

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

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We have advanced the following physics analyses: I) understanding the bottomonium (Upsilon) production mechanism via Upsilon+hadron correlations and a spin-alignment measurement, II) long-range pseudorapidity correlations in heavy-ion collisions via high- p_T π^0 and direct γ triggers, and III) the energy loss mechanism in heavy-ion collisions via γ -jet correlations. Finally, we have performed simulation studies for a STAR upgrade project, the Muon Telescope Detector.

Upsilon Production Mechanism:

We have performed the Upsilon+hadron correlation analysis on the Run-9 p+p data set, as well as the Run-8 d+Au data set, and the spin-alignment measurement on the Run-9 p+p data. Fig.1 shows the reconstructed mass from e^+e^- pairs (black) and like-sign pairs (red) from our Run-9 p+p analysis. The blue lines indicate his mass cuts for the Upsilon-hadron correlations and the spin-alignment analysis. The high signal to background ratio enables us to perform the analyses with high purity.

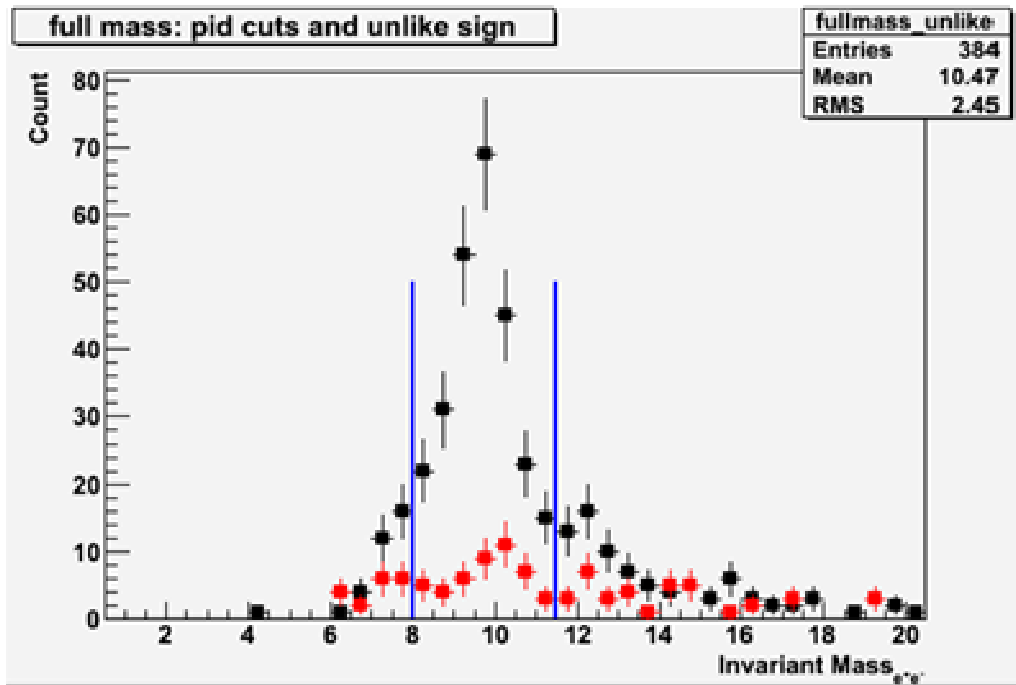


FIG. 1. Invariant mass distribution of e^+e^- pairs (black) and like-sign pairs (red) calculated in p+p events. The blue lines indicate the mass cuts used for the analyses.

Possible insight into the prompt production mechanism of heavy quarkonium can be obtained from hadronic activity measured near the Upsilon. Since more soft gluons are produced together with the Upsilon in the Color Octet model, one would expect more soft hadrons to be correlated with the Upsilon at close azimuthal angle ($\Delta\Phi \sim 0$). Fig. 2 shows the results for the azimuthal correlation between hadrons

and the Upsilon in p+p events. In the past year, the results have been corrected for the tracking efficiency determined from pions embedded into p+p events. Additionally, the cuts have been optimized for pile-up rejection using the comparison of the effect of cuts on embedded pions vs. the effect on data. We found that the most effective cut for rejecting pile-up was a cut on the distance of closest approach of the track to be within 1 cm of the primary vertex.

