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

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We are studying relativistic heavy-ion collisions with two different probes: bottomonium and γ-jet.

I. Bottomonium (Y) Measurement

The bottomonium measurement is important to disentangle competing effects, dissociation in the deconfined plasma vs. $q\bar{q}$ recombination, both possibly playing a role in the production of charmonium in heavy-ion collisions. During the past year, we developed the tools for mass reconstruction of the Y(b $\bar{\text{b}}$), measured via its decay to an electron-positron pair in the STAR detector. STAR presented a preliminary Y mass peak from the Year-7 Au+Au data set at QM 2008 [1], from the UC Davis group, who is also working on this analysis. Prior to this, Y had not been measured in heavy-ion collisions. Because of the low statistical significance of the measurement, it is important to have systematic cross-checks. We are doing an independent analysis to compare with and provide such systematic checks for the parallel analysis effort by the UC Davis group. In particular, there are 2 fronts on which we are investigating systematics. First, we have been looking at the effect of the Barrel Preshower (BPRS) detector for electron identification. Second, we have used an alternate determination of the combinatorial background, in which tracks from different events are combined ("event-mixing") rather than combining only like-sign pairs from within an event. This alternate method reduces the statistical uncertainty on the background subtraction because the event-mixing can be performed over many events, while the number of like-sign pairs is similar in magnitude to the number of unlike-sign pairs within a single event (i.e. the foreground).

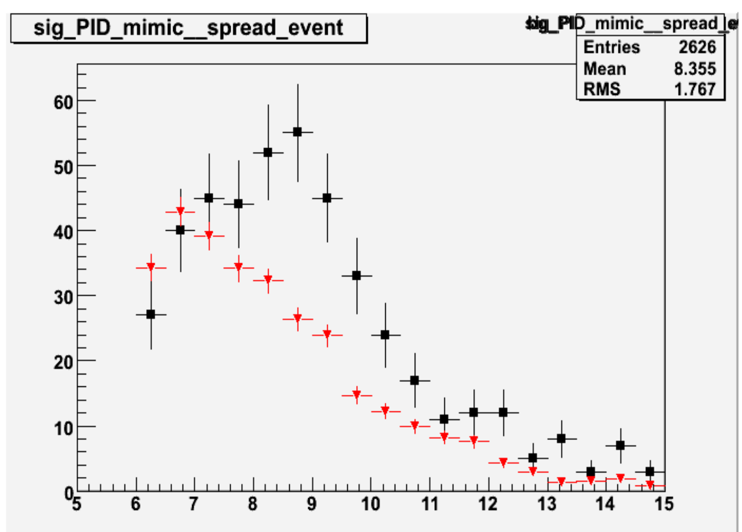

Figure 1. Reconstructed mass calculated from e^+e^- pairs (black squares), and from pairs from mixed events (red triangles) normalized by $\sqrt{(2N_{++}N_{--})}$ from the real events.

Fig. 1 shows the invariant mass distribution of e^+e^- pairs, together with the combinatorial background distribution generated from mixed-events. Fig. 2 shows the background-subtracted mass distributions with and without a cut on the BPRS signal, as electron identification for the lower-energy track. The peak loses approximately 20% of its counts when the cut is applied, as expected from the number of bad BPRS channels.

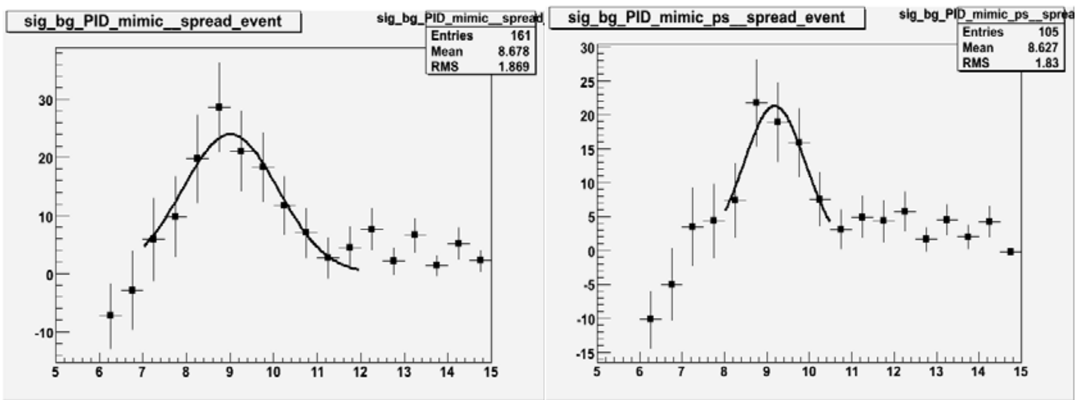

Figure 2. Background-subtracted invariant mass distributions, shown without a cut on the BPRS signal (left) and with a cut on the BPRS for electron identification (right).

II. Gamma-Jet Measurement

In order to measure the medium-induced parton energy loss as a function of the parton's original energy, one must measure photon-hadron correlations (γ-jet) [2]. The idea is to trigger on a "direct" photon, which originates directly from a hard scattering and does not interact strongly with the medium, and measure the jet on the away-side which does suffer from parton energy loss. In order to distinguish direct photons from photons from high-p_T π^0 decays, we used the Barrel Shower Maximum (BSMD) detector to discriminate between the shower profile of a single photon and that of two close photons. Fig. 3 shows a quantity, derived from the distribution of energy in 15 BSMD strips, on which the discrimination cut was made.

