Supplement to Di-Jet Imbalance Measurements in Au+Au and p+p collisions at $\sqrt{s_{NN}} = 200$ GeV at STAR

STAR Collaboration
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I. SCOPE

In the Letter, the A_J distributions in p+p HT and Au+Au HT are compared at the detector level via embedding p+p HT events into Au+Au minimum bias (i. e., without a high tower trigger) events with a 0-20% centrality requirement identical to the HT data (p+p HT $\oplus$ Au+Au MB). The different tracking performance in the higher occupancy Au+Au environment is accounted for during embedding. In this supplement, we want to provide relevant information concerning detector effects and influence of detector background fluctuations on Jet Energy Resolution and Scale, in order to allow interested parties to fold an ideal vacuum jet, for example the output of an event generator, to the environment in the STAR detector. Note that this treatment differs from STAR's approach to pure p+p analyses, see e. g. Ref. [1].

In Sections II and III we present the Jet Energy Resolution and Scale uncertainty induced by detector performance, determined using a GEANT3 simulation of STAR. In Section IV, the influence of the heavy-ion background on the embedded p+p sample is discussed.

II. DETECTOR RESPONSE

To assess the response of the STAR detector, a PYTHIA 6.410 [2] simulation with CTEQ5L pdfs [3] at $\sqrt{s}$=200 GeV was conducted. The result of the analysis on the particle (generator) level was compared to the result after a full simulation of the STAR detector in GEANT3 [4], taking into account the lower tracking efficiency in central heavy-ion events. Figure 1 shows the correspondence between particle level jet p_T^{Part} and detector level jet p_T^{Det}. Scale factors from this Figure can be used to emulate the detector response to generated p+p events. The RMS shown as vertical error bars represents the jet resolution.

In comparison to Figure 2 (b) in Ref. [5], we note that the significantly more faithful response is mainly due to the 100% hadronic correction, and the main reason for its adoption compared to the reference which applied no correction at the detector level, or to other schemes using smaller correction amounts.

III. JET ENERGY SCALE UNCERTAINTY

We calculate the the relative p_T^{Det} uncertainty at the detector level by combining the uncertainties on BEMC measurements (gain calibration, efficiency) and TPC measurements (tracking efficiency, momentum resolution, hadronic correction) according to the neutral energy fraction in reconstructed jets [5]. We find a total uncertainty on the jet energy scale of 5%, same as in Ref. [6] (for charged jets), and essentially independent of constituent cuts, p_T, and resolution parameter R. This value is slightly higher than 4.1% in Ref. [5] due mainly to the higher tracking efficiency uncertainty in central Heavy Ion collisions, which was also applied in a Monte Carlo manner to p+p events in the analysis.

IV. EFFECTS OF THE HEAVY ION BACKGROUND

In the Letter, the p_T of matched jets with constituents above 0.2 GeV/c is corrected for the average background level using $p_T = p_T^{\text{jet,rec}} - \rho A^{\text{jet}}$, where A^{jet} is the jet area. The event-by-event background energy density ρ is determined as the median of $p_T^{\text{jet,rec}}/A^{\text{jet}}$ of all but the two leading jets, using the k_T algorithm with the same resolution parameter R as in the nominal jet reconstruction [7]. When only particles with $p_T > 2$ GeV/c are considered, the median background energy density is 0, and no pedestal subtraction is necessary. The remaining effect of ρ fluctuations is not corrected for in the analysis, instead comparison between Au+Au and the p+p baseline is carried out at the detector level by embedding p+p into 0-20% central Au+Au MB.

In this Section, we provide the means to apply the effect of these background fluctuations on p+p jets, provided they have already been distorted to account for STAR detector conditions as described in Section II. To this end, we evaluated the p_T smear-