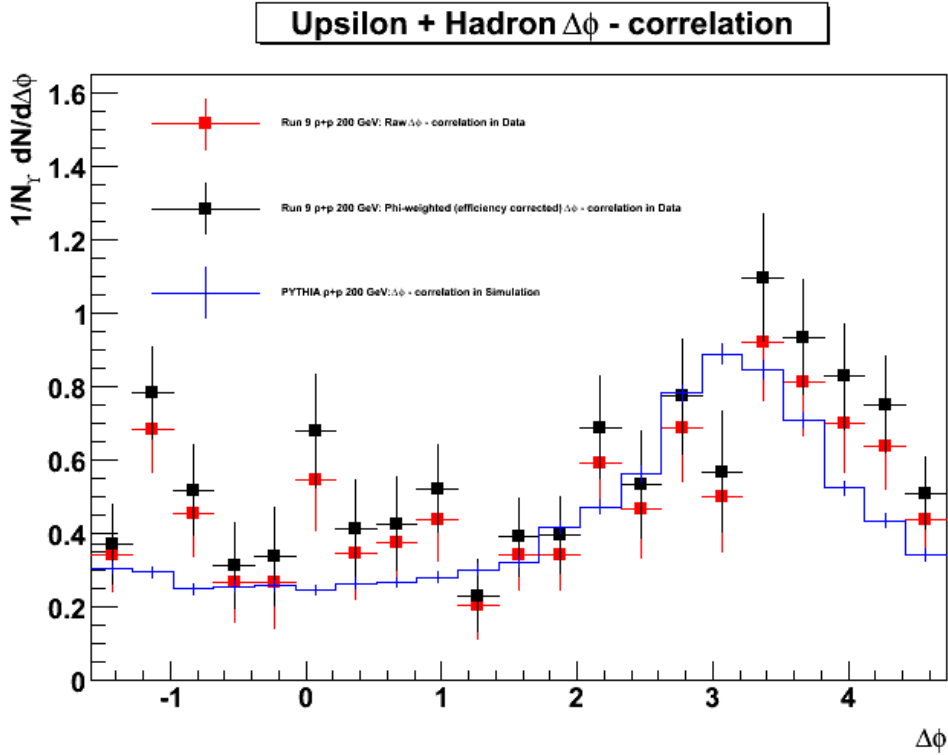
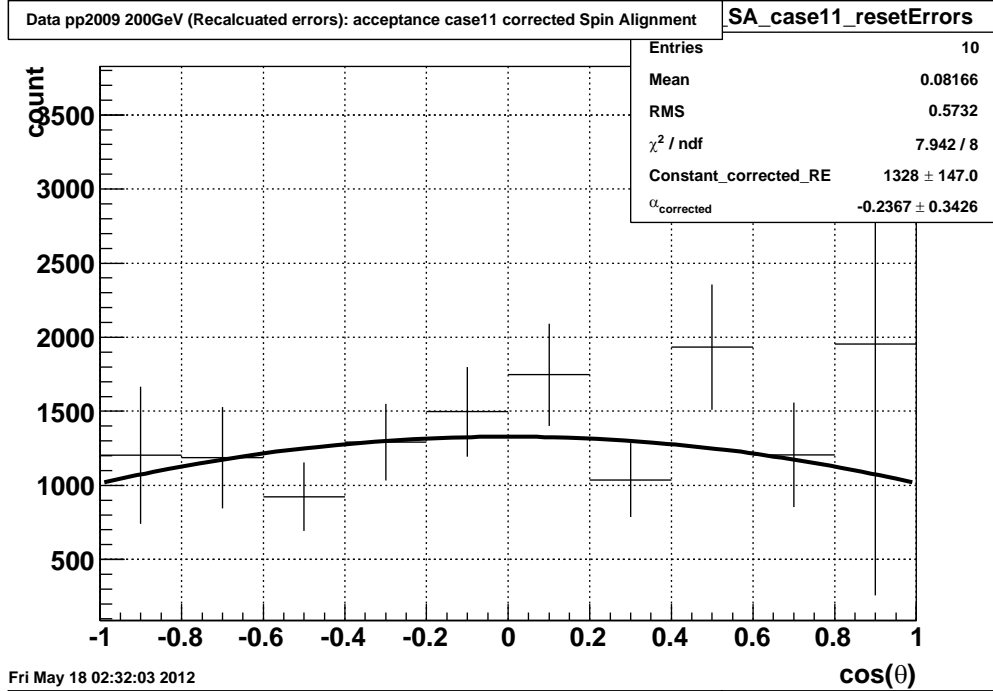
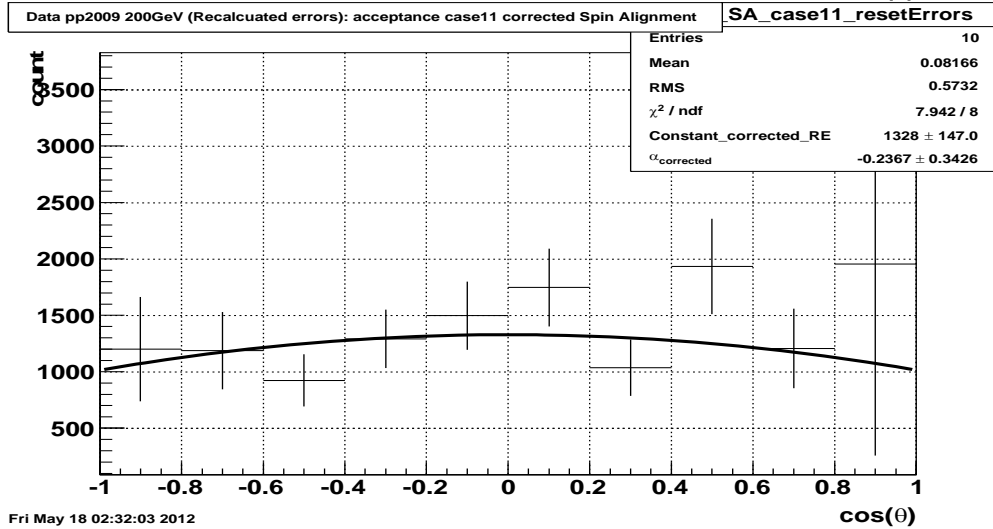


