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High p_T Direct Photon Production as a Probe of Nuclear Modification to disentangle Centrality Bias in Small System Collisions

In recent studies of small system collisions at RHIC, significant suppression of high transverse momentum (high p_T) neutral hadrons has been observed in high-activity events, contrasted by an unexpected enhancement in low-activity events. This phenomenon, seen in d+Au and p+Au collisions at $\sqrt{s_{NN}} = 200$ GeV, challenges conventional interpretations of nuclear modification based solely on medium-induced energy loss as seen in large-ion collisions.

High p_T direct photons, unaffected by the colored medium due to their color-neutrality, serve as an essential probe in understanding these discrepancies. In this study, we use direct photon and π^0 production data from PHENIX to investigate the dependence of nuclear modification factor R_{xA} on event centrality. Our findings suggest that the observed suppression and enhancement patterns are less likely due to true medium effects and more likely attributed to deviations in the standard Glauber model's centrality scaling, which may misrepresent event activity and centrality.

By leveraging direct photon production as an empirical measure of binary collisions (N_{coll}) in small systems, we aim to correct for these biases, providing a clearer interpretation of high p_T particle yields in small system collisions. This analysis sheds light on the limitations of applying large-ion collision frameworks to small systems and highlights the need for refined models in understanding nuclear effects in asymmetric collisions.

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