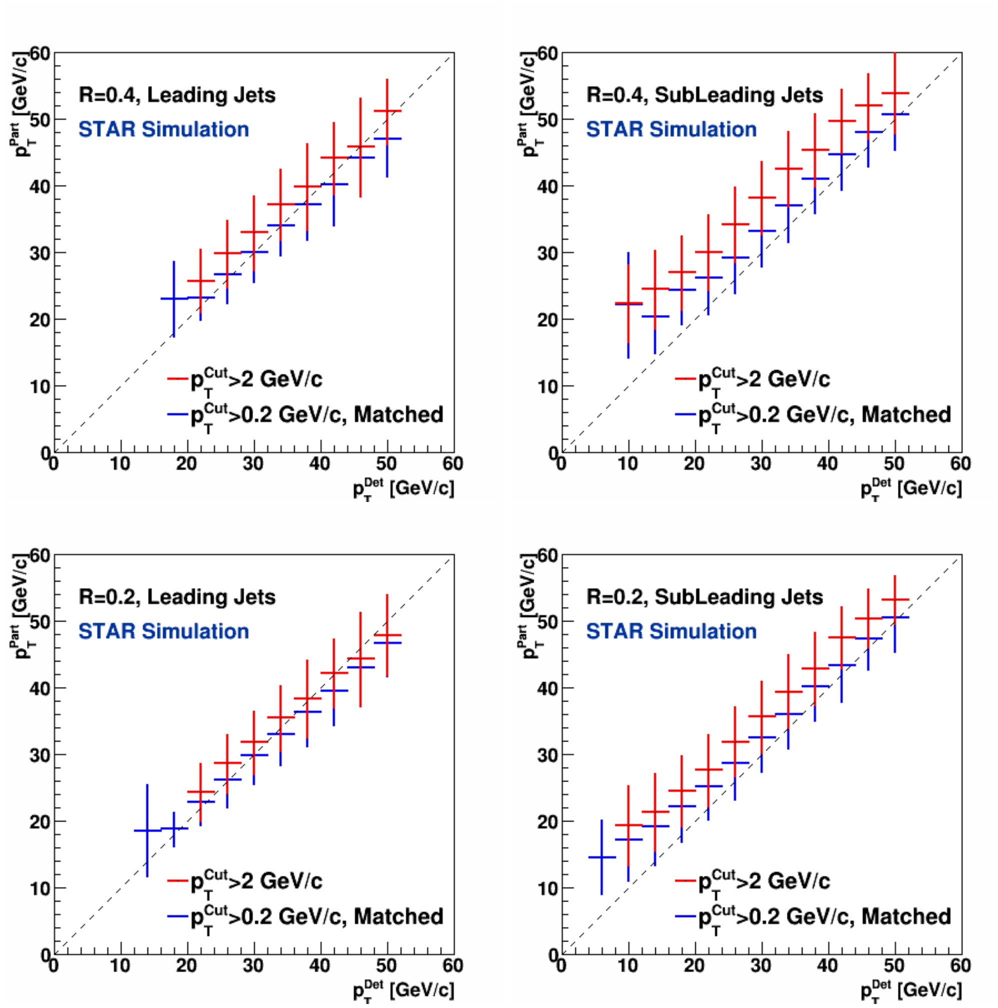

FIG. 1. Correlation between reconstructed jet p_T at the particle and detector levels. Vertical error bars show the RMS widths within the detector jet bins for leading and sub-leading jets (left, right) and both values of R (top, bottom). Note that the analysis cuts lead to some "missing" data points at low p_T^{Det}.

ing during the embedding process into 0-20% central Au+Au, similar to other jet studies in heavy ion collisions[6, 8–10]. In Figure 2, the difference $\delta p_T \equiv p_T^{\mathrm{pp}\oplus\mathrm{AA}} - p_T^{\mathrm{pp}}$ between jet p_T before (p_T^{pp}) and after embedding ($p_T^{\mathrm{pp}\oplus\mathrm{AA}}$) is shown for leading "hard-core" jets above 10 GeV/c with a constituent cut of $p_T^{\mathrm{Cut}} > 2$ GeV/c, as well as for their corresponding matched jets with $p_T^{\mathrm{Cut}} > 0.2$ GeV/c. Hard-core Jets are largely unmodified; only a small fraction of the population is shifted predominantly by one or more captured background hadrons just above the 2 GeV/c cutoff point. The average shift is less than 1 GeV/c (0.2 GeV/c for $R = 0.2$, 0.9 GeV/c for $R = 0.4$), similar to findings in [9, 10].