FIG. 2. Efficiency-corrected $\Delta\Phi$ -correlation (black squares) of hadrons with respect to the Upsilon in p+p events. The raw $\Delta\Phi$ -correlation is also shown (red squares). The result is compared to PYTHIA (blue).

The spin alignment measurement is parameterized as $dN/d(\cos\theta)=1+\alpha(\cos^2\theta)$, where θ is the angle between the direction of the decay e^+ momentum, measured in the Upsilon's rest frame with respect to the Upsilon's direction of motion, i.e. the polarization axis. This measurement contributes to the understanding of the production mechanism of heavy quarkonia because the Color Octet Model predicts a sizable non-zero polarization ($\alpha>0$), while the Color Singlet Model predicts a value of ~ 0 . We performed this measurement on Run-9 p+p collisions and corrected the measured distribution (Fig. 3) using Upsilon's embedded into p+p events. Checks are currently being made to finalize these results.



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FIG. 3. Raw (upper panel) and acceptance-corrected (lower panel) spin-alignment measurement $dN/d(\cos\theta)$ fit with function $C[1+\alpha(\cos^2\theta)]$.

The “ridge” via high- p_T γ/π^0 triggers:

The “ridge” has been observed as a long-range correlation in $\Delta\eta$ with respect to a high p_T trigger. It has previously only been measured in correlations with charged hadron triggers. This previous measurement has large uncertainties (including large statistical errors for $p_T > 5$ GeV/c) making it difficult to conclude whether the ridge persists up to trigger p_T exceeding 5 GeV/c. However, it was concluded that within the uncertainties, the ridge yield is constant as a function of trigger p_T . We extended the measurement of the ridge to higher p_T using π^0 triggers. As a consistency check, we first performed the

measurement using charged-particle triggers to compare with previously published results. Fig. 4 shows his results for two different methods of extracting the ridge yields from the correlation in $\Delta\Phi-\Delta\eta$ using Run-7 and Run-10 central Au+Au collision data, and compares to previous STAR results using Run-4 central Au+Au collision data.

