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Jet-Medium Interactions in Pb-Pb Collisions

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Abstract

Previous experimental measurements from nuclear collisions have indicated modifications of jets by interaction with the medium created in the collision. Observables from particle correlations in the ALICE detector continue to provide access to key properties of the hot deconfined nuclear matter. New results from two- and three-particle number and transverse momentum correlations are discussed. Specifically, correlation function properties are characterized as a function of transverse momentum and centrality and for different charge combinations. Fourier decompositions are performed, identified particle ratios are studied in the jet-like peak and in the bulk, and the away-side shape is looked at in three-particle correlations.

1. Introduction

One method of studying the hot and dense matter created in heavy-ion collisions is through trigger particle correlations. In these correlations, the requirement of an intermediate or high-p_T trigger particle biases the near-side jet to be nearer to the surface reducing its path length in the medium. This may also bias the away-side jet towards longer path lengths with potential for significant medium interaction. The near-side jet-like peak is studied by looking at the proton to pion ratio in the peak. This is interesting to look at because the inclusive baryon/meson ratio is significantly enhanced in central heavy-ion collisions relative to pp collisions. The away-side jet peak shape is studied by looking at three-particle correlations to look for medium modification. Also, the medium is studied in untriggered correlations and flow coefficients are extracted.

2. Proton to Pion Ratio in the Near-Side Peak

Identified particle ratios have shown an enhanced baryon to meson ratios in central heavy-ion collisions relative to peripheral collisions and pp collisions at intermediate p_T [1, 2, 3]. By studying the ratio in the near-side peak in triggered two-particle correlations, it can be determined whether this observable in the jet is enhanced at intermediate p_T as the bulk is in central heavy-ion collisions or whether the ratio is more like the that in pp collisions. Trigger particles of $5 < p_{T,Trigger} < 10$ GeV/c are correlated with lower p_T associated particles. Associated particles are identified through their energy loss in the Time Projection Chamber and utilizing their time of flight in the Time Of Flight detector. Associated particle yields of the indentified protons and

[1]A list of members of the ALICE Collaboration and acknowledgments can be found at the end of this issue.

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pions, are calculated in two regions, both with $|\Delta\phi| < 0.52$. The near-side peak region is selected with $|\Delta\eta| < 0.4$ and the bulk region with $0.6 < |\Delta\eta| < 1.5$. To obtain the yield in the jet peak, the bulk yield, normalized to the same angular area, is subtracted from the peak region yield for each particle specie. Since the regions have the same azimuthal angle, the both the flow component and the uncorrelated background are subtracted with this technique. In Fig. 1, the ratio in the bulk region is shown to agree with the inclusive ratio. However, the ratio in the near-side jet-like peak does not show the enhancement seen in the bulk region, but agrees with the ratio from Pythia and therefore agrees with vacuum fragmentation.

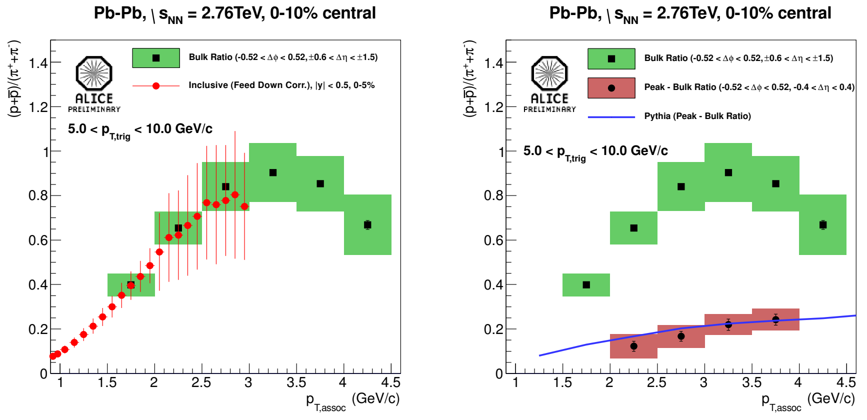

Figure 1: Proton to pion ratio in the bulk and jet-like peak. Left: Bulk, black squares, and the ratio from inclusive events, red circles. Right: Bulk, black squares, peak, black circles, and the ratio from Pythia v6.4.2.1 default tune, red line.