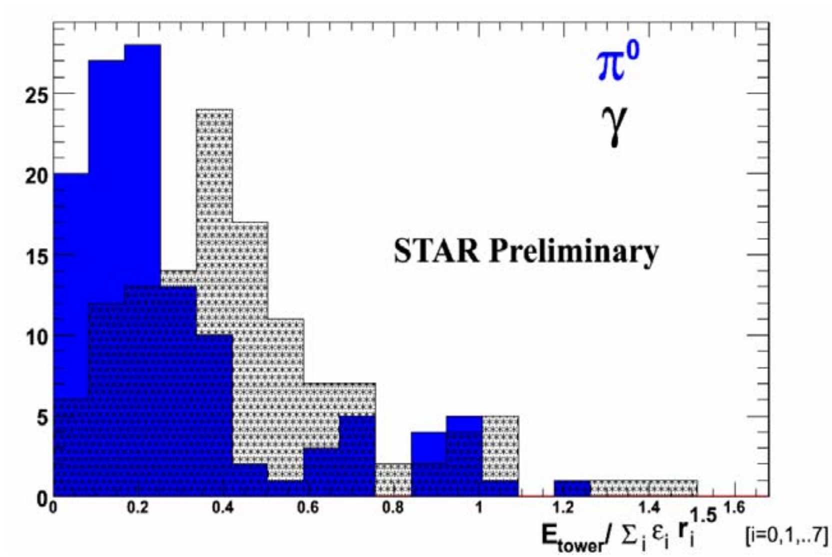

Figure 3. A quantity related to the transverse-shower profile, as measured by the BSMD, used to discriminate between direct photons and two photons from high-p_T π^0 decays. The solid blue histogram is from simulated π^0 and the hashed black is simulated photons, both embedded into real events.

With a pure sample of π^0 triggers and a sample of direct photon-rich triggers, the correlation function of each is constructed by calculating $\Delta\Phi$ for each charged hadron, within a given momentum range, with respect to the trigger particle. The flat background in the resulting distribution is subtracted. Since direct photons should have no associated yield at leading order, any remaining yield on the near-side is assumed to originate from π^0 triggers. Then the direct-photon associated yields can be obtained using the following prescription,

$$Y_{\gamma direct+h} = (Y^a_{\gamma rich+h} - RY^a_{\pi 0+h}) / (1-R),$$

where $R = Y^n_{\gamma rich+h} / Y^n_{\pi 0+h}$, Y^n represents the near-side yield, and Y^a represents the away-side yield.

We analyzed the Year-7 Au+Au data, and presented first results at Quark Matter 2008 [3], on behalf of the STAR Collaboration. The results are shown in Fig. 4.

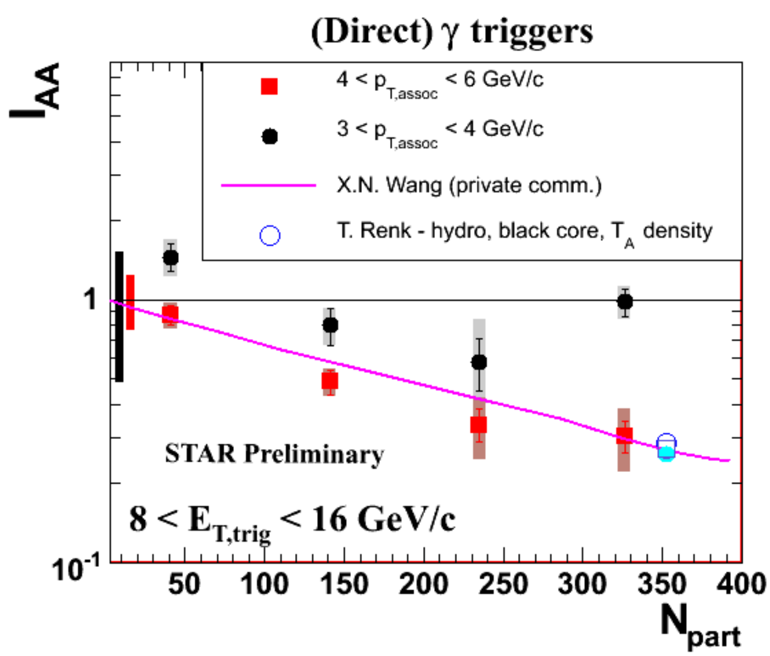

Figure 4. Ratio of associated yields for a direct-photon trigger measured in Au+Au collisions to that measured in p+p collisions, as a function of centrality.

[1] D. Das *et al.* (STAR Collaboration), in Proceedings of the 20th International Conference on Ultrarelativistic Nucleus-Nucleus Collisions (Quark Matter 2008), Jaipur, India, 2008.
[2] X. -N. Wang, Z. Huang, and I. Sarcevic, Phys. Rev. Lett. **77**, 231 (1996).
[3] A. Hamed *et al.* (STAR Collaboration), in Proceedings of the 20th International Conference on Ultrarelativistic Nucleus-Nucleus Collisions (Quark Matter 2008), Jaipur, India, 2008.