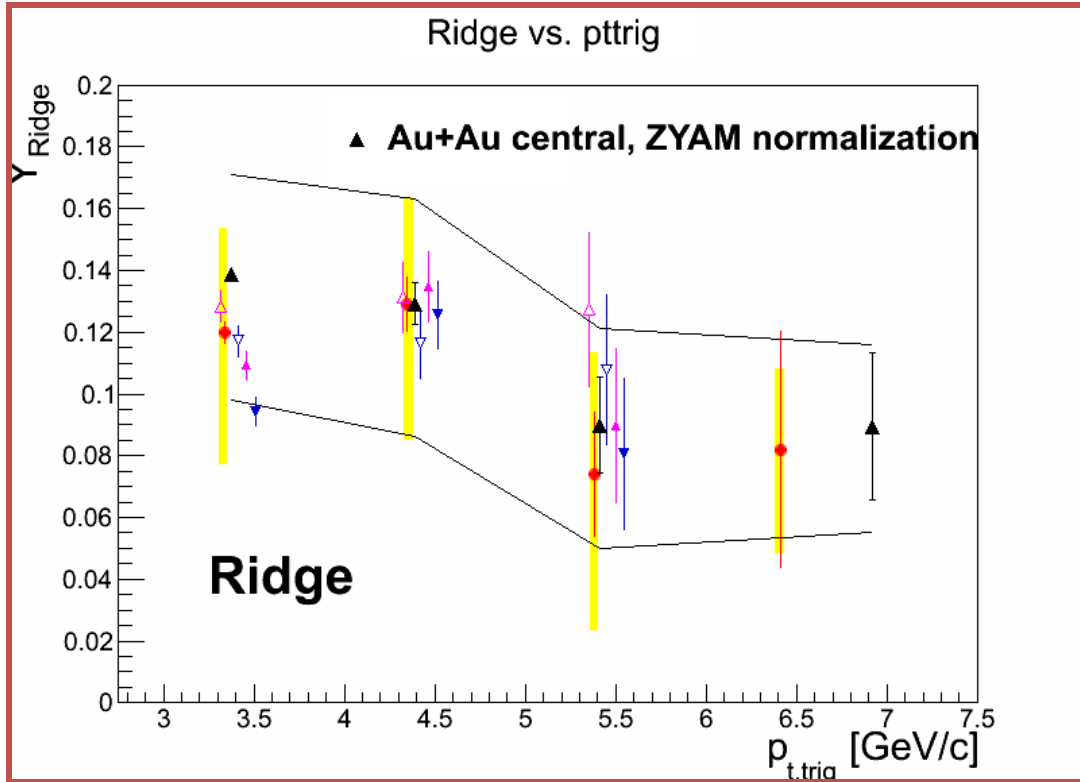


FIG. 4. The “ridge” yields measured in central Au+Au collisions (Run 7 and Run 10) via charged-particle triggered correlations, as a function of trigger-particle p_T , compared with results from Run 4. The black triangles are the Run-4 published result. The red circles are also from Run 4, from the Ph.D. thesis of Christine Nattrass, and the blue and magenta points are from this analysis of Run-7 (open triangles) and Run-10 (closed triangles) data for the two different methods of extracting the ridge yield.

Fig. 5 shows the ridge yield in central Au+Au events, extracted by two different methods, as a function of trigger p_T , for π^0 triggers. The direct γ/π^0 discrimination is performed using the transverse shower profile measured with the Barrel Shower Maximum Detector (BSMD), and was shown to be >90% pure for π^0 with $p_T > 8$ GeV/c for a previous publication on γ -jet correlations.

Although the statistical errors are still large (even in the Run-10 data set), we performed a χ^2 analysis, testing the consistency of the results at higher p_T ($p_T > 6$ GeV/c) with a constant value fit to the lower p_T ($p_T < 6$ GeV/c) yields vs. the consistency with zero yield. We found that the higher p_T yields, which were not previously measured by STAR, were more consistent with zero, than with a constant value of ~ 0.1 . We also concluded that combining the Run-7, Run-10, and Run-11 data sets would result in an increase in statistics, relative to Run-7 data alone, of a factor of 6.

