Suppression of leading particles and flavor correlation modifications in heavy ion collisions

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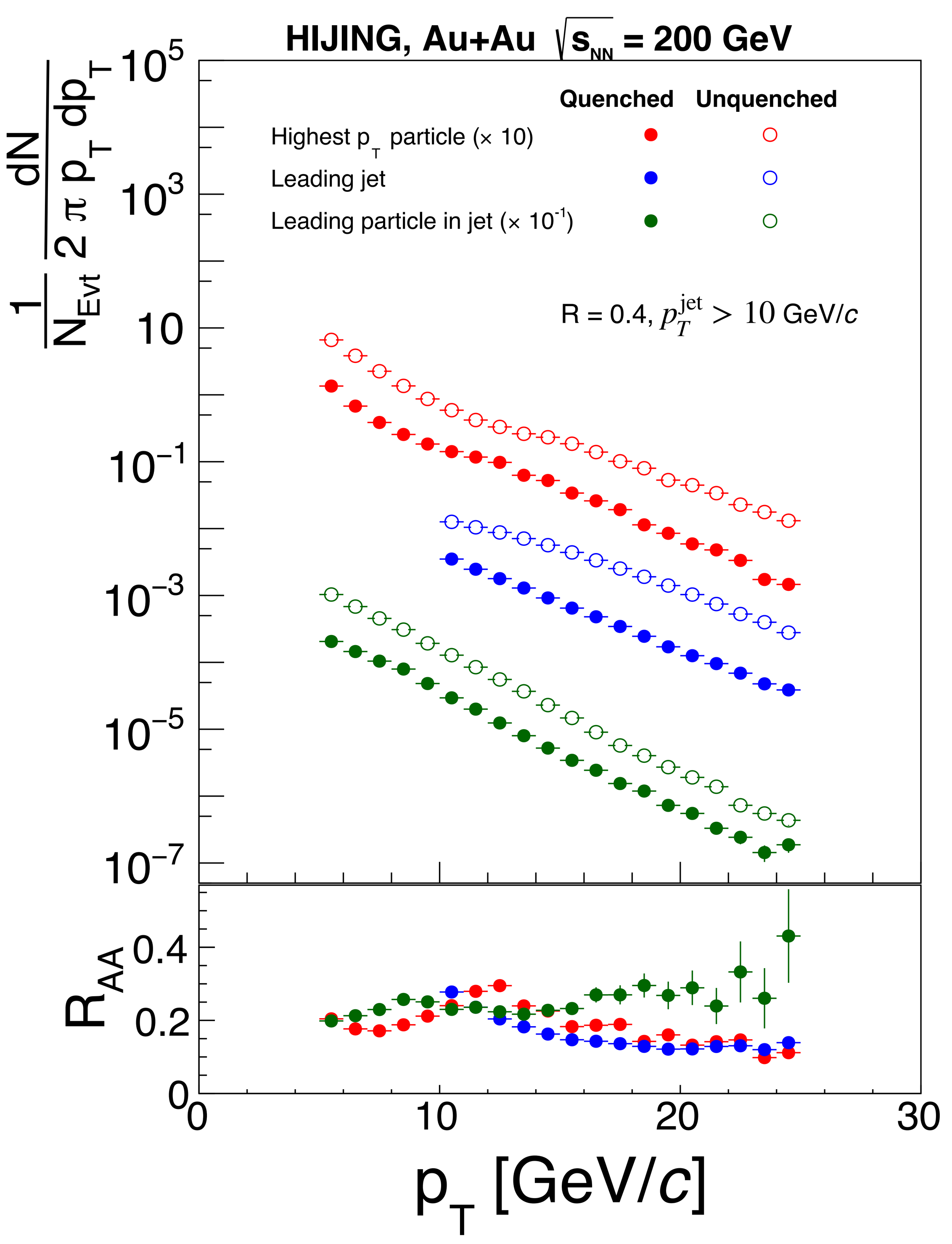
We study the suppression of leading two hadrons within jets and the modifications of their flavor correlations in heavy ion collisions. The di-hadron system is robust against the underlying event background therefore allows its precision measurements. Their suppression is sensitive to any partonic energy loss mechanism and can be used to cleanly test the onset of jet quenching in the evolution history. Also, their flavor correlation probes hadronization in the last stage of jet evolution. We will discuss di-hadron observables in the context of the upcoming RHIC measurements and present studies based on a variety of Monte Carlo simulations, which will lead to realistic measurement in the near future.

The rich information contained in jet substructure opened up the possibility of determining medium properties and jet-medium interactions through the study of jet modifications. Jet quenching, i.e. the suppression of hadron and jet cross sections, had lead us to the paradigm of jet energy loss for two decades. Qualitatively, we observed that energy can be transported away from jets and carried by low energy particles. However, with the huge underlying event background which consists mostly of soft particles, modifications of jet observables which are sensitive to soft particle contributions are very challenging to interpret.

$$R_{AA} = \frac{\frac{1}{N_{\text{events}}}\frac{d^2N^{\text{quenched}}}{dp_T dy}}{\frac{1}{N_{\text{events}}}\frac{d^2N^{\text{unquenched}}}{dp_T dy}}$$

A systematic examination of jet substructure from the highest energy scale down to lower scales becomes necessary in order to decouple possible medium effects at various scales. The work presented in this poster focuses on a specific recoil free observable (*see Bin Wu's talk: 28 Mar 2023, 11:30*) constructed using exclusively the leading and next-to-leading hadrons inside jets. These particles are the hardest component of a jet and are the most robust against underlying event background.



We note that the suppression of the leading particle in the jet is distinct from that of the leading particle. This may be due to the inclusion of the jet as a dominant energy flow in the event, giving more resilience to dramatic p_T shuffling or being dropped from the sample due to quasi-particle scattering.