3. Three-Particle Azimuthal Correlations

Three-particle azimuthal correlations are interesting for studying the away-side jet. Three-particle correlations can distinguish between physics that gives away-side broadening to both sides in a single event, such as conical emission from a Mach-cone or Čerenkov gluon radiation, from broadening to one side in a single event such as k_T broadening and jet deflection. At RHIC indications of conical events were seen in these correlations[4].

A trigger particle of $3 < p_{\mathrm{T,Trigger}} < 4$ GeV/c is correlated with two associated particles of $1 < p_{\mathrm{T,Associated}} < 2$ GeV/c in azimuth. Backgrounds have subtracted due to the two-particle correlations, three-particle flow, and the flow correlation of one particle to the jet-like (non-flow) correlation of the other two. Two-particle backgrounds are constructed using two-particles from the same event and a third particle from a mixed event distribution. The average of the two-particle and four-particle flow measurements are used to obtain the three-particle flow and the jet-like X flow background terms[5, 6] and both measurements are included in the systematic errors. The background subtracted two-particle and three-particle correlations are assumed to be zero at the minimum to obtain the normalization of mixed event backgrounds.

Figure 2 shows the correlations and off-diagonal projections for two centrality bins. The away-side is elongated along the diagonal, $\Delta\phi_1 = \Delta\phi_2$ axis. This elongation can come from k_T broadening, deflected jets or other physics. The 40-50% bin is consistent with the away-side shape being entirely from k_T broadening. However, in the central bin, there are, in addition, significant off-diagonal structures.

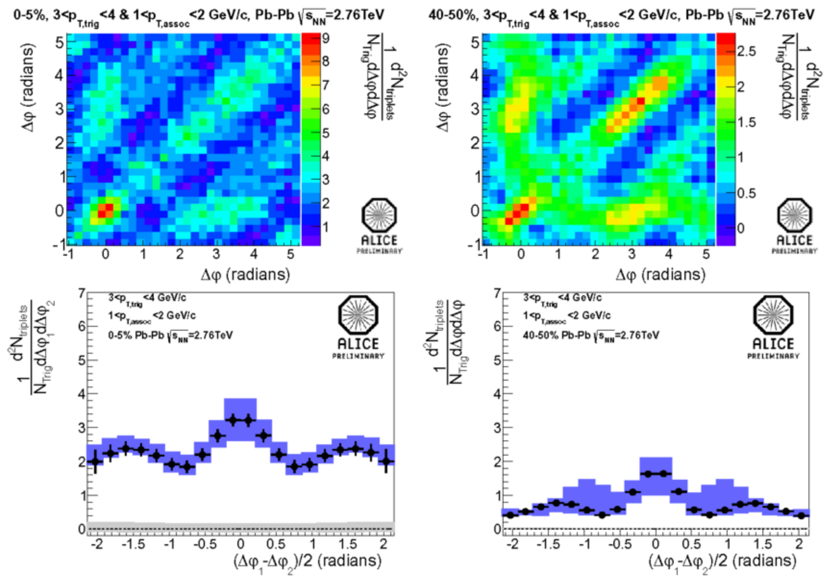

Figure 2: Top: Background subtracted three-particle correlations for 0-5% and 40-50% centrality Pb-Pb collisions, right two panels, for $3 < p_{\mathrm{T,Trigger}} < 4$ and $1 < p_{\mathrm{T,Associated}} < 2$ GeV/c. Bottom: Off-diagonal, along $(\Delta\phi_1 + \Delta\phi_2)/2 = \pi$ axis, projections of the plots above. Blue bands show the uncorrelated systematic errors. Correlated systematic errors are shown with the grey band at zero.

4. Fourier Decomposition of Number and Momentum Correlations

Two-particle correlations are performed in azimuth and pseudorapidity for different charge combinations (+,+), (+,-), and (-,-) from all pairs of low-p_{T} particles. The Fourier components, v_n were extracted from the correlations. As can be seen in Fig. 3, the directed flow, v_1, shows dependence both on the $\Delta\eta$ region and on the charge combination. A larger v_1 is seen for smaller $\Delta\eta$ and for like-sign pairs. For v_2, v_3, and v_4, not shown here, there is no significant dependence on the charge or the $\Delta\eta$ region. The results of the directed flow from $\Delta p_{\mathrm{T}} - \Delta p_{\mathrm{T}}$ correlations are also shown in Fig. 3. In $\Delta p_{\mathrm{T}} - \Delta p_{\mathrm{T}}$ correlations, no significant difference is seen for the different charge combinations or the $\Delta\eta$ region. There are also no significant differences seen in the $\Delta p_{\mathrm{T}} - \Delta p_{\mathrm{T}}$ correlations for higher orders of flow, not shown here. The dependence of just the directed flow on the charge combination and the $\Delta\eta$ region in the number correlation is likely an effect of momentum conservation.