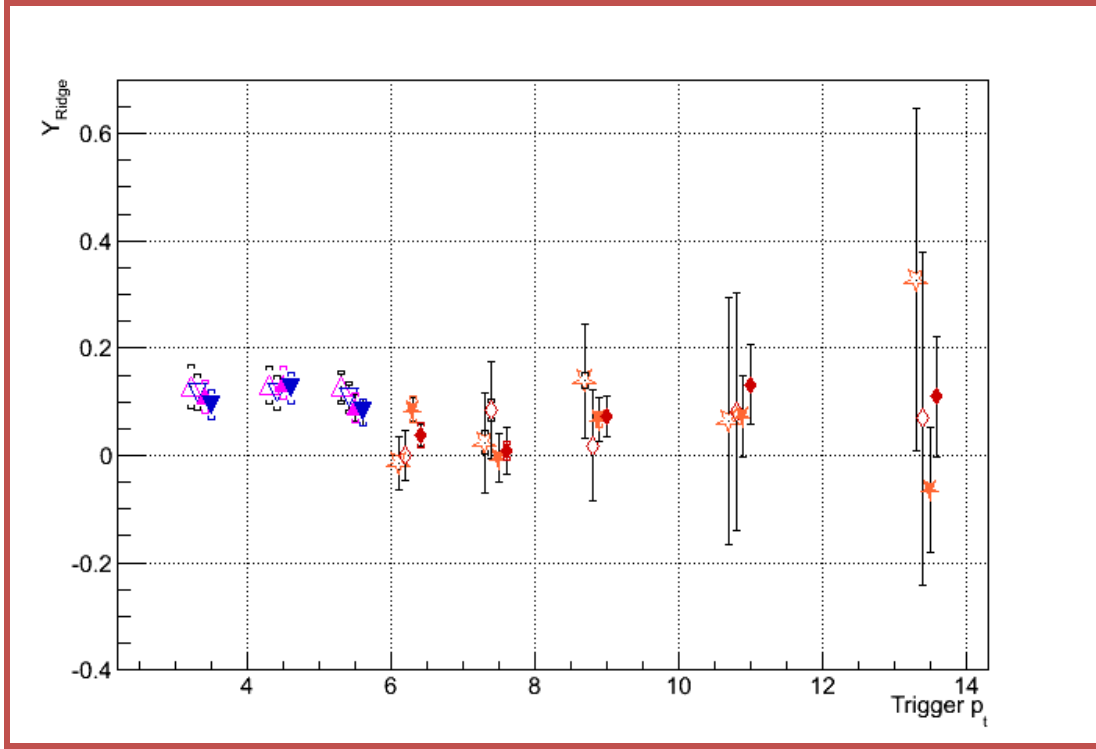


FIG. 5. Ridge yields shown for charged-charged correlations (blue) and π^0 -charged correlations (red), for Run-7 (closed symbols) and Run-10 (open symbols) central Au+Au collisions, all from this analysis.

γ -Jet Correlations:

We are currently repeating the γ -jet analysis on Run-10 and Run-11 data, aiming to reproduce the published results and then extending the measurement to 1) lower $z_T = p_{T,assoc}/p_{T,trig}$ (i.e higher $p_{T,trig}$), 2) more centralities, and 3) the 2+1 correlations. Because of adjustments to the BSMD settings to prevent saturation, the transverse shower profile cut (on the quantity of $E_{cluster}/(\sum E_{i,r_1})^{1.7}$), used for distinguishing single photons from π^0 , needed to be adjusted accordingly. Before adjustments, the π^0 trigger sample had more contamination from direct γ , reducing the near-side associated yields. With the current cuts, we found agreement between Run-7 and Run-11 yields associated with π^0 triggers, shown in Fig. 6.