Matched jets with all constituents above 0.2 GeV/c show a Gaussian distribution peaked near zero with a power law tail at positive δp_T due to the presence of true jets in the background. A Gaussian fit to only the negative side of the distribution leads to a width of 5.1 GeV/c for $R = 0.4$ and 2.5 GeV/c for $R = 0.2$. Ignoring the power law component and fitting a gaussian over the whole range leads to a still very reasonable description with a σ of 5.9 GeV/c for $R = 0.4$ and 2.7 GeV/c for $R = 0.2$.

The influence of background fluctuations is decoupled from the jet itself and only depends on its area; anti-k_T jets in this analysis are circular with an area close to πR^2, independent of the jet p_T. In a true Au+Au event the potential presence of odd

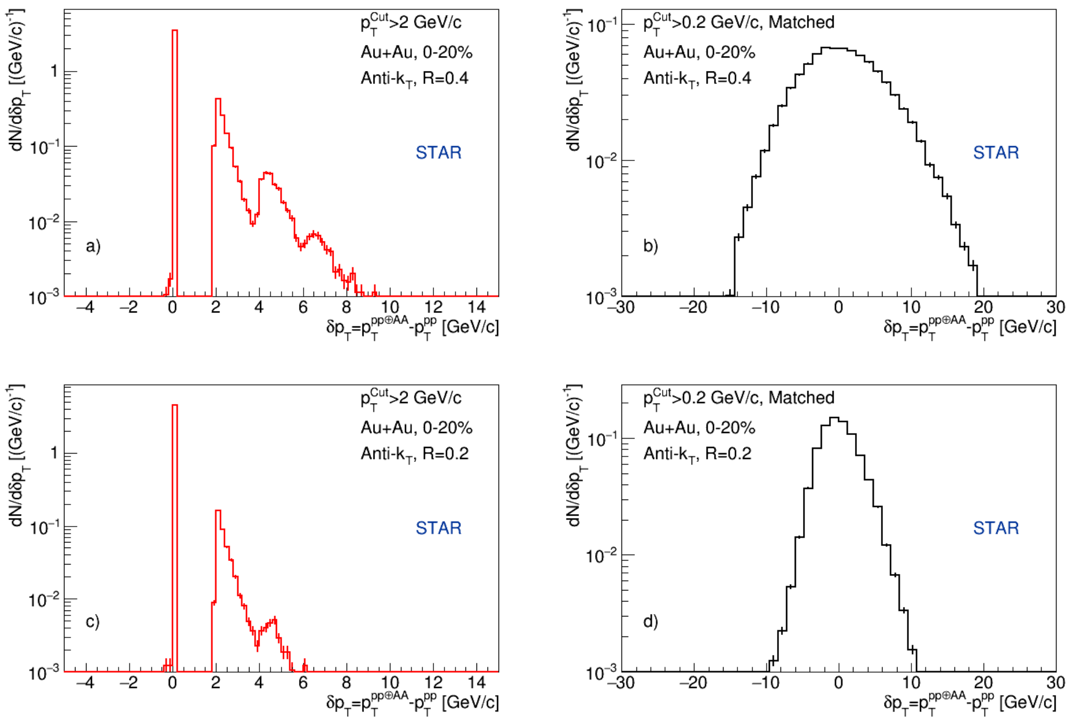

FIG. 2. Probability distributions for δp_T of leading jets in 0-20% central Au+Au collisions. Panels a) and c) show the shift in the "hard core" selection caused by the fluctuating background for $R = 0.4$ and $R = 0.2$, respectively. These jets are largely unmodified, with a small fraction of the population shifted predominantly by one or more captured background hadrons just above 2 GeV/c. Panels b) and d) show the same for geometrically matched jets including all constituents with $p_T^{\rm Cut} > 0.2$ GeV/c, displaying a Gaussian distribution peaked near zero with a power law tail.

harmonics modulating the background can lead to different background levels between the leading and sub-leading jet. In the Letter, we investigate this potential difference at the detector level by contrasting the "Eta Cone" (EC) method, where circles of radius R are placed in the same ϕ regions as real dijets in Au+Au HT events, with the "Random Cone" (RC) method which places circles at arbitrary points into 0-20% central Au+Au MB. The EC method is sensitive to the influence of hydrodynamic flow, yet it leads to similar results as RC, indicating that this influence is small; further analysis would go beyond the scope and statistical power of the current Letter.

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