5. Conclusions

The near-side jet was studied by looking at the proton to pion ratio in the near-side jet-like correlation peak. In central Pb-Pb collisions, the ratio in the peak was found to be consistent with the ratio in Pythia. The away-side shape was studied though three-particle correlations. In 40-50% collisions, it was found to be consistent with k_T broadened di-jets while in central Pb-Pb collisions potential non-di-jet structures are seen. The bulk was studied by determining the flow from low-p_{T} two-particle correlations. Directed flow showed both pair charge and $\Delta\eta$

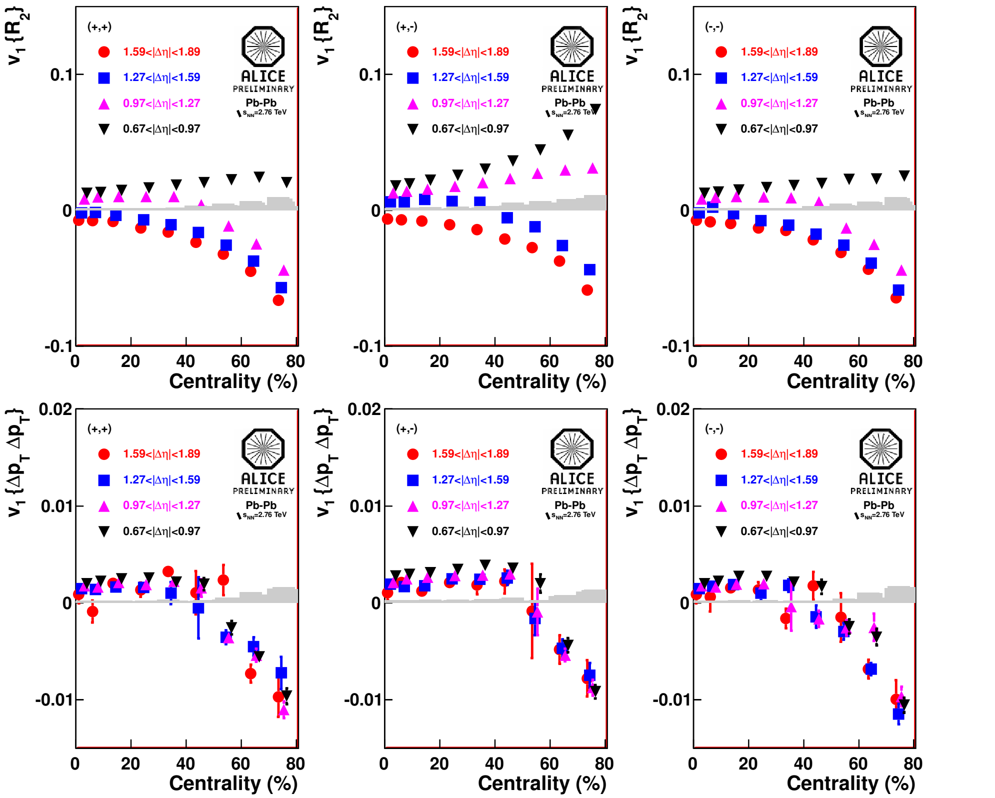

Figure 3: Directed flow from two-particle correlations with $0.2 < p_T < 2$ GeV/c for different change combinations and different relative pseudorapidity regions as a function of centrality in Pb-Pb collisions. Top: From number correlations, $v_1\{R_2\}$. Bottom: From $\Delta p_T - \Delta p_T$ correlations, $v_1\{\Delta p_T \Delta p_T\}$.

dependence which were not present in the higher orders of flow from the flow extracted from number correlations but not from $\Delta p_T - \Delta p_T$ correlations.

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