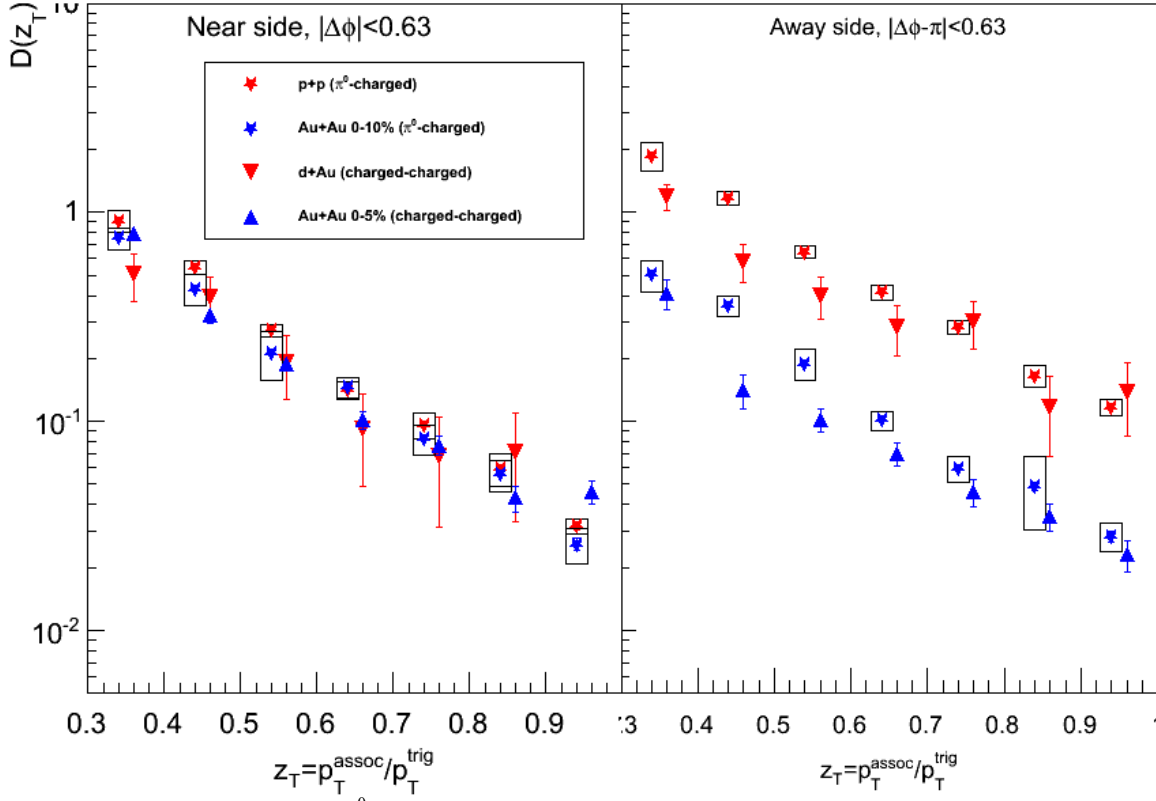


FIG. 6. Yields associated with π^0 triggers on the near side (left panel) and away side (right panel). The blue stars are Run-11 central Au+Au collisions and the blue triangles are Run-4 central Au+Au collisions (published results used for comparison). The red triangles are d+Au collisions and red stars are p+p collisions, as the baseline.

MTD-Related Research:

We studied the feasibility of using the Muon Telescope Detector (MTD), together with the Heavy Flavor Tracker (HFT), for separating J/Ψ particles from B-meson decays from primordial J/Ψ particles. The B-meson has a decay channel into a J/Ψ particle together with a kaon, and the J/Ψ decay channel that will be reconstructed is the two-muon decay. The B-meson has a lifetime large enough to allow the reconstruction of a decay vertex (displaced from the primary event vertex), with fine enough position resolution. The MTD is used to identify the muons from the $J/\Psi \rightarrow \mu^+ \mu^-$, and the HFT is a silicon detector with the necessary resolution to reconstruct a displaced vertex. The simulation used simulated B-mesons and primordial J/Ψ in this study. Our study concluded that a cut on the decay-length (as measured using hits in the HFT) to be greater than 0.15 mm results in nearly 100% rejection of primordial J/Ψ and a B-meson reconstruction efficiency of approximately 7%.