Toward understanding relativistic heavy-ion collisions with the STAR detector at RHIC

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The focus of this project is the study of high-energy heavy-ion collisions at the Relativistic Heavy Ion Collider (RHIC). Two valuable probes of the matter created in these collisions are direct-photon-triggered (jet) correlations and heavy-quarkonium production.

Measurement of γ-Jet at low z_T and high trigger p_T

Direct photons produced in hard collisions, early in the evolution of a heavy-ion collision, are promising probes [1], as they do not interact via the strong force. Jet correlations (of the recoiling parton) with a direct-photon trigger can give information about the parton energy loss in the medium. The correlations with a photon trigger are compared to those measured with a π^0 trigger because of the difference in expected surface biases. While direct photons are not affected by the medium and can originate from anywhere in the medium without bias, π^0 triggers are likely to be have a bias of production near the surface of the medium. Therefore, on average, one would expect that the away-side jet for a π^0 trigger has a larger path length to traverse and experiences larger energy loss than the away-side jet of a γ^{dir} trigger. To enhance our sensitivity to the dependence on the path length through the medium, the measurement was extended to lower z_T (z_T is the ratio of the p_T of the associated particle to the p_T of the trigger particle, $z_T = p_{T,assoc}/p_{T,trig}$). To reach lower z_T, one can increase the trigger-particle p_T, which requires higher statistics, or lower the associated-particle p_T. To avoid the large uncertainties associated with background subtraction when lowering the associated-particle p_T, the trigger-particle, p_T, was increased to 12-20 GeV/c.

To measure the effect of the medium, Fig.1 shows the ratio of per-trigger yields I_{AA}, defined as the yield measured in Au+Au to that measured in p+p, as a function of z_T.

At low z_T ($0.1<z_T<0.2$), both the suppression levels in π^0-triggered yields, ${I_{AA}}^{\pi^0}$, and in γ^{dir}-triggered yields, ${I_{AA}}^{\gamma_{dir}}$, appear to be less than at higher z_T. At high z_T, the suppression factor is approximately 3−5. The theory calculations, labeled Wang [3, 4] and Qin [5] describe the data for γ^{dir}+$h^{\pm}$ correlations. Since the model calculations do not include a redistribution of the lost energy to the low-p_T jet fragments, the rise in ${I_{AA}}^{\gamma_{dir}}$ at low z_T is likely due to the volume emission of the γ^{dir} triggers (vs. surface emission of π^0 triggers). Also shown is the calculation for ${I_{AA}}^{\pi^0}$ [3, 4], which does not show the same rise at low z_T. However, within the measured uncertainties, there is no difference in the suppression of π^0-triggered yields and γ^{dir}-triggered yields, even at low z_T. This figure is included in the manuscript written by our group, which was recently submitted for publication [2]. It will be important to measure this more precisely with higher-statistics data (allowing for more systematic studies), in order to understand whether the rise is due to a redistribution of lost energy or effects of surface vs. volume emission trigger biases.

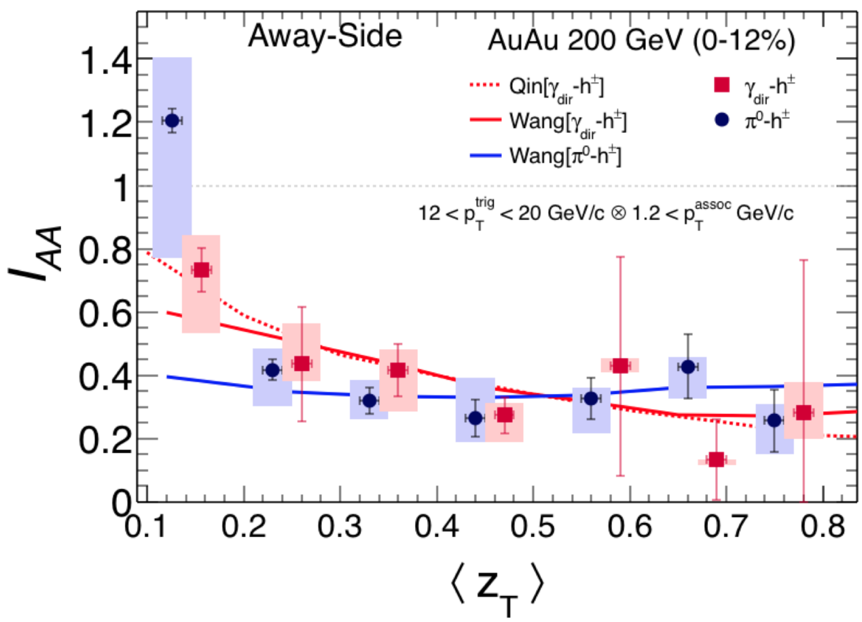

FIG. 1. I_{AA} vs. z_T for π^0-triggered away-side yields (blue) and γ^{dir}-triggered away-side yields (red) from Run-9 p+p and Run-11 central Au+Au data.

