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Implications of Realistic Centrality Determination for QGP Formation in Small Systems

Signatures of collective behaviour consistent with a QGP-like medium have been observed in proton–lead (p–Pb) collisions, but jet quenching has not been observed despite theoretical predictions of partonic energy loss. The nuclear modification factor, a common signature of jet quenching, can be affected by biases introduced by multiplicity-based centrality selection.

In p–Pb collisions, multiplicity fluctuations at fixed collision geometry are large, causing multiplicity-based selections to preferentially select events with particular particle-production dynamics at a given collision geometry. This can bias the inferred number of binary nucleon–nucleon collisions for a centrality class used in determining the nuclear modification factor.

Experimentally, Zero Degree Calorimeters provide an alternative centrality estimator based on spectator neutrons near beam rapidity, which is less directly influenced by mid-rapidity particle production. This project investigates ZDC-based centrality selection in theoretical simulations using the heavy-ion collision framework Trajectum by modelling spectator fragmentation with GEMINI and constructing a ZDC signal from the resulting spectator neutrons.

Preliminary results show that the choice of centrality estimator affects the inferred collision geometry and high- p_T suppression, with ZDC-based selection currently showing weaker suppression than multiplicity-based selection in most central events. Further analysis will investigate the physical origin of this difference.

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