Forward-Backward Multiplicity Correlations for Identified Particles at STAR

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Abstract

Long-Range Forward-Backward multiplicity correlations (LRC) may be a signal for multiple partonic interactions in dense matter, whereas short-range correlations (SRC) are due to independent sources. Previously, strong LRC have been measured at STAR in 200 GeV central Au+Au collisions, and were shown to decrease with decreasing centrality. The Color Glass Condensate model, which describes sources as longitudinal flux tubes, predicts that the correlation will grow with centrality. Furthermore, fluctuations in the number of gluons at early times will produce a long range correlation significantly larger for pions than protons and anti-protons. We present the forward-backward correlation of identified hadrons (pions, kaons, protons and anti-protons) as a function of rapidity for Au+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV. The particle identification is carried out by measuring their average energy loss in the STAR Time Projection Chamber. The centrality dependence of the correlation strength will also be discussed for each particle species.

Introduction

The Relativistic Heavy Ion Collider (RHIC) was designed to study the QCD phase diagram of nuclear matter. QCD predicts that at sufficiently high temperatures and energy densities partons will be liberated to create the quark-gluon plasma (QGP). Kinematic observables of hadrons produced in heavy-ion collisions are measured using various detectors at the Solenoidal Tracker At RHIC (STAR) to search for signals of quark-gluon degrees of freedom.

Long-range (rapidity separation > 1) multiplicity correlations (LRC) are predicted in high-energy nucleon-nucleon collisions by the Dual Parton Model (DPM) and in nucleus-nucleus collisions by DPM, the Color String Percolation Model, and the Color Glass Condensate (CGC) picture. CGC predicts the LRC will grow with increasing centrality [1,2]. Strong LRC in central heavy-ion collisions using inclusive charged particles have been measured in the STAR TPC [3]. Stong LRC may indicate the occurrence of multiple partonic interactions.

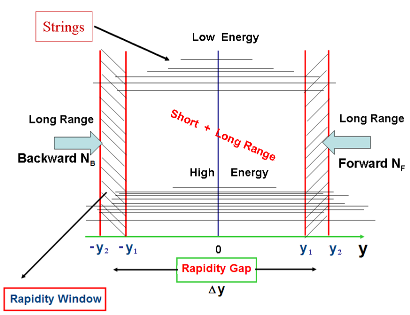
What is the origin of the LRC? In the context of the DPM the LRC is due to the fluctuation in the number of strings [4,5]. The fluctuation in the number of strings is due to multiple partonic interactions. Is the LRC reflected in mesons or baryons? DPM does not make a prediction with respect to particle type. The CGC picture predicts the correlation for pions should be larger than for baryons (protons and anti-protons) due to fluctuations in the gluon distribution at early times [1].

As seen previously in hadron-hadron experiments [6], the average multiplicity of particles in the backward region can be related to the multiplicity in the forward region.

$$\langle N_b \rangle_{N_f} = a + bN_f$$

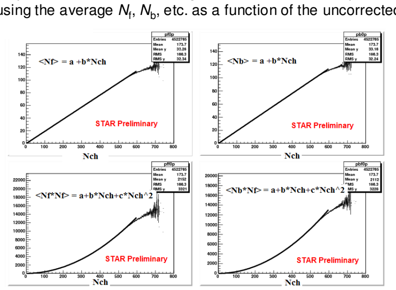
Applying a linear regression one can obtain the correlation strength *b*.

$$b = \frac{<N_f N_b> - <N_f><N_b>}{<N_f^2> - <N_f>^2} = \frac{D_{bf}^2}{D_{ff}^2}$$



Analysis

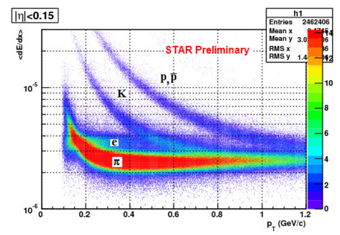
For each centrality bin, the correlation strength is measured event-by-event in each rapidity separation by using the average N_f, N_b, etc. as a function of the uncorrected $dN_{ch}/d\eta$.



The particles used to determine the centrality must not be used to calculate the FB correlation strength in order to avoid auto-correlations.

Rapidity separation	Centrality determination region
Δy = 0.16, 0.32, 0.48, 0.64	0.5<|η|<1.0
Δy = 0.80, 0.96	|η|<0.3 and 0.8<|η|<1
Δy = 1.12, 1.28, 1.44, 1.60	|η| <0.5

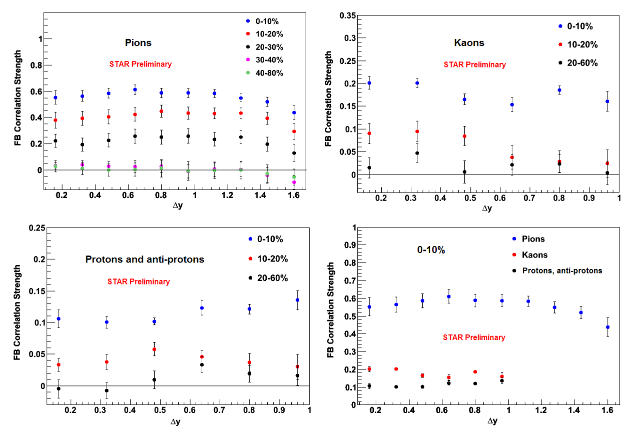
The data in this analysis is from Au+Au collisions with a center of mass energy of 200 GeV. The Time Projection Chamber (TPC) at STAR has the capability to identify pions, kaons, protons and anti-protons by measuring their ionization energy loss and comparing it to the theoretical expectation.



Particle ID Cuts

- Pions
  - $0.2 < p_T < 0.6$ GeV/c
- Kaons
  - $0.2 < p_T < 0.6$ GeV/c
- Protons and anti-protons
  - $0.4 < p_T < 1.0$ GeV/c

Results



DPM Interpretation:

$$D_{bf}^2 = \langle N_f N_b \rangle - \langle N_f \rangle \langle N_b \rangle$$
$$= \langle k \rangle \left(\langle N_{0f} N_{0b} \rangle - \langle N_{0f} \rangle \langle N_{0b} \rangle \right) + \left(\langle k^2 \rangle - \langle k \rangle^2 \right) \langle N_{0f} \rangle \langle N_{0b} \rangle$$

Fluctuation in the number of elementary collisions which gives rise to the LRC

- k is the number of elementary collisions
- N_{0f} and N_{0b} are the multiplicities from a single collision in the forward and backward regions, respectively

Conclusions

- Measurements show a strong, uniform LRC across Δ*y* for pions in central Au+Au collisions at 200 GeV, which decreases from central to peripheral collisions indicating multiple partonic interactions in central nucleus-nucleus collisions.
- The small SRC for kaons and protons and anti-protons, compared to pions, suggests the LRC will also be small for these species.
- CGC predicts that the LRC seen for pions is primarily due to the fluctuation in the number of gluons, and can only be created at early times.
- Time of Flight detector can be used to study the high p_T dependence of the correlation

References

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