrow 0$ and replace $p_{Tk}^{g} \rightarrow p_{Tk}^{g} - p_{T,i}$.

- We repeat this process until we are left with no ghost particles.
- This removes the average background from each event at the particle level.

2. Heavy-Flavour Jets:

- Jets are collimated bunches of hadrons originating from the fragmentation of partons produced in hard scattering processes.
- Because jets are produced early in Heavy-ion collisions they traverse through the QGP and lose energy as they interact with the medium. This energy loss is a very important tool in understanding the properties of the QGP.
- Heavy-Flavour jets are initiated by a beauty or charm quark which are scattered in the initial stages of the collisions. Due to the large mass of these quarks their production is well described down to low pT, making them an ideal probe with which to study mass dependent effects in the QGP at low pT.

5. Special Considerations for Heavy-Flavour Jets:

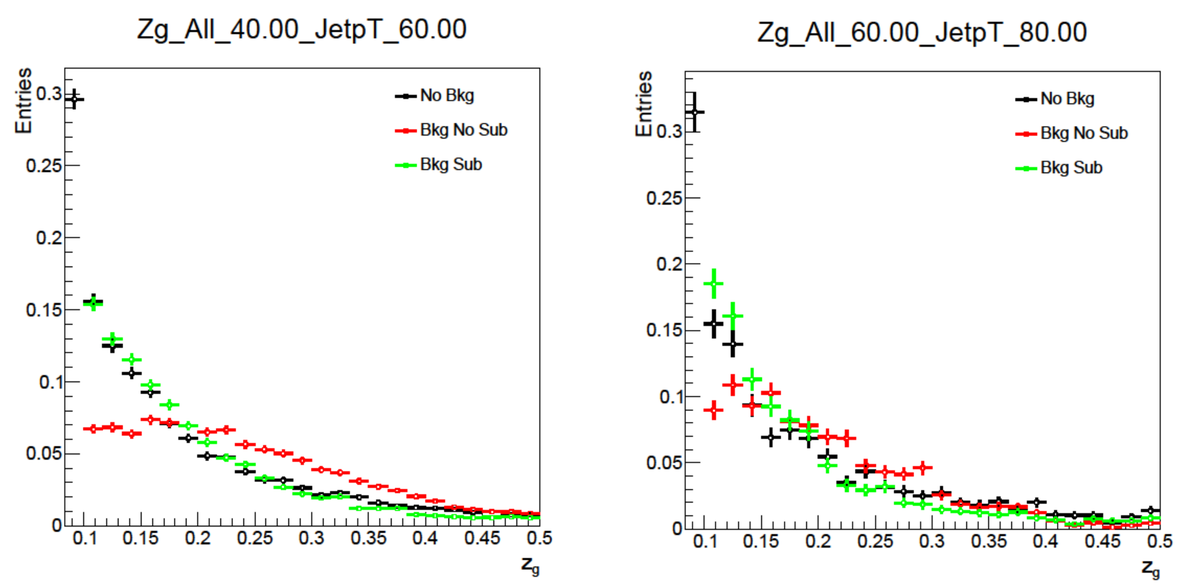
- In Non-Flavour tagged jets it is not possible to know if a particle is from the jet itself or from the background. However, in Heavy-Flavour jets the Heavy-Flavour hadron must be a jet particle since it is too heavy to be created as a background particle.
- This requires an adaptation of the subtraction technique in order to fully preserve the Heavy-Flavour hadron during the subtraction.

6. Plots:

- First we generate pythia events, which are without background -> No Background
- Then we embed the pythia events into a Thermal Background -> With background without subtraction
- Then we perform the background subtraction -> With background with subtraction

➢ Here we show the first studies of Background Subtraction of charm quark initiated jets which have been tagged with a D_0 meson

➢ These are an example of a substructure variable measured for 3 the cases:



➢ Background subtraction algorithms perform well for certain jet substructure observables, by bringing the background subtracted distributions back to the no-background case.

Next: Investigate the impact of the Subtraction on the Heavy-Flavour hadron in the jet!

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