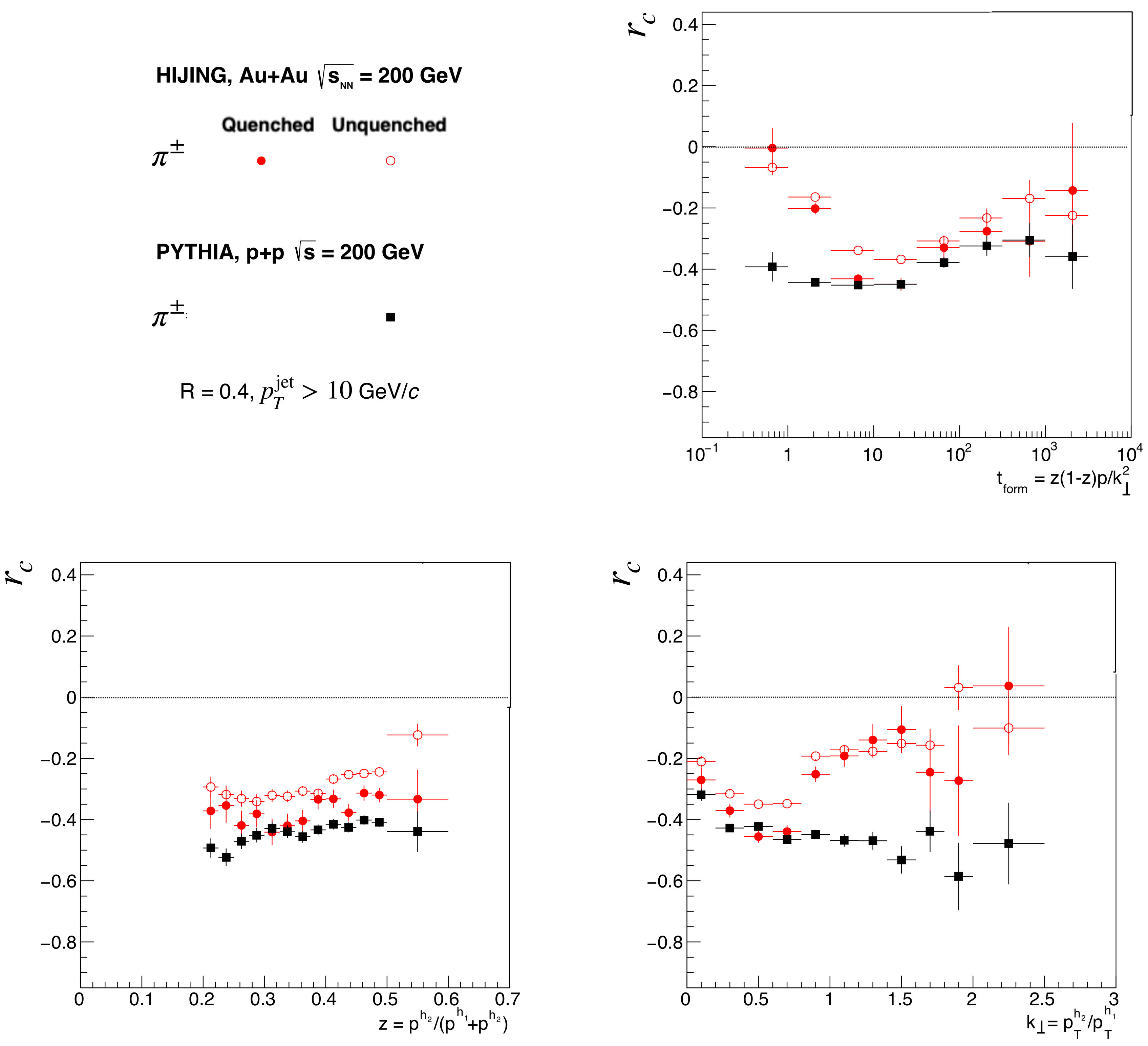
By comparing the leading particle spectra in the quenched and unquenched cases, a similar quantity to the S_{loss} observable (*Phys. Rev. C 93 (2016) 024911*) could be extracted, allowing for a quantitative determination of energy loss of the hard particles.

On the other hand, the leading di-hadron system was shown to probe hadronization with unique non-perturbative origin in the context of the future Electron Ion Collider study (*Phys. Rev. D 105, L051502*). Therefore, the suppression of leading di-hadron is sensitive to the sources of parton energy loss, and the modification of di-hadron correlation will inform us about the modification of the hadronization process which is the latest stage of jet evolution.

With the reconstruction of leading di-hadrons, their kinematic distribution forms a unique set of jet substructure observables. Following the work (Phys. Rev. D 105, L051502), we use the ratio observable

$$r_c(h_1h_2) = \frac{d\sigma_{h_1h_2} - d\sigma_{h_1\overline{h_2}}}{d\sigma_{h_1h_2} + d\sigma_{h_1\overline{h_2}}}$$

to probe the charge constraint in hadronization by contrasting the cross sections of producing same-sign and opposite-sign leading di-hadrons. The modification of the above distributions then gives us information about jet-medium interactions.



We expect the suppression of leading hadrons within jets to be experimentally accessible at RHIC and the LHC. By reducing the influence of the thermal background in heavy-ion collisions, experimental correction and systematic uncertainties should be reduced, allowing for precise measurements.

As with all heavy-ion suppression observables, there is some degree of selection bias, as experimentally reconstructed jets with a given momentum are more likely to originate from hard partons close to this momentum with shorter in-medium path length. This effect could be reduced by setting the initial scale with a hard photon, which will be explored in the future.

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