Heavy Quarkonium Studies using the Muon Telescope Detector in STAR

The J/ψ has long been considered one of the most promising direct probes of deconfinement [6]. In order to quantify effects of deconfinement, cold nuclear matter effects (via p+A collisions) must be measured and disentangled [7].

We have been working on determining the trigger efficiency in Run-14 Au+Au collisions. We have done this for low-luminosity and mid-luminosity data separately. The high-luminosity data was not yet reconstructed when Y. Liu started this study, but it will also be analyzed soon. Shown in Fig. 2 (left panel) is the "Single-Muon" trigger efficiency, requiring an energy signal within a "trigger patch" (region) in the MTD, as a function of p_T, in the mid-luminosity data. It is found to approach 91% at high p_T.

The di-muon efficiency is also calculated and shown in Fig. 2 (right panel), as a function of the pair p_T, where $p_T^{pair} = \sqrt{(p_x^{\mu_1} + p_x^{\mu_2})^2 + (p_y^{\mu_1} + p_y^{\mu_2})^2}$. The measured di-muon efficiency agrees with a simple simulation of two uncorrelated muons, each having trigger efficiency as shown in the left panel of Fig. 2.

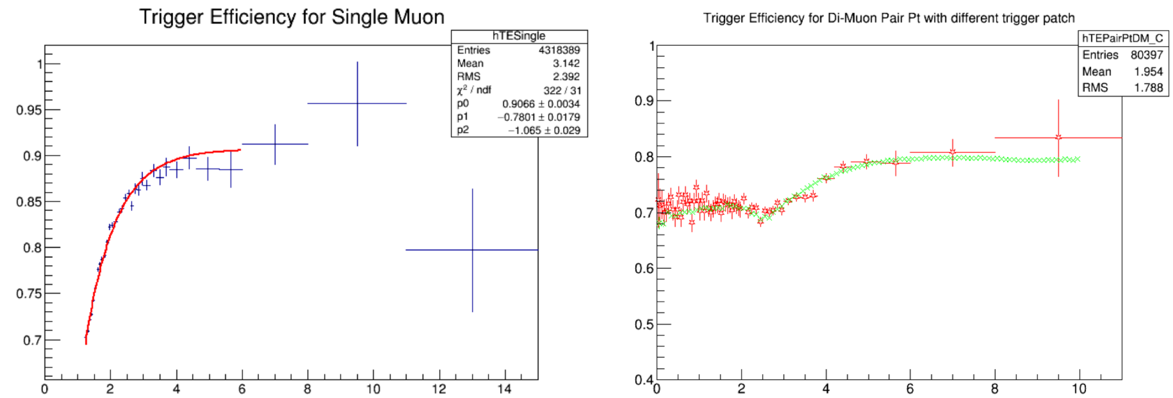

FIG. 2. (Left) Single-muon trigger efficiency in Run-14 Au+Au mid-luminosity data, as a function of p_T. The line is a fit to the data. (Right) Di-muon trigger efficiency in Run-14 Au+Au mid-luminosity collisions, as a function of pair p_T. The red are the measured data points, and the green is the simulated di-muon efficiency taking as input the p_T distribution of muon candidates and the single-muon efficiency, as shown on the left panel.

Last summer's REU student calculated survival probabilities of background particles in the MTD (pions, proton, and kaons). He used a sample of simulated particles embedded into and reconstructed within Au+Au collision data. He found that for p_T>1.2 GeV, muons had a 20% efficiency of being detected and passing the particle-identification criteria, while pions, protons, and kaons had less than 0.3% probability of detection and survival of the selection criteria.

The effort that the group has invested in understanding the response of the MTD and the triggers using the MTD will be useful for the J/Ψ